City of Houston
Houston Public Works

Standard Construction Specifications for Wastewater Collection Systems, Water Lines, Storm Drainage, Street Paving, and Traffic

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Division 02-16: Standard Specifications
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NEW IN THE 2026 REVISION

Standard Construction Specifications for Wastewater Collection Systems, Water Lines, Storm Drainage, Street Paving, and Traffic – 2026 Revisions to the 2023 Edition

The City of Houston Standards Review Committee (SRC) was established to review, revise, and update documents and standards for Houston Public Works. Public input and participation was requested by the submittal of proposals for suggested changes, comments, recommendations and other information.

The 2023-2026 City of Houston Review Cycle Committee reviewed Infrastructure Design Manual (IDM) Chapters 1, 3, 6, 9 and 17 along with their associated standard drawings and standard construction specifications. Refer to the IDM Executive Summary for a summary of major updates to the design requirements made this review cycle. Below is a list of Division 02-16 standard specifications and standard drawings that were revised during this review cycle. The Standard Construction Specifications have change bars on the left side of the page to indicate a major revision has taken place.

New Standard Specifications:

- None

Standard Specifications Updated*:

- 02081 – Cast-in-place Concrete Manholes
- 02082 – Precast Concrete Manholes
- 02091 – Non Metallic Frames, Grates, Rings, and Covers
- 02221 – Removing Existing Pavements, Structures, Wood, and Demolition Debris
- 02317 – Excavation and Backfill for Utilities
- 02321 – Cement Stabilized Sand
- 02322 – Flowable Fill
- 02400 – Tunnel Shafts
- 02445 – Jack and Bore/ Jack and Mine/ Pilot Tube Guided Boring Tunnels
- 02501 – Ductile Iron Pipe and Fittings
- 02504 – Fiberglass Reinforced Pipe
- 02505 – High Density Polyethylene (HDPE) Solid and Profile Wall Pipe
- 02506 – Polyvinyl Chloride Pipe
- 02507 – Prestressed Concrete Cylinder Pipe
- 02508 – Extra Strength Clay Pipe
- 02509 – Fiberglass Reinforced Pipe for Pressure Mains
- 02510 – Polypropylene (PP) Corrugated Wall Pipe
- 02533 – Acceptance Testing for Sanitary Sewers
- 02611 – Reinforced Concrete Pipe
- 02612 – Precast Reinforced Concrete Box Sewers
- 02631 – Storm Sewers
- 02633 – Precast Concrete Inlets, Headwalls, and Wingwalls
- 03315 – Concrete for Utility Construction

Standard Specifications Retired/Deleted:

- None

New Standard Details:

- 02082-14 – Precast Concrete Top Slab Lid
- 02090-03 – 32” Storm Sewer Manhole Frame and Grate
- 02090-11 - 48” Storm Sewer Manhole Frame and Cover
- 02090-13 – 30” Storm Sewer Manhole Frame and Hinged Cover
- 02090-14 - Storm Sewer Frame and Grate for Type “B-B” Inlet Double Assembly with Camlock
- 02091-02 - Storm Sewer Non-Metallic Manhole Frame and Cover
- 02317-10G – Storm Sewer Bedding and Backfill for Thermoplastic Pipe in Dry Stable Trench
- 02633-01 - Precast Concrete Storm Sewer Inlet Type “A”
- 02633-02 - Precast Concrete Storm Sewer Inlet Type “B-B”, “B-B(1)” and “B-B(2)”
- 02633-03 - Precast Concrete Storm Sewer Inlet Type “C”, “C-1” And “C-2”
- 02633-04 - Precast Concrete Storm Sewer Inlet Type “D”
- 02771-03 - Curb and Gutter Transition For Precast Inlet Type “B-B”, “B-B(1)” and “B-B(2)”
- 02771-04 - Curb and Gutter Transition For Precast Inlet Type “C”, “C-1”, and “C-2”

Standard Details Updated*:

- 02082-13 - Storm Sewer Precast Box Inlet/Manhole
- 02082-15 (prev. 02081-04) - Storm Sewer Manhole Type ‘C’ For Proposed Concrete Box Sewer

Standard Details Updated* (Cont'd):

- 02082-16 (prev. 02081-08) - Proposed Manhole on Existing Box Storm Sewer
- 02082-17 (prev. 02081-05) – Storm Sewer Manhole for Existing Monolithic Reinforced Concrete 48" Dia and Greater
- 02090-02 (prev. 02084-02) - Storm Sewer Manhole Frame and Cover
- 02090-04 (prev. 02084-04) - Storm Sewer Type "B-B" Inlet Double Assembly
- 02090-05 (prev. 02084-05) - Storm Sewer Frame and Grate for Type "B-B" Inlet Double Assembly
- 02090-06 (prev. 02084-06) - Storm Sewer Type "D" Inlet Grate and Frame
- 02090-07 (prev. 02084-08) - Storm Sewer Type "A" Inlet Grate and Frame
- 02090-08 (prev. 02084-09) - Storm Sewer Type "C", "C-1" and "C-2" Inlet Frame and Cover
- 02090-09 (prev. 02084-10) - 32" Inverted Manhole Frame
- 02090-10 (prev. 02084-11) Storm Sewer Ring Grate for Open End of 18" to 72" RCP Stubs to Ditch
- 02317-02 - Sanitary or Storm Sewer Crushed Stone Foundation for Wet Stable Trench
- 02317-03 – Sanitary or Storm Sewer Bedding and Backfill for Dry Stable Trench
- 02317-05 – Precast Concrete Box Storm Sewer Bedding and Backfill for Dry Stable Trench
- 02317-06 - Precast Concrete Box Storm Sewer Bedding and Backfill for Wet Stable Trench
- 02317-07 - Precast Concrete Box Storm Sewer Bedding and Backfill with Seal Slab
- 02632-04 – Storm Sewer Type "B-B" Inlet for Maintenance Only
- 02632-09 - Storm Sewer Type "E" Inlet
- 02632-10 - Storm Sewer Type "E" Inlet on Exist Monolithic Conc Sewers of 48" Dia & Greater
- 02631-GD01 (prev. 02632-11) - Side Street Ditch Reception
- 02754-02 – Driveways With Culverts on Open Ditch Type Streets

Standard Details Retired/Deleted:

- 02081-07 - Lateral Connection to Existing Monolithic Reinforced Concrete Storm Sewer
- 02084-03 - Storm Sewer Type "B" Inlet Assembly
- 02084-07 - Storm Sewer Type "D-1" Inlet Grate and Frame
- 02632-01 - Storm Sewer Type "A" Grate Inlet
- 02632-03 - Storm Sewer Type "B" Inlet Relocation
- 02632-05 - Storm Sewer Type "B" Inlet Relocation
- 02632-06 - Storm Sewer Type "C-1", "C-2" and "C-2A" Inlet
- 02632-07 - Storm Sewer Type "D" Inlet
- 02632-08 - Storm Sewer Type "D-1" Inlet

*Only specifications and standard details with technical changes have been included in the list.

CHANGES MADE IN THE 2023 REVISION

Standard Construction Specifications for Wastewater Collection Systems, Water Lines, Storm Drainage, Street Paving, and Traffic – 2023 Revisions to the 2022 Edition

The City of Houston Standards Review Committee (SRC) was established to review, revise, and update documents and standards for Houston Public Works. Public input and participation was requested by the submittal of proposals for suggested changes, comments, recommendations and other information.

The 2022-2023 City of Houston Review Cycle Committee reviewed Infrastructure Design Manual (IDM) Chapters 15-17 along with their associated standard drawings and standard construction specifications. Refer to the IDM Executive Summary for a summary of major updates to the design requirements made this review cycle. Below is a list of Division 02-16 standard specifications and standard drawings that were revised during this review cycle. The Standard Construction Specifications have change bars on the left side of the page to indicate a major revision has taken place.

New Standard Specifications:

- 02871 – Bike Racks
- 02890 – Pedestrian Crosswalk System Rectangular Rapid Flashing Beacon (RRFB)
- 16130 – Advanced Transportation Controller (ATC) Cabinet Assembly

Standard Specifications Updated*:

- 02221 Removing Existing Pavements, Structures, Wood, and Demolition Debris
- 02581 – Street Lighting Conduit
- 02582 – Traffic Pole Assemblies - Steel
- 02775 – Concrete Sidewalks
- 02893 – Traffic Signal Construction
- 02921 – Hydro Mulch Seeding
- 16711 – Traffic Signal Conduit
- 16712 – Solar Powered School Zone Field Equipment
- 16715 – Vehicle Signal Heads
- 16716 – Pedestrian Signal Heads
- 16718 – Vehicle Traffic Control Signal Heads –Light Emitting Diode (LED) Circular Signal Supplement
- 16719 – Countdown Pedestrian Signal Module
- 16727 – Traffic Signal Saw-Cut Loop Detector
- 16732 – Uninterruptable Power Supply (UPS) System for Traffic Signal Cabinets
- 16733 – Field Hardened Ethernet Switch
- 16735 – Fiber Optic Splice Enclosure
- 16750 – Accessible Pedestrian Push Button Station

Standard Specifications Retired/Deleted:

- 16734 – WiMax
- 16738 – Wireless Communication System

Standard Specifications Retired/Deleted (Continued):

- 16743 – Code Division Multiple Access (CDMA) Modem Assembly
- 16744 – Ethernet Video MPEG-4 Encoder
- 16745 – Ethernet Video MPEG-4 Decoder
- 16751 – Wireless Magnetometer Vehicle Detection System

New Standard Details:

- 02760-11 – Bicycle Intersection Treatments (Sheet 2)
- 02771-02 – 14” Wide Precast Curb Stop Delineator for Bicycle Lanes
- 02775-09 – Perpendicular Curb Ramp
- 02775-10 - Retrofit Bikeway at Floating Bus Stop
- 02871-01 – Bicycle Rack Details

Standard Details Updated*:

- 02582-02 (prev. 02583-04A) - Traffic Signal Structures (Sheet 1 of 2)
- 02582-03 (prev. 02893-04B) - Traffic Signal Structures (Sheet 2 of 2)
- 02751-01 - Concrete Pavement Details
- 02752-01 - Pavement Expansion and Construction Joint Details
- 02752-02 - Sidewalk Expansion and Construction Joint Details
- 02754-01A - Driveway with 4"x12" Curb for Local Residential Street
- 02754-01B - Driveway Detail With 6" Curbed Streets
- 02754-02 - Driveways with Culverts on Open Ditch Type Streets
- 02754-03 - Proposed Driveway Through Sidewalk with Excessive Elevation Difference
- 02754-04 - Proposed Sidewalk Through Driveway with Minimal Elevation Difference

Standard Details Updated* (Cont'd):

- 02760-01 (prev. 01510-01) - Pavement Markings General Notes and Legends
- 02760-04 (prev. 01510-04) - Standard Pavement Marking – Symbols
- 02760-09 (prev. 01510-09) - Bicycle Lane Pavement Markings
- 02760-10 (prev. 01510-09A) - Bicycle Intersection Treatments (Sheet 1 of 2)
- 02760-11 (prev. 01510-09B) - Bicycle Intersection Treatments (Sheet 2 of 2)
- 02775-01 - Typical Sidewalk Layout and Details for Streets with Curbs
- 02775-02 - Typical Curb Ramp Details
- 02775-03 - Parallel Curb Ramp
- 02775-04 - Curb Modification for Curb Ramps & Crosswalks
- 02775-05 - Commercial & High-Density Conditions Curb Ramp Details
- 02775-07 - Detectable Warning Surface (Options)
- 02775-08 - Sidewalks and Clear Zone Transit Corridor Street

Standard Details Retired/Deleted:

- None

*Only specifications and standard details with technical changes have been included in the list.

CHANGES MADE IN THE 2022 REVISION

Standard Construction Specifications for Wastewater Collection Systems, Water Lines, Storm Drainage, Street Paving, and Traffic – 2022 Revisions to the 2021 Edition

The 2021-2022 City of Houston Review Cycle reviewed Infrastructure Design Manual (IDM) Chapters 1-5 and 13 along with their associated standard drawings and standard construction specifications. Below are the Division 02-16 standard specifications and standard drawings that were revised during 2021-2022 review cycle.

New Specifications:

- 02445 – Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels
- 02447 – Installation of Water Lines by Slurry Bore

Specifications with major updates:

- 02441 – Microtunneling
- 02501 – Ductile Iron Pipe and Fittings
- 02504 – Fiberglass Reinforced Pipe
- 02526 – Water Meters

Specifications Retired/Deleted:

- 02447 – Augering Pipe and Conduit

New Standard Details:

- None

Standard Details with major updates:

- None

Standard Details Retired/Deleted:

- None

CHANGES MADE IN THE 2021 REVISION

Standard Construction Specifications for Wastewater Collection Systems, Water Lines, Storm Drainage, Street Paving, and Traffic – 2021 Revisions to the 2020 Edition

The 2020-2021 City of Houston Review Cycle reviewed Infrastructure Design Manual (IDM) Chapters 7, 8, 11 and 14 along with their associated standard drawings and standard construction specifications. Below are the standard specifications and standard drawings that were revised during 2020-2021 review cycle.

New Specifications:

- 02614 – Large Diameter Line Stop
- 02615 – Insertion Valves and Line Stops
- 16124 – Conductive Trace Wire for Non-Metallic Water Line Pipes

Specifications with major updates:

- 02082 – Precast Concrete Manholes
- 02400 – Tunnel Shafts
- 02431 – Tunnel Grout
- 02501 – Ductile Iron Pipe and Fittings
- 02506 – Polyvinyl Chloride Pipe
- 02507 – Prestressed Concrete Cylinder Pipe
- 02511 – Water Lines
- 02512 – Water Tap and Service Line Installation
- 02513 – Wet Connections
- 02514 – Disinfection of Water Lines
- 02517 – Water Line in Tunnels
- 02518 – Steel Pipe and Fittings for Large Diameter Water Lines
- 02520 – Fire Hydrants
- 02524 – Air Release and Vacuum Relief Valves
- 02527 – Polyurethane Coatings on Steel or Ductile Iron Pipe
- 02528 - Polyethylene Encasement/Wrap
- 02613 - Bar-Wrapped Steel Cylinder Pipe

Specifications Retired/Deleted:

- 16717 - Programmable Vehicle Signal Head

New Standard Details:

- 02082-12 – Storm Sewer Precast Box Manhole (Storm Water)
- 02082-13 – Storm Sewer Type ‘C’ Precast Round Manhole (Storm Water)
- 16124-01 – Complete Utility Locating System Sample Plan (Water)

New Standard Details (Continued):

- 16124-02 – Complete Utility Locating System Water Service Detail (Water)
- 16124-03 – Complete Utility Locating System Hydrant Detail (Water)

Standard Details with major updates:

- 02091-01 – Non-Metallic Frame and Cover (Wastewater)
- 02082-06 – Sanitary Sewer Manhole Vent for Sealed Manhole (Wastewater)
- 02082-10 – Standard LDWL Access Manhole Details (Water)
- 02317-09 – Standard LDWL Excavation and Backfill Detail (Water)
- 02517-01 – LDWL Tunnel and Casing Details for Water Lines 24-Inch and Larger (Water)
- 02520-01 – Standard Fire Hydrant Detail (Water)
- 02524-03 – LDWL Air Valve Assembly in Service Manhole Detail (Water)
- 15641-01 – Standard LDWL Cathodic Protection Details for Test Stations (Sheet 1 of 3) (Water)
- 15641-02 – Standard LDWL Cathodic Protection Details for Test Stations (Sheet 2 of 3) (Water)
- 15641-03 – Standard LDWL Cathodic Protection Details for Test Stations (Sheet 3 of 3) (Water)
- 16640-01 – Standard LDWL Cathodic Protection Details for Test Stations & Anodes (Water)

Standard Details Retired/Deleted:

- 02081-01 - Storm Sewer Manhole Type "C" for 42" Diameter RCP and Smaller
- 02081-02 - Storm Sewer Manhole Type "C" for 48" to 72" Diameter RCP
- 02081-03 Storm Sewer Manhole Type "C" for 78" Diameter RCP and Greater
- 02081-04 Storm Sewer Manhole Type "C" for Proposed Concrete Box Sewer

CHANGES MADE IN THE 2020 REVISION

Standard Construction Specifications for Wastewater Collection Systems, Water Lines, Storm Drainage, Street Paving, and Traffic – 2020 Revisions to the 2019 Edition

The 2019-2020 City of Houston Review Cycle reviewed Infrastructure Design Manual (IDM) chapters 6, 10, and 12 along with their associated standard drawings and standard construction specifications. Below are the standard specifications and standard drawings that were revised during the 2019-2020 review cycle.

Specifications with major updates:

- 02751 - Concrete Paving
- 02752 - Concrete Paving Joints

Standard Details with major updates:

- 02741-01 - Hot-Mix Asphaltic Concrete Pavement Details
- 02741-04 - Hot-Mix Asphalt Concrete Pavement Details for Alleys (DELETED)
- 02751-01 - Concrete Pavement Details
- 02754-03 - Proposed Sidewalk Through Driveway with Excessive Elevation Difference

DIVISION 02-16 SPECIFICATIONS

Section	Title	Pages
DIVISION 2- SITE WORK		
	UTILITY MATERIALS	
02081	**CAST-IN-PLACE CONCRETE MANHOLES**	**11**
02082	**PRECAST CONCRETE MANHOLES**	**18**
02083	FIBERGLASS MANHOLES.	8
02085	VALVE BOXES, METER BOXES, AND METER VAULTS	7
02086	ADJUSTING MANHOLES, INLETS, AND VALVE BOXES TO GRADE	4
02088	PRECAST POLYMER CONCRETE MANHOLES	11
02090	FRAMES, GRATES, RINGS, AND COVERS	4
02091	**NON METALLIC FRAMES, GRATES, RINGS, AND COVERS**	**4**
	SITE DEMOLITION	
02136	WASTE MATERIAL HANDLING, TESTING AND DISPOSAL	7
02201	SITE PREPARATION, GRADING, RESTORATION AND CLEAN UP FOR WATER STORAGE TANKS	3
02221	**REMOVING EXISTING PAVEMENTS, STRUCTURES, WOOD, AND DEMOLITION DEBRIS**	**6**
02222	ABANDONMENT OF SEWERS	8
02233	CLEARING AND GRUBBING	2
02260	TRENCH SAFETY SYSTEM	4
	EXCAVATION AND FILL	
02315	ROADWAY EXCAVATION	4
02316	EXCAVATION AND BACKFILL FOR STRUCTURES	10
02317	**EXCAVATION AND BACKFILL FOR UTILITIES**	**20**
02318	EXTRA UNIT PRICE WORK FOR EXCAVATION AND BACKFILL	3
02319	BORROW	2
02320	UTILITY BACKFILL MATERIALS	11
02321	**CEMENT STABILIZED SAND**	**8**
02322	**FLOWABLE FILL.**	**4**
	EMBANKMENT	
02330	EMBANKMENT	4
	SUBGRADE AND ROADBED	
02336	LIME STABILIZED SUBGRADE	8
02337	LIME/FLY ASH STABILIZED SUBGRADE	3
02338	PORTLAND CEMENT STABILIZED SUBGRADE	6
02340	COMPACTED SAND FILL UNDER TANK FLOOR PLATE	3

TUNNELING, BORING AND JACKING

02400 TUNNEL SHAFTS 8
02401 COMMON TUNNEL SHAFTS 6
02425 TUNNEL EXCAVATION AND PRIMARY LINER 11
02426 SEWER LINE IN TUNNELS 4
02427 PLASTIC LINER FOR LARGE-DIAMETER CONCRETE SEWERS AND STRUCTURES 13
02431 TUNNEL GROUT 8
02441 MICROTUNNELING 16
02445 JACK AND BORE/JACK AND MINE/PILOT TUBE GUIDED BORING TUNNELS 18
02447 INSTALLATION OF WATER LINES BY SLURRY BORE 10
02448 PIPE AND CASING AUGERING FOR SEWERS 7

FOUNDATION AND LOAD BEARING ELEMENTS

02465 DRILLED SHAFT FOUNDATIONS 4
02476 CAISSION FOR LIFT STATION 6

PIPE MATERIALS

02501 DUCTILE IRON PIPE AND FITTINGS 9
02502 STEEL PIPE AND FITTINGS 11
02503 COPPER TUBING 3
02504 FIBERGLASS REINFORCED PIPE 6
02505 HIGH DENSITY POLYETHYLENE (HDPE) SOLID AND PROFILE WALL PIPE ... 9
02506 POLYVINYL CHLORIDE PIPE 12
02507 PRESTRESSED CONCRETE CYLINDER PIPE 17
02508 EXTRA STRENGTH CLAY PIPE 4
02509 FIBERGLASS REINFORCED PIPE FOR PRESSURE MAINS 12
02510 POLYPROPYLENE (PP) CORRUGATED WALL PIPE 8

WATER DISTRIBUTION

02511 WATER LINES 21
02512 WATER TAP AND SERVICE LINE INSTALLATION 7
02513 WET CONNECTIONS 4
02514 DISINFECTION OF WATER LINES 5
02515 HYDROSTATIC TESTING OF PIPELINES 3
02516 CUT, PLUG, AND ABANDONMENT OF WATER LINES 2
02517 WATER LINE IN TUNNELS 7
02518 STEEL PIPE AND FITTINGS FOR LARGE DIAMETER WATER LINES 31
02520 FIRE HYDRANTS 6
02521 GATE VALVES 6
02522 BUTTERFLY VALVES 9
02523 PRESSURE REDUCING VALVES 3
02524 AIR RELEASE AND VACUUM RELIEF VALVES 4
02525 TAPPING SLEEVES AND VALVES 6

02526 WATER METERS....13
02527 POLYURETHANE COATINGS ON STEEL OR DUCTILE IRON PIPE 11
02528 POLYETHYLENE ENCASEMENT/WRAP....9
02529 TAPE COATINGS ON STEEL PIPE 6

SANITARY SEWER
02531 GRAVITY SANITARY SEWERS....8
02532 SANITARY SEWER FORCE MAINS. 6
02533 ACCEPTANCE TESTING FOR SANITARY SEWERS....13
02534 SANITARY SEWER SERVICE STUBS OR RECONNECTIONS....12
02550 SLIPLINING SANITARY SEWERS....14
02551 SANITARY SEWER RENEWAL BY SPIN CAST PIPE LINING METHOD....11
02553 POINT REPAIRS AND OBSTRUCTION REMOVALS....9
02555 MANHOLE REHABILITATION....13
02556 CURED-IN-PLACE PIPE 13
02557 FOLDED AND FORMED PIPE 8
02558 CLEANING AND TELEVISION INSPECTION....12
02571 PIPE BURSTING/CRUSHING SANITARY SEWERS....15

ELECTRICAL AND COMMUNICATION STRUCTURES
02581 STREET LIGHTING CONDUIT 2
02582 TRAFFIC POLE ASSEMBLIES - STEEL 7
02590 STREETLIGHT LUMINAIRES 6

PIPE CULVERTS
02611 REINFORCED CONCRETE PIPE....5
02612 PRECAST REINFORCED CONCRETE BOX SEWERS....4
02613 BAR WRAPPED STEEL CYLINDER PIPE 17
02614 LARGE DIAMETER LINE STOP....6
02615 INSERTION VALVES AND LINE STOPS....4

SUBDRAINAGE
02621 GEOTEXTILE 3

STORM DRAINAGE
02631 STORM SEWERS....8
02632 CAST-IN-PACE INLETS, HEADWALLS, AND WINGWALLS 3
02633 PRECAST CONCRETE INLETS, HEADWALLS, AND WINGWALLS 5

CULVERTS AND MANUFACTURED CONSTRUCTION
02642 CORRUGATED METAL PIPE 7
02643 PLATE CULVERT STRUCTURES 7
02662 PIPING, VALVES, FITTINGS, AND ACCESSORIES FORWATER STORAGE TANKS 10

BOUND BASE COURSES

02711 HOT MIX ASPHALT BASE COURSE....9
02712 CEMENT STABILIZED BASE COURSE....7
02713 RECYCLED CRUSHED CONCRETE BASE COURSE....7
02714 FLEXIBLE BASE COURSE FOR TEMPORARY DRIVEWAYS....5

FLEXIBLE PAVING
02741 ASPHALTIC CONCRETE PAVEMENT....10
02742 PRIME COAT. 4
02743 TACK COAT....3

RIGID PAVING
02751 CONCRETE PAVING 14
02752 CONCRETE PAVEMENT JOINTS 7
02753 CONCRETE PAVEMENT CURING 3
02754 CONCRETE DRIVEWAYS 2

PAVING SPECIALTIES
02761 COLORED CONCRETE FOR MEDIANS AND SIDEWALKS....2
02762 BLAST CLEANING OF PAVEMENT....2
02764 RAISED PAVEMENT MARKERS 3
02765 PREFORMED PAVEMENT MARKINGS 4
02767 THERMOPLASTIC PAVEMENT MARKINGS 7
02768 EPOXY PAVEMENT MARKINGS 8

CURBS, GUTTERS AND SIDEWALKS
02771 CURB, CURB AND GUTTER, AND HEADERS 4
02772 CONCRETE MEDIANS AND DIRECTIONAL ISLANDS....2
02775 CONCRETE SIDEWALKS 6

SITE IMPROVEMENTS AND AMENITIES
02811 LANDSCAPE IRRIGATION....5
02871 BIKE RACKS....3
02890 PEDESTRIAN CROSSWALK SYSTEM RECTANGULAR RAPID FLASHING BEACON (RRFB) 13
02893 TRAFFIC SIGNAL CONSTRUCTION 21

PLANT PREPARATION
02911 TOPSOIL 3
02912 TREE, PLANT, & HARDSCAPE PROTECTION....6

SHRUB AND TREE TRANSPLANTING
02915 TREE PLANTING....9

LAWNS AND GRASS
02921 HYDRO MULCH SEEDING....4
02922 SODDING....5

SITE RESTORATION AND REHABILITATION

02951 PAVEMENT REPAIR AND RESTORATION 4
02960 MILLING PAVEMENT....4
02983 REMOVAL AND RESTORATION OF BRICK PAVED STREETS....4

DIVISION 3 - CONCRETE

03315 CONCRETE FOR UTILITY CONSTRUCTION 18

DIVISION 4 - MORTAR

04061 MORTAR. 5
04210 BRICK MASONRY FOR UTILITY CONSTRUCTION 5

DIVISION 5 – METALS

05501 METAL FABRICATIONS....5

DIVISION 9 – FINISHES

09901 PROTECTIVE COATINGS....32
09971 PAINTING AND PROTECTIVE COATINGS FOR POTABLE WATER STORAGE TANKS 24

DIVISION 13 – SPECIAL CONSTRUCTION

13111 CATHODIC PROTECTION FOR WATER TANK INTERIORS (SACRIFICIAL ANODE) 7
13112 CATHODIC PROTECTION FOR WATER TANK INTERIORS (ICCP) 10
13113 CATHODIC PROTECTION FOR NEW TANK BOTTOMS....12
13201 WELDED STEEL WATER STORAGE TANKS....14
13202 REHABILITATION OF WELDED STEEL WATER STORAGE TANKS....11
13203 TANK CLEAN-UP AND DISINFECTION 5
13501 SPEED CUSHIONS 4

DIVISION 15 – MECHANICAL

15640 JOINT BONDING AND ELECTRICAL ISOLATION....9
15641 CORROSION CONTROL TEST STATIONS....6

DIVISION 16 – ELECTRICAL

16010 BASIC ELECTRICAL REQUIREMENTS 4
16124 CONDUCTIVE TRACE WIRE FOR NON-METALLIC WATER LINE PIPES 5
16130 ADVANCED TRANSPORTATION CONTROLLER (ATC) CABINET

ASSEMBLY 49
16640 CATHODIC PROTECTION FOR PIPELINES 18
16641 CATHODIC PROTECTION FOR EXISTING TANK BOTTOMS 13
16642 CATHODIC PROTECTION FOR PLANT PIPING 18
16644 CATHODIC PROTECTION FOR CLARIFIERS 3
16645 CATHODIC PROTECTION FOR WET WELLS 3
16709 COMMUNICATIONS CONDUIT 6
16710 PULL BOXES 4
16711 TRAFFIC SIGNAL CONDUIT 5
16712 SOLAR POWERED SCHOOL ZONE FIELD EQUIPMENT 24
16713 PRE-FORMED LOOPS 4
16715 VEHICLE SIGNAL HEADS (POLYCARBONATE) (ADJUSTABLE, EXPANDABLE TYPE) 8
16716 PEDESTRIAN SIGNAL HEADS 4
16718 VEHICLE TRAFFIC CONTROL SIGNAL HEADS – LIGHT EMITTING DIODE (LED) CIRCULAR SIGNAL SUPPLEMENT 18
16719 COUNTDOWN PEDESTRIAN SIGNAL MODULE 9
16720 TRAFFIC SIGNAL CABLE 3
16724 EMERGENCY VEHICLE PREEMPTION (EVP) 8
16725 DYNAMIC MESSAGE SIGN (DMS) 23
16727 TRAFFIC SIGNAL SAW-CUT LOOP DETECTOR 20
16730 INTELLIGENT TRANSPORTATION SYSTEM (ITS) CONTROLLER CABINET ASSEMBLY 220
16731 MODEL 2070 CONTROLLER UNIT 38
16732 UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM FOR TRAFFIC SIGNAL CABINETS 11
16733 FIELD HARDENED ETHERNET SWITCH 10
16735 FIBER OPTIC SPLICE ENCLOSURE 4
16736 FIBER DISTRIBUTION UNIT 3
16737 COMMUNICATION SERVICE BOX 6
16739 BLUETOOTH SPECIFICATION (ANONYMOUS WIRELESS ADDRESS MATCHING DEVICE) 6
16740 SINGLE MODE FIBER OPTIC CABLE SYSTEM 22
16741 VIDEO COLOR QUAD UNIT 4
16742 VIDEO DETECTION SYSTEM 8
16746 VIDEO MANAGEMENT SOFTWARE 4
16747 PERMANENT COUNT STATION RADAR VEHICLE SENSING DEVICE (RVSD) 13
16748 SYSTEM INTEGRATION 2
16750 ACCESSIBLE PEDESTRIAN PUSH BUTTON STATION 6
16780 CCTV FIELD EQUIPMENT 9
16785 GPS SERIAL COMMUNICATIONS 6

*Bold Specifications have technical revisions or are new.

SECTION 02081

CAST-IN-PLACE CONCRETE MANHOLES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Cast-in-place concrete manholes for sanitary sewers, water lines and storm sewers, including box sewers.

B. Pile-supported concrete foundation used for unstable subgrade treatment for manhole base.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02090 – Frames, Grates, Rings, and Covers

D. Section 02317 – Excavation and Backfill for Utilities

E. Section 02321 – Cement Stabilized Sand

F. Section 02533 – Acceptance Testing for Sanitary Sewers

G. Section 02911 – Topsoil

H. Section 02921 – Hydro Mulch Seeding

I. Section 02922 – Sodding

J. Section 03315 – Concrete for Utility Construction

K. Section 04061 – Mortar

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for manholes is on a unit price basis for each manhole installed.

2. Payment for Type C manhole with BB inlet top is on a unit price basis for each.

3. Payment for pile-supported concrete foundation used for unstable subgrade treatment for manhole base is on a unit price basis for each foundation installed.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASME B 16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. ASTM A 307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength.

C. ASTM A 1107 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures and Corrugated Steel Drainage Pipes.

D. ASTM C 478 - Precast Reinforced Concrete Manhole Sections.

E. ASTM C 890 – Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.

F. ASTM C 913 - Standard Specification for Precast Concrete Water and Wastewater Structure.

G. ASTM C 923 - Standard Specifications for Resilient Connectors Between Reinforced Concrete Manhole Structures and Pipes.

H. ASTM C 1107 - Standard Specification for Packaged Dry, Hydraulic - Cement Grout (Non-shrink).

I. ASTM C 1821 – Standard Practice for Installation of Underground Circular Precast Concrete Manhole Structures.

J. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3 (600 kN-m/m3)).

K. ASTM D 2665 - Standard Specification for Poly Vinyl Chloride (PVC) Plastic Drain, Waste and Vent Pipe, and Fittings.

L. ASTM D 2996 - Standard Specification for Filament-wound Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.

M. ASTM D 2997 - Standard Specification for Centrifugally Cast Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.

N. ASTM F 2510 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures and Corrugated Dual- and Triple-Wall Polyethylene and Polypropylene Pipes.

O. AWWA C 213 - Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings.

P. AASHTO HL-93 Design Live Loading Loads as Referred to in AASHTO LRFD Bridge Design Specifications.

Q. OSHA Occupational Safety and Health Standards.

1.05 DEFINITIONS

A. Resilient Connectors - Flexible connectors consisting of a natural or synthetic rubber material and resilient seal that can be deformed or deflected up to a certain hydrostatic head pressure without leakage or rupture.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit proposed design mix and test data for each type and strength of concrete.

C. Submit manufacturer's data and details of following items for approval:

1. Frames, grates, rings, and covers.

2. Materials to be used in fabricating drop connections.

3. Materials to be used for pipe connections at manhole walls.

4. Materials to be used for stubs and stub plugs.

5. Plugs to be used for sanitary sewer hydrostatic testing.

6. Installation instructions for forms.

D. Submit structural design calculations, signed and sealed by a licensed Engineer.

PART 2 PRODUCTS

2.01 CONCRETE

A. Conform to requirements of Section 03315 - Concrete for Utility Construction.

B. Provide Class A concrete with minimum compressive strength of 4,000 psi unless otherwise indicated on Drawings.

C. Design Loading Criteria: Manhole walls, transition slabs, cone tops, and manhole base slab shall be designed to requirements of ASTM C 478, ASTM C 890, and/or ASTM C 913 for depth as shown on Drawings and to resist following loads.

1. AASHTO HL-93 design live loading loads as referred to in AASHTO LRFD Bridge Design Specifications applied to manhole cover and transmitted down to transition and base slabs.

2. Unit soil weight of 120 pcf located above portions of manhole, including base slab projections.

3. Lateral soil pressure based on saturated soil conditions producing an at-rest equivalent fluid pressure of 100 pcf.

4. Internal liquid pressure based on unit weight of 63 pcf.

5. Dead load of manhole sections fully supported by transition and base slabs.

D. Design: Manhole walls, transition slabs, cone tops, and manhole base slab shall be designed according to requirements of ASTM C 478, ASTM C 890 and/or ASTM C 913 and following:

1. Design additional reinforcing steel to transfer stresses at openings. Area of steel to be no less than shown on Drawings.

2. Wall loading conditions:

a. Saturated soil pressure acting on empty manhole.

b. Manhole filled with liquid to a halfway depth as measured from invert to cover, with no balancing external soil pressure.

3. Minimum clear distance between two wall penetrations shall be 12-inches or half diameter of smaller penetration, whichever is greater

2.02 REINFORCING STEEL

A. Conform to requirements of Section 03315 - Concrete for Utility Construction.

2.03 MORTAR

A. Conform to requirements of Section 04061 - Mortar

2.04 MISCELLANEOUS METALS

A. Provide cast-iron frames, grates, rings, and covers conforming to requirements of Section 02090 - Frames, Grates, Rings, and Covers.

2.05 DROP CONNECTIONS AND STUBS

A. Provide drop connections and stubs conforming to same pipe material requirements used in main pipe, unless otherwise indicated on Drawings.

2.06 PIPE CONNECTIONS

A. Sanitary Sewers.

1. Provide resilient connectors conforming to requirements of ASTM C 923. Use the following materials for metallic mechanical devices as defined in ASTM C 923:

a. External clamps: Type 304 stainless steel

b. Internal, expandable clamps on Standard manholes: Type 304 stainless steel, 11 gauge minimum

c. Internal, expandable clamps on corrosion-resistant manholes:

(1) Type 316 stainless steel, 11 gauge minimum

(2) Type 304 stainless steel, 11 gauge minimum, coated with minimum 16 mil fusion-bonded epoxy conforming to AWWA C213

2. Where rigid joints between pipe and cast-in-place manhole base are specified or shown on Drawings, provide polyethylene-isoprene waterstop meeting physical property requirements of ASTM C 923, such as Pres-Seal WS Series, or approved equal.

B. Storm Sewers:

1. For watertight connections provide Resilient Connectors in accordance with ASTM C 923, ASTM A 1107 or ASTM F 2510 as applicable for pipe material.

2. For soil-tight connections, provide the following:

a. Rigid (concrete) pipe to manhole connections: Grouted in accordance with ASTM C 1821.

b. Flexible pipe to manhole connections: Resilient connectors in accordance with ASTM C 923, ASTM A 1107 or ASTM F 2510 as applicable for pipe material.

3. If no connection type is specified in Contract documents, a soil-tight connection shall be provided.

C. Water Lines

1. Where smooth exterior pipes, i.e., steel, ductile iron, or PVC pipes are connected to manhole base or barrel, seal space between pipe and manhole wall with assembly consisting of rubber gasket or links mechanically compressed to form a watertight barrier. Assemblies: Press-Wedge, Pres-Seal, Thunderline, Link-Seals, or approved equal. See Drawings for placement of assembly in manhole sections.

2. When connecting concrete or cement mortar coated steel pipes, or as option for connecting exterior pipes to manhole base or barrel, space between pipe and manhole wall may be sealed with an assembly consisting of a stainless steel power sleeve, stainless steel take-up clamp and a rubber gasket. Take-up clamp: Minimum of 9/16 inch wide. Provide PSX positive seal gasket system by Press-Seal Gasket Corporation or approved equal.

2.07 SEALANT MATERIALS

A. Provide sealing materials between precast concrete adjustment ring and manhole cover frame, such as Adeka Ultraseal P 201, or approved equal.

B. Provide external sealing material from Canusa Wrapid Seal manhole encapsulation system, or approved equal.

C. Butyl Sealant: Provide Press-Seal EZ Stick, or equal, for HDPE rings.

2.08 CORROSION-RESISTANT MANHOLE MATERIALS

A. Where corrosion-resistant manholes are indicated on the Drawings, refer to City of Houston Approved Product List for liner and/or coating materials.

2.09 BACKFILL MATERIALS

A. Conform to the requirements of Section 02317 - Excavation and Backfill for Utilities.

2.10 NON-SHRINK GROUT

A. Provide prepackaged, inorganic, flowable, non-gas-liberating, non-metallic, cement-based non-shrink grout requiring only addition of water.

B. Provide grout meeting requirements of ASTM C 1107 and having minimum 28-day compressive strength of 7,000 psi.

2.11 VENT PIPES

A. Provide external vent pipes for manholes where indicated on Drawings.

B. Buried Vent Pipes: Provide 3-inch or 4-inch PVC DWV pipe conforming to ASTM D 2665. Alternatively, provide FRP pipe as specified for vent outlet assembly.

C. Vent Outlet Assembly: Provide vent outlet assembly as shown on Drawings, constructed of following specified materials:

1. FRP Pipe: Provide filament-wound FRP conforming to ASTM D 2996 or centrifugally cast FRP conforming to ASTM D 2997. Seal cut ends in accordance with manufacturer's recommendations.

2. Joints and Fittings: Provide epoxy- bodied fittings and join pipe to fittings with epoxy adhesive, according to pipe manufacturer's instructions.

3. Flanges: Provide socket-flange fittings for epoxy adhesive bonding to pipe ends where shown on Drawings. Meet bolt pattern and dimensions for ASME B 16.1, 125-pound flanges. Use Type 304 stainless steel or hot-dip zinc coated, conforming to ASTM A 307, Class A or B flange bolts.

4. Coating: Provide 2-component, aliphatic polyurethane coating, using primer or tie coat recommended by manufacturer. Provide two or more coats to yield dry film thickness of at least 3 mils. Provide Amershield, Tnemec 74, or approved equal. Project Manager selects color from manufacturer's standard colors.

2.12 MANHOLE LADDER FOR WATERLINE MANHOLES

A. Manhole Ladder: Fiberglass with 300-lb rating at appropriate length; conform to requirements of Occupational Safety and Health Standards (OSHA), U.S. Department of Labor except where shown on Drawings.

1. Use components, including rungs, made of fiberglass, fabricated with nylon or aluminum rivets and/or epoxy. Apply non-skid coating to ladder rungs. Mount ladder using manufacturer's recommended hardware.

2. Provide ladder as manufactured by Saf-Rail or approved equal. Locate ladder as shown on Drawings.

3. Fiberglass: Premium type polyester resin, reinforced with fiberglass; constructed to provide complete wetting of glass by resin; resistant to rot, fungi, bacterial growth and adverse effects of acids, alkalis and residential and industrial waste; yellow in color.

4. Provide approved petroleum-based tape encapsulating bolts in access manhole.

2.13 PROHIBITED MATERIALS

A. Use of brick masonry is prohibited for construction of manholes, including adjustment of manholes to grade.

B. For Storm Water manholes, use of mortar is prohibited for pipe to manhole connections.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify lines and grades are correct.

B. Determine if subgrade, when scarified and recompacted, can be compacted to 95 percent of maximum Standard Proctor Density at ±3 percent optimum moisture content according to ASTM D 698 prior to placement of material and base section. If it does not meet the moisture-density requirement, condition the subgrade until the required moisture-density requirement is met or treat as an unstable subgrade.

C. Do not build manholes in ditches, swales, or drainage paths unless approved by Project Manager.

3.02 MANHOLES

A. Construct manholes to dimensions shown on Drawings. Commence construction as soon as possible after pipes are laid. On monolithic sewers, construct manholes at same time sewer is being constructed.

B. Unstable Subgrade Treatment: When unstable subgrade is encountered, notify Project Manager for examination of subgrade to determine if subgrade has heaved upwards after being excavated. When heaving has not occurred, over-excavate subgrade to allow for 24-inch-thick layer of crushed stone wrapped in filter fabric as foundation material under manhole base. When there is evidence of heaving, provide pile-supported concrete foundation, as detailed on Drawings, under manhole base.

C. Cast manhole foundations and walls monolithically. Use cold joint with approved waterstop when manhole flow line depth exceeds 12 feet. No other joints will be allowed unless shown on Drawings. Wrap cold joints with external sealing material, minimum 6-inch width.

D. For concrete containing micro silica admixtures, place, finish, and cure concrete for manholes following procedures in Section 03315 - Concrete for Utility Construction.

E. Top of manhole elevations shown on Drawings are approximate, based on current pavement and natural ground conditions as determined from elevations measured on 50-foot spacing. No additional payment will be made if final elevation of manhole ring and cover is higher or lower due to requirements of finished grade or replaced pavement surface.

F. For water lines place concrete for manhole base on 12-inch thick (minimum) foundation of cement stabilized sand. Compact cement stabilized sand in accordance with requirements of 02321 – Cement Stabilized Sand.

G. For manholes located over large diameter water lines, place base on a foundation of cement stabilized sand extending from bottom of manhole to bottom of trench. Manhole base is to be a minimum of 12-inches above water line.

3.03 PIPE CONNECTIONS

A. Sanitary Sewer and Water Line Manholes:

1. Install approved resilient connectors at each pipe entering and exiting water line and sanitary sewer manholes in accordance with manufacturer's instructions. See article 2.06 for approved connection materials.

B. Storm Sewer Manholes:

1. Install connections at each pipe entering and exiting manholes in accordance with manufacturer's instructions and specifications. See article 2.06 for connection material requirements. When pipe to manhole connections are to be grouted, all voids are to be completely filled with grout and grouted on both sides inside and outside of manhole.

C. Ensure no concrete, cement stabilized sand, fill, or other solid material is allowed to enter space between pipe and edge of wall opening at and around resilient connector on interior or exterior of manhole. When necessary, fill space with compressible material to ensure resilient connector will maintain full flexibility where evidence of reduced flexibility is encountered.

D. Where new manhole is to be constructed on existing sewer, a rigid joint pipe may be used. Install waterstop gasket around existing pipe at center of cast-in-place wall. Join ends of split waterstop material at pipe spring line using adhesive recommended and supplied by waterstop manufacturer.

E. Do not construct joints on sanitary sewer pipe within wall sections of manholes. Use approved connection material.

F. Construct pipe stubs with Resilient Connectors for future connections at locations and with material indicated on Drawings. Install approved stub plugs at interior of manhole.

G. Test connection for watertight seal before backfilling.

3.04 INVERTS FOR SANITARY SEWERS

A. Construct inverted channels to provide smooth flow transition waterway with no disruption of flow at pipe-manhole connections. Conform to the following criteria:

1. Slope of invert bench: 1-inch per foot minimum; 1-1/2 inch per foot maximum.

2. Depth of bench to invert:

a. Pipes smaller than 15-inches: one-half of largest pipe diameter.

b. Pipes 15 to 24 inches: three-fourths of largest pipe diameter.

c. Pipes larger than 24-inches: equal to largest pipe diameter.

3. Invert slope through manhole: 0.10 foot drop across manhole with smooth transition of flow at pipe-manhole connections. Conform to following criteria.

B. Form invert channels with Class A concrete if not integral with manhole base. For direction changes of mains, construct channels tangent to mains with maximum possible radius of curvature. Provide curves for side inlets and smooth invert fillets for flow transition between pipe inverts.

3.05 INVERTS FOR STORM SEWERS

A. When precast, square or rectangular structures are used for sewer manholes, construct invert channels to provide smooth flow transition waterway with no disruption of flow at pipe manhole connections. Conform to following criteria:

1. Slope of invert bench: 1-inch per foot minimum; 1-½ inches per foot maximum.

2. Depth of bench to invert: 1/2 of largest pipe diameter.

3. Invert slope through manhole: 0.10 foot drop across manhole with smooth transition of invert through manhole, unless otherwise indicated on drawings.

B. Form invert channels with concrete, after all connections have been made.

1. Use 5 sack premix (bag) concrete or Class A concrete for inverts, with minimum compressive strength of 4,000 psi.

3.06 DROP CONNECTIONS FOR SANITARY SEWERS

A. Backfill drop assembly with crushed stone wrapped in filter fabric, cement-stabilized sand, or Class A concrete to form solid mass. Extend cement stabilized sand or concrete encasement minimum of 4-inches outside bells.

B. Install connection when sewer line enters manhole higher than 24-inches above invert of manhole.

3.07 STUBS FOR FUTURE CONNECTIONS

A. In manholes where future connections are indicated on Drawings, install resilient connectors and pipe stubs with approved watertight plugs.

3.08 ADJUSTMENT RINGS AND FRAME

A. Combine precast concrete or HDPE adjustment rings so elevation of installed casting cover matches pavement surface. Seal between concrete adjustment ring and precast top section with non-shrink grout; do not use mortar between adjustment rings. Apply latex-based bonding agent to precast concrete surfaces to be joined with non-shrink grout. Set cast iron frame on adjustment ring in a bed of approved sealant material. Install a sealant bed consisting of two beads of sealant, each bead having minimum dimensions of 1/2-inch and 1/2-inch wide.

B. Wrap manhole frame and adjustment rings with external sealing material, minimum 3-inches beyond joint between ring and frame, and ring and precast section.

C. For manholes in unpaved areas, set top of frame minimum of 6-inches above existing ground line unless otherwise indicated on Drawings. Encase manhole frame in mortar or non-shrink grout placed flush with face of manhole ring and top edge of frame. Provide rounded corner around perimeter.

3.09 BACKFILL

A. After concrete obtains adequate strength, place and compact backfill materials in area of excavation surrounding manholes in accordance with requirements of Section 02317 - Excavation and Backfill for Utilities. Use embedment zone backfill material for adjacent utilities, as shown in City of Houston Standard Details over each pipe connected to manhole. Provide trench zone backfill, as specified for adjacent utilities, above embedment zone backfill.

B. Where rigid joints are used for connecting existing sewers to manhole, backfill under existing sewer up to springline of pipe with Class B concrete or flowable fill.

C. In unpaved areas, provide positive drainage away from manhole frame to natural grade.

D. Provide minimum of 4-inches of topsoil conforming to requirements of Section 02911 - Topsoil.

E. Seed in accordance with Section 02921 - Hydro Mulch Seeding, or sod disturbed areas in accordance with Section 02922 - Sodding.

3.10 FIELD QUALITY CONTROL

A. Conduct leakage testing of Sanitary Sewer manholes in accordance with requirements of Section 02533 - Acceptance Testing for Sanitary Sewers.

3.11 PROTECTION

A. Protect manholes from damage until subsequent work has been accepted. Repair or replace damaged elements of manholes at no additional cost to City.

END OF SECTION

SECTION 02082

PRECAST CONCRETE MANHOLES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Precast concrete manholes for sanitary sewers, storm sewers, and water lines. Manhole bases may be round or square.

B. Precast concrete sanitary sewer manholes with PVC liner where corrosion resistant manholes are specifically indicated in Drawings.

C. Pile-supported concrete foundation used for unstable subgrade treatment for manhole base.

1.02 RELATED SECTIONS

A. Section 01270 - Measurement and Payment

B. Section 01330 - Submittal Procedures

C. Section 01630 - Product Substitution Procedures

D. Section 02090 - Frames, Grates, Rings, and Covers

E. Section 02317 - Excavation and Backfill for Utilities

F. Section 02321 - Cement Stabilized Sand

G. Section 02533 - Acceptance Testing for Sanitary Sewers

H. Section 02911 – Topsoil

I. Section 02921 - Hydro Mulch Seeding

J. Section 02922 – Sodding

K. Section 03315 - Concrete for Utility Construction

L. Section 04061 - Mortar

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Payment for normal depth manholes, up to 8 feet deep, is on a unit price basis for each manhole installed. Manhole depth is measured from top of cover to sewer invert. Air release manhole depth is measured from top of cover to inside base for air release or vacuum release manholes. Manholes for water lines are measured from top of cover to inside base of manhole.

2. Payment for shallow depth manholes is on a unit price basis for each manhole installed. Shallow manholes have a depth of 5 feet or less measured from top of cover to sewer invert.

3. Payment for extra depth manholes is on a unit price basis per vertical foot for each foot of depth greater than 8 feet. Sewer manhole depth is measured from top of cover to sewer invert. Air release manhole depth is measured from top of cover to inside base for air release or vacuum release manholes. Manholes for water lines are measured from top of cover to inside base of manhole.

4. Payment for normal depth corrosion resistant manholes is on a unit price basis for each manhole installed.

5. Payment for standard manhole drops is on a unit price basis for each drop installed. Standard manhole drops include both internal and external drops.

6. Payment for watertight manholes, including external vent pipe and/or wraps, are on a unit price basis for each.

7. Payment for air-release manhole with valves and fittings installed is on a unit price basis for each manhole with air-release valves and fittings installed.

8. Payment for pile-supported concrete foundation used for unstable subgrade treatment for manhole base is on a unit price basis for each foundation installed.

9. Pay estimates for partial payments will be made as measured above according to the following schedule for sanitary sewer manholes:

   a. Estimate for 90 percent payment will be authorized when the manhole is completely installed and surrounding soil backfilled.

   b. Estimate for 100 percent payment will be authorized when manhole has been tested as specified in Section 02533 - Acceptance Testing for Sanitary Sewers.

10. Refer to Section 01270 - Measurement and Payment for unit price procedures

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASME B 16.1 – Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250

B. ASTM A 307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength

C. ASTM A 1107 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures and Corrugated Steel Drainage Pipes

D. ASTM C 443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.

E. ASTM C 478 - Standard Specification for Circular Precast Reinforced Concrete Manhole Sections

F. ASTM C 890 - Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.

G. ASTM C 913 – Standard Specification for Precast Concrete Water and Wastewater Structures.

H. ASTM C 923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals

I. ASTM C 990 – Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

J. ASTM C 1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

K. ASTM C 1821 - Standard Practice for Installation of Underground Circular Precast Concrete Manhole Structures

L. ASTM C 1837 - Standard Specification for Production of Dry Cast Concrete Used for Manufacturing Pipe, Box, and Precast Structures

M. ASTM C 1889 – Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Utility, Water, and Wastewater Structures Using AASHTO LRFD Design

N. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3 (600kN-m/m3))

O. ASTM D 2665 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste and Vent Pipe and Fittings

P. ASTM D 2996 - Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber- Reinforced Thermosetting-Resin) Pipe

Q. ASTM D 2997 - Standard Specification for Centrifugally Cast "Fiberglass" (Glass-Fiber- Reinforced Thermosetting Resin) Pipe

R. ASTM F 2510 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures and Corrugated Dual- and Triple-Wall Polyethylene and Polypropylene Pipes.

S. AWWA C 213 - Fusion Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings

T. (AASHTO M-306 Section 5 Loading)

U. AASHTO HL-93 design live loading loads as referred to in AASHTO LRFD Bridge Design.

V. Texas Department of Transportation (TxDOT) – Item 465 "Junction Boxes, Manholes, and inlets"

W. Occupational Safety and Health Standards (OSHA).

1.05 DEFINITIONS

A. Resilient Connectors - Flexible connectors consisting of a natural or synthetic rubber material and resilient seal that can be deformed or deflected up to a certain hydrostatic head pressure without leakage or rupture.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer's data and details of following items for approval:

1. Shop drawings of manhole sections, base units and construction details, including reinforcement, jointing methods, materials, and dimensions.

2. Summary of criteria used in manhole design including, as minimum, material properties, loadings, load combinations, and dimensions assumed. Include certification from manufacturer that precast manhole design is in full accordance with ASTM C 478 and/or ASTM C 890 and design criteria as established in Paragraph 2.01E of this Specification.

3. Frames, grates, rings, and covers.

4. Materials to be used in fabricating drop connections.

5. Materials to be used for pipe connections at manhole walls.

6. Materials to be used for stubs and stub plugs, if required.

7. Materials and procedures for corrosion-resistant liner and coatings, if required.

8. Plugs to be used for sanitary sewer hydrostatic testing.

9. Manufacturer's data for pre-mix (bag) concrete, if used for channel inverts and benches.

C. Seal submittal drawings by Professional Engineer registered in State of Texas.

PART 2 PRODUCTS

2.01 PRECAST CONCRETE MANHOLES

A. Provide machine-made manhole sections, base sections, and related components conforming to ASTM C 478 and/or ASTM C 913. Provide base riser section with integral floors, unless shown otherwise. Provide adjustment rings which are standard components of manufacturer of manhole sections. Mark date of manufacture and name or trademark of manufacturer on inside of barrel.

B. Construct risers and reduced risers for precast manholes from standard reinforced concrete manhole sections of diameter indicated on Drawings. Use various lengths of manhole sections in combination to provide correct height with fewest joints.

C. Minimum Thickness Requirements for Riser Walls and Bases:

1. Sanitary Sewer and Waterline Manholes

a. Design Wall sections for depth and loading conditions in paragraph 2.01.F, with minimum thickness of 5 inches.

b. Base sections shall have a minimum thickness of 12 inches under invert.

2. Storm Sewer Manholes

a. Design riser sections, base and base slabs for depth and loading conditions in Paragraph 2.01.F, with minimum thicknesses according to precast storm water manhole standard details. Minimum base thickness specified in the precast storm water manhole details excludes benching and invert material thickness.

D. Provide tops to support cast iron casting meeting AASHTO M-306 Section 5 loading, and receive manhole frame and covers, as indicated on Drawings.

E. Transition Slabs:

1. Sanitary Sewer & Waterline Manholes:

a. Where manholes larger than 48-inch diameter are indicated on Drawings, provide precast base sections with flat slab top precast sections used to transition to 48-inch diameter manhole access riser sections. Transition can be concentric or eccentric unless otherwise shown on Drawings. Locate transition to provide minimum of 7-foot head clearance from base to underside of transition unless otherwise approved by Project Manager.

2. Storm Sewer Manholes:

a. Where manholes larger than 48-inch diameter are indicated on Drawings, provide precast base sections with flat slab top precast sections used to transition to 48-inch or 60-inch diameter manhole access riser sections. Transition can be concentric or eccentric unless otherwise shown on Drawings.

F. Design Loading Criteria: Manhole walls, transition slabs, cone tops, and manhole base slab shall be designed, by manufacturer, to requirements of ASTM C 890, and/or ASTM C 1889 for depth as shown on Drawings and to resist following loads.

1. AASHTO HL-93 design live loading loads as referred to in AASHTO LRFD Bridge Design Specifications applied to manhole cover and transmitted down to transition and base slabs.

2. Unit soil weight of 120 pcf located above portions of manhole, including base slab projections.

3. Lateral soil pressure based on saturated soil conditions producing an at-rest equivalent fluid pressure of 100 pcf.

4. Internal liquid pressure based on unit weight of 63 pcf.

5. Dead load of manhole sections fully supported by transition and base slabs.

G. Design: Manhole walls, transition slabs, cone tops, and manhole base slab shall be designed according to requirements of ASTM C 478, and/or ASTM C 913 and following:

1. Design additional reinforcing steel to transfer stresses at openings. Area of steel to be no less than shown on Drawings.

2. Wall loading conditions:

a. Saturated soil pressure acting on empty manhole.

b. Manhole filled with liquid to a halfway depth as measured from invert to cover, with no balancing external soil pressure.

3. Wall Penetrations:

a. Sanitary Sewer and Waterline Manholes:

(1) Minimum clear distance between two wall penetrations shall be 12 inches or half diameter of smaller penetration, whichever is greater.

b. Storm Sewer Manholes:

(1) Minimum clear distance between two wall penetrations shall be 6 inches or the base units wall thickness, whichever is greater. Clear distance shall be measured along the inside wall arc of manhole.

(2) When Resilient Connectors are specified in the contract documents, minimum clear distance between wall penetrations shall be 12 inches. Minimum clear distance is to be verified with resilient connector manufacturer before fabricator's engineering design of manhole.

(3) All bases and risers may have cast or cored round wall penetrations. Wall penetrations shall not extend into the slabs or walls. Wall penetrations shall not be within a distance less than the wall thickness, or a minimum of 6 inches, from the joint above or below.

(4) Only box bases and box risers may have thin wall panels (KO) that are round and do not extend into the slab, into walls, or within 6" of the joint above or below. KO dimensions to conform to requirements on standard details.

(5) For box manholes, wall penetrations at corners are prohibited.

(6) For rigid pipe, cut hole in thin wall panel (KO) 4" max, 2" min larger than pipe OD.

(7) For flexible pipe, consult Resilient Connectors manufacturer's specification for placement tolerance and hole size.

H. Provide vertical joints between sections with gaskets conforming to ASTM C 443 and/or ASTM C 990.

I. When base is cast monolithic with portion of vertical section, extend reinforcing in vertical section into base.

J. Precast Concrete Base: Supply suitable cutouts, knockouts or holes to receive pipe and connections. Lowest edge of holes or cutouts: For water line manhole, no less than 6 inches above inside surface of floor of base. For storm sewer manholes, refer to requirements set by standard details.

K. Lifting Hole, Marking and Storage and Shipment for Storm Water Manholes Only:

1. Lifting Holes: Provide no more than 4 lifting holes in each section for precast units. Lifting holes may be cast, cut into fresh concrete after form removal, or drilled. Provide lifting holes large enough for adequate lifting devices based on the size and weight of the section. The maximum hole diameter is 3 inches. at the inside surface of the wall and 4 inches. at the outside surface. Cut no more than 5 inches. in any direction of reinforcement per layer for lifting holes. Repair spalled areas around lifting holes.

2. Marking. Clearly mark each precast manhole with the following information:

   a. Name or trademark of fabricator and plant location

   b. Product designation

   c. ASTM designation (if applicable)

   d. Date of manufacturing; and

   e. Designated fabricator's approval stamp

3. Storage and Shipment: Store Precast units on a level surface. Do not ship precast units until design strength requirements have been met.

L. Third-Party Certification Requirement:

1. Precast concrete manufacturers supplying precast concrete products shall maintain active certification from an accepted third-party quality control program at the time of manufacture.

2. Accepted third-party quality control programs are the National Precast Concrete Association (NPCA) Plant Certification Program and the American Concrete Pipe Association (ACPA) Q-Cast Program

3. Copies of certificates demonstrating compliance with the above third-party plant certification requirements shall be furnished upon the first delivery to the project. Certifications shall be resubmitted annually thereafter or upon request by the Project Manager.

2.02 CONCRETE

A. Manholes

1. Sanitary Sewer and Waterline Manholes

   a. Conform to requirements of Section 03315 - Concrete for Utility Construction or ASTM C 1837.

2. Storm Sewer Manholes

a. Conform to concrete material requirements of TxDOT Specification Item 465 “Junction Boxes, Manholes and Inlets”.

b. Cure precast manholes in accordance with ASTM C 478.

B. Channel Inverts

1. Sanitary Sewer and Waterline Manholes

a. Use 5 sack premix (bag) concrete or Class A concrete for inverts not integrally formed with manhole base, with minimum compressive strength of 4,000 psi.

2. Storm Sewer Manholes

a. Conform to concrete material requirements of TxDOT Specification Item 465 “Junction Boxes, Manholes and Inlets”.

C. Cement Stabilized Sand Foundation: Provide cement stabilized sand foundation under base section in lieu of foundation slab, as shown on Drawings, conforming to requirements of Section 02321 - Cement Stabilized Sand.

D. Concrete Foundation: Provide Class A concrete with minimum compressive strength of 4,000 psi for concrete foundation slab under manhole base section where indicated on Drawings.

2.03 REINFORCING STEEL

A. Conform to requirements of Section 03315 - Concrete for Utility Construction.

2.04 MORTAR

A. Conform to requirements of Section 04061 - Mortar.

2.05 MISCELLANEOUS METALS

A. Provide cast-iron frames, rings, and covers conforming to requirements of Section 02090 - Frames, Grates, Rings and Covers.

2.06 DROP CONNECTIONS AND STUBS

A. Provide drop connections and stubs conforming to same pipe material requirements used in main pipe, unless otherwise indicated on Drawings.

2.07 PIPE CONNECTIONS TO MANHOLE

A. Sanitary Sewer Connections

1. Provide Resilient Connectors conforming to requirements of ASTM C 923. Use the following materials for metallic mechanical devices as defined in ASTM C 923:

    a. External clamps: Type 304 stainless steel.

    b. Internal, expandable clamps on standard manholes: Type 304 stainless steel, 11 gauge minimum.

    c. Internal, expandable clamps on corrosion-resistant manholes:

        (1) Type 316 stainless steel, 11 gauge minimum.

        (2) Type 304 stainless steel, 11 gauge minimum, coated with minimum 16 mil fusion-bonded epoxy conforming to AWWA C 213.

2. Where rigid joints between pipe and cast-in-place manhole base are specified or shown on Drawings, provide polyethylene-isoprene water-stop meeting physical property requirements of ASTM C 923, such as Press-Seal WS Series, or approved equal.

B. Storm Sewer Connections

1. For watertight connections provide Resilient Connectors in accordance with ASTM C 923, ASTM A 1107 or ASTM F 2510 as applicable for pipe material.

2. For soil-tight connections, provide the following:

    a. Rigid (concrete) pipe to manhole connections: Grouted in accordance with ASTM C 1821.

    b. Flexible pipe to manhole connections: Resilient Connectors in accordance with ASTM C 923, ASTM A 1107 or ASTM F 2510 as applicable for pipe material.

3. If no connection type is specified in Contract documents, a soil-tight connection shall be provided.

C. Water Line Connections

1. Where smooth exterior pipes, i.e., steel, ductile iron, or PVC pipes are connected to manhole base or barrel, seal space between pipe and manhole wall with assembly consisting of rubber gasket or links mechanically compressed to form a watertight barrier. Assemblies: Press-Wedge, Res-Seal, Thunderline Link-Seal, or approved equal. See Drawings for placement of assembly in manhole sections.

2. When connecting concrete or cement mortar coated steel pipes, or as option for connecting smooth exterior pipes to manhole base or barrel, space between pipe and manhole wall may be sealed with an assembly consisting of a stainless-steel power sleeve, stainless steel take-up clamp and a rubber gasket. Take-up clamp: Minimum of 9/16 inch wide. Provide PSX positive seal gasket system by Press-Seal Gasket Corporation or approved equal.

2.08 SEALANT MATERIALS

A. Approved products in accordance with Section 01630 - Product Substitution Procedures.

B. Sealing material between precast concrete adjustment ring and manhole, between each adjustment ring, and between adjustment ring and manhole cover frame shall be a hydrophilic elastic sealant, which adheres to both concrete and metal, or approved equal.

C. Provide approved external sealing material from Canusa Wrapid Seal manhole encapsulation system, or approved equal.

D. Provide Butyl Sealant: Provide Press-Seal EZ Stick, or equal, for HDPE rings.

2.09 CORROSION RESISTANT MANHOLE MATERIALS

A. Where corrosion-resistant manholes are indicated on Drawings, refer to City of Houston Approved Product List for liner and/or coating materials.

2.10 BACKFILL MATERIALS

A. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

2.11 NON-SHRINK GROUT

A. Provide prepackaged, inorganic, flowable, non-gas-liberating, non-metallic, cement-based grout requiring only addition of water.

B. Meet requirements of ASTM C 1107 and have minimum 28-day compressive strength of 7,000 psi.

2.12 VENT PIPES

A. Provide external vent pipes for manholes where indicated on Drawings.

B. Buried Vent Pipes: Provide 3-inch or 4-inch PVC DWV pipe conforming to ASTM D 2665. Alternatively, provide FRP pipe as specified for vent outlet assembly.

C. Vent Outlet Assembly: Provide vent outlet assembly as shown on Drawings, constructed of the following specified materials:

1. FRP Pipe: Provide filament wound FRP conforming to ASTM D 2996 or centrifugally cast FRP conforming to ASTM D 2997. Seal cut ends in accordance with manufacturer's recommendations.

2. Joints and Fittings: Provide epoxy bodied fittings and join pipe to fittings with epoxy adhesive.

3. Flanges: Provide socket-flange fittings for epoxy adhesive bonding to pipe ends where shown on Drawings. Meet bolt pattern and dimensions for ASME B 16.l, 125- pound flanges. Flange bolts shall be Type 304 stainless steel or hot-dip zinc coated, conforming to ASTM A 307, Class A or B.

4. Coating: Provide approved 2-component, aliphatic polyurethane coating using primer or tie coat recommended by manufacturer. Provide two or more coats to yield dry film thickness of at least 3 mils. Color shall be selected by Project Manager from manufacturer's standard colors.

2.13 PROHIBITED MATERIALS

A. Use of brick masonry is prohibited for construction of manholes, including adjustment of manholes to grade.

B. For Storm Water manholes, use of mortar is prohibited for pipe to manhole connections.

2.14 MANHOLE LADDER FOR WATERLINE MANHOLES

A. Manhole Ladder: Fiberglass with 300-lb rating at appropriate length; conform to requirements of Occupational Safety and Health Standards (OSHA), U.S. Department of Labor except where shown on Drawings:

1. Use components, including rungs, made of fiberglass, fabricated with nylon or aluminum rivets and/or epoxy. Apply non-skid coating to ladder rungs. Mount ladder using manufacturer's recommended hardware.

2. Provide ladder as manufactured by Saf-Rail or approved equal. Locate ladder as shown on Drawings.

3. Fiberglass: Premium type polyester resin, reinforced with fiberglass; constructed to provide complete wetting of glass by resin; resistant to rot, fungi, bacterial growth and adverse effects of acids, alkalis and residential and industrial waste; yellow in color

B. Provide approved petroleum-based tape encapsulating bolts in access manhole.

2.15 SOURCE QUALITY CONTROL

A. Representatives of City Engineer will inspect manufacturer's plant and casting operations as deemed necessary.

B. Precast Unit Identification: Mark date of manufacture and name or trademark of manufacturer clearly on inside of pipe.

C. Rejection: Precast units rejected for non-conformity with these specifications and for following reasons:

1. Fractures or cracks passing through shell, except for single end crack that does not exceed depth of joint.

2. Surface defects indicating honeycombed or open texture.

3. Damaged or misshaped ends, where damage would prevent making satisfactory joint.

D. Replacement: Immediately remove rejected units from Work site and replace with acceptable units.

E. Repairs: Occasional imperfections resulting from manufacture or accidental damage may be repaired if, in opinion of Project Manager, repaired units conform to requirements of these specifications

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that lines and grades are correct.

B. Determine if subgrade, when scarified and recompacted, can be compacted to 95 percent of maximum Standard Proctor Density, at ±3 percent optimum moisture content according to ASTM D 698 prior to placement of foundation material and base section. If it does not meet the moisture-density requirement, condition the subgrade until the required moisture-density requirement is met or treat as an unstable subgrade.

C. Do not build manholes in ditches, swales, or drainage paths unless approved by Project Manager.

3.02 PLACEMENT

A. Install precast manholes to conform to locations and dimensions shown on Drawings.

B. Place sanitary manholes at points of change in alignment, grade, size, pipe intersections, and end of sewer unless otherwise shown on Drawings.

C. Place storm manholes at points of change in alignment, grade, size, pipe intersections, and end of sewer unless otherwise shown on Drawings. Pipe connections into storm sewer precast box manholes that exceed a 7-degree angle of entry shall use a pipe elbow, bend, or curved approach as shown per detail 02082-13 Storm Sewer Precast Box Inlet/Manhole, Pipe Connection Detail.

3.03 MANHOLE BASE SECTIONS AND FOUNDATIONS

A. Foundation Material:

1. Sanitary Sewer and Waterlines

a. Place precast base on 12-inch thick (minimum) foundation of crushed stone wrapped in filter fabric, cement stabilized sand, or concrete foundation slab. Compact cement-sand in accordance with requirements of Section 02321 - Cement Stabilized Sand.

2. Storm Sewer

a. Foundation material is to be selected based on site soil type and bearing capacity established by the geotechnical investigation report. Place precast base on the foundation material that is selected, by the Engineer of Record and Geotechnical Engineer, from the options below:

(1) 12-inch thick (minimum) foundation of crushed stone wrapped in filter fabric, placed in maximum 6-inch compacted lift thickness layers.

(2) Cement stabilized sand compacted in accordance with requirements of section 02321 – Cement Stabilized Sand. Cement stabilized sand foundations are prohibited to be placed on fault lines.

(3) Concrete foundation slab.

B. Unstable Subgrade Treatment: When unstable subgrade is encountered, notify Project Manager for examination of subgrade to determine if subgrade has heaved upwards after being excavated. When heaving has not occurred, over-excavate subgrade to allow for 24-inch-thick layer of crushed stone wrapped in filter fabric as foundation material under manhole base. When there is evidence of heaving, provide pile-supported concrete foundation, as detailed on Drawings, under manhole base.

C. For manholes located over large diameter water lines, place precast base on a foundation of cement stabilized sand extending from bottom of manhole to bottom of trench. Manhole base is to be a minimum of 12-inches above water line.

3.04 PRECAST MANHOLE SECTIONS

A. Install sections, joints, and gaskets in accordance with ASTM C 1821 and the manufacturer's printed recommendations.

B. Install precast adjustment rings above tops of cones or flat-top sections as required to adjust finished elevation and to support manhole frame.

C. Seal any lifting holes with non-shrink grout.

D. Where PVC liners are required, seal joints between sections in accordance with manufacturer’s recommendations.

E. Place at least two precast concrete grade rings with thickness of 12 inches or less, under casting. Refer to standard details for additional requirements of precast concrete grade rings.

3.05 PIPE CONNECTIONS AT MANHOLES

A. Sanitary Sewer and Water Line Manholes

1. Install approved Resilient Connectors at each pipe entering and exiting manholes in accordance with manufacturer's instructions and specifications. Resilient/flexible connectors shall not be grouted unless allowed by the manufacturer. See article 2.07 for approved connection materials.

B. Storm Sewer Manholes

1. Install connections at each pipe entering and exiting manholes in accordance with manufacturer's instructions and specifications. See 2.07 for connection material requirements. When pipe to manhole connections are to be grouted, all voids are to be completely filled with grout and grouted on both sides inside and outside of manhole.

C. .Ensure no concrete, cement stabilized sand, fill, or other rigid material is allowed to enter space between pipe and edge of wall opening at and around Resilient Connector on either interior or exterior of manhole. If necessary, fill space with compressible material to ensure full flexibility provided by Resilient Connector.

D. Where a new manhole is constructed on an existing sewer, rigid joint pipe may be used. Install waterstop gasket around existing pipe at center of cast-in-place wall. Join ends of split waterstop material at pipe springline using an adhesive recommended and supplied by waterstop manufacturer.

E. Test connection for watertight seal before backfilling.

3.06 INVERTS FOR SANITARY SEWERS

A. Construct invert channels to provide smooth flow transition waterway with no disruption of flow at pipe-manhole connections. Conform to following criteria:

1. Slope of invert bench: 1 inch per foot minimum; 1-1/2 inches per foot maximum.

2. Depth of bench to invert shall be at least equal to the largest pipe diameter.

3. Invert slope through manhole: 0.10-foot drop across manhole with smooth transition of invert through manhole, unless otherwise indicated on Drawings.

B. Form invert channels with concrete if not integral with manhole base section. For direction changes of mains, construct channels tangent to mains with maximum possible radius of curvature. Provide curves for side inlets and smooth invert fillets for flow transition between pipe inverts.

3.07 DROP CONNECTIONS FOR SANITARY SEWERS

A. Backfill drop assembly with crushed stone wrapped in filter fabric, cement stabilized sand, or Class A concrete to form solid mass. Extend cement stabilized sand or concrete encasement minimum of 4 inches outside bells.

B. Install drop connection when sewer line enters manhole higher than 24 inches above invert of manhole.

3.08 INVERTS FOR STORM SEWERS

A. When precast, square or rectangular structures are used for sewer manholes, construct invert channels to provide smooth flow transition waterway with no disruption of flow at pipe- manhole connections. Conform to following criteria:

1. Slope of invert bench: 1 inch per foot minimum; 1-1/2 inches per foot maximum.

2. Depth of bench to invert: one half of largest pipe diameter.

3. Invert slope through manhole: 0.10-foot drop across manhole with smooth transition of invert through manhole, unless otherwise indicated on drawings.

B. Form invert channels with concrete, after all connections have been made

1. Refer to 2.02.B.2 for material requirements.

3.09 STUBS FOR FUTURE CONNECTIONS

A. In manholes, where future connections are indicated on Drawings, install Resilient Connectors and pipe stubs with approved watertight plugs.

3.10 MANHOLE FRAME AND ADJUSTMENT RINGS

A. Combine precast concrete or HDPE adjustment rings so elevation of installed casting cover matches pavement surface. Seal between concrete adjustment ring and precast top section with non-shrink grout; do not use mortar between adjustment rings. Apply latex-based bonding agent to precast concrete surfaces joined with non-shrink grout. Set cast iron frame on adjustment ring in bed of approved sealant material. Install sealant bed consisting of two beads of sealant, each bead having minimum dimensions of 1/2-inch and 1/2-inch wide.

B. Wrap manhole frame and adjustment rings with external sealing material, minimum 3 inches beyond joint between ring and frame and adjustment rings and precast section.

C. Manholes in unpaved areas:

1. Sanitary Sewer and Waterlines

a. For manholes in unpaved areas, set top of frame minimum of 6 inches above existing ground line unless otherwise indicated on Drawings. In unpaved areas, encase manhole frame in mortar or non-shrink grout placed flush with face of manhole ring and top edge of frame. Provide rounded corner around perimeter.

2. Storm Sewers

a. For manholes in unpaved areas, set top of frame minimum of 6 inches above existing ground line unless otherwise indicated on Drawings. In unpaved areas, where existing manholes are to be fitted with a grated cover for the purpose of storm water drainage, it is permitted to set the top of the frame at existing/proposed grade. In unpaved areas, encase manhole frame in mortar or non-shrink grout placed flush with face of manhole ring and top edge of frame. Provide rounded corner around perimeter.

3.11 BACKFILL

A. Place and compact backfill materials in area of excavation surrounding manholes in accordance with requirements of Section 02317 - Excavation and Backfill for Utilities. Provide embedment zone backfill material, as specified for adjacent utilities, from manhole foundation up to an elevation 12 inches over each pipe connected to manhole. Provide trench zone backfill, as specified for adjacent utilities, above embedment zone backfill.

B. Where rigid joints are used for connecting existing sewers to manhole, backfill under existing sewer up to springline of pipe with Class B concrete or flowable fill.

C. In unpaved areas, provide positive drainage away from manhole frame to natural grade. Provide minimum of 4 inches of topsoil conforming to requirements of Section 02911 - Topsoil. Seed in accordance with Section 02921 - Hydro Mulch Seeding. When shown on Drawings, sod disturbed areas in accordance with Section 02922 - Sodding.

3.12 FIELD QUALITY CONTROL

A. Conduct leakage testing of sanitary sewer manholes in accordance with requirements of Section 02533 - Acceptance Testing for Sanitary Sewers.

B. Before installation of storm water manholes, if the foundation's subgrade soil conditions are inconsistent with the contract documents, notify the Engineer of Record and Geotechnical Engineer. Follow the Engineer of Record's and Geotechnical Engineer's instructions on any additional soil testing, proper selection of foundation materials, and soil remediation.

3.13 PROTECTION

A. Protect manholes from damage until work has been accepted. Repair damage to manholes at no additional cost to City.

END OF SECTION

SECTION 02083

FIBERGLASS MANHOLES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Fiberglass manholes for unpaved areas placed on top of a precast base to form a manhole.

B. Fiberglass for construction in back lot easements placed on cast-in-place base.

C. Fiberglass manholes are not permitted underneath existing or proposed pavement.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02082 – Precast Concrete Manholes

D. Section 02090 – Frames, Grates, Rings, And Covers

E. Section 02317 – Excavation and Backfill for Utilities

F. Section 02321 – Cement Stabilized Sand

G. Section 02533 – Acceptance Testing for Sanitary Sewers

H. Section 02911 – Topsoil

I. Section 02921 – Hydro Mulch Seeding

J. Section 02922 – Sodding

K. Section 03315 – Concrete for Utility Construction

L. Section 04061 – Mortar

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for fiberglass manholes is on unit price basis for each manhole installed.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASME B 16.1 – Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250

B. ASTM A 307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength.

C. ASTM C 1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).

D. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3 (600kN-m/m3).

E. ASTM D 2665 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste and Vent Pipe and Fittings.

F. ASTM D 2997 - Standard Specification for Centrifugally Cast “Fiberglass” (Glass-Fiber-Reinforced Thermosetting Resin) Pipe.

G. ASTM D 3753 - Standard Specification for Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Manholes and Wetwells.

H. American Association of State Highway and Transportation Officials (AASHTO).

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer's data and details of following items for approval:

1. Design and fabrication details of fiberglass manhole components

2. Installation instruction for fiberglass manholes

3. Frames, grates, rings, and covers

4. Materials to be used in fabricating drop connections

5. Materials to be used for pipe connections at manhole walls

6. Materials to be used for stubs and stub plugs, if required

7. Plugs to be used for sanitary sewer hydrostatic testing

8. Manufacturer's data for pre-mix (bag) concrete if used for channel inverts and benches

9. Manufacturer's color chart for fiberglass vent pipe coatings.

C. Submittals listed in Section 02082 – Precast Concrete Manholes, paragraph 1.05.

PART 2 PRODUCTS

2.01 FIBERGLASS MANHOLES AND BASE SECTIONS

A. Provide prefabricated fiberglass manholes which conform in shape, size, dimensions, and details shown on Drawings. Unless modified by Drawings, use manhole sections conforming to ASTM D 3753.

B. Provide products manufactured by companies listed on the City of Houston Standard Product List.

C. Mark date of manufacture and name or trademark of manufacturer in 1-inch high stenciled letters on inside of barrel.

D. Unless larger size is required, provide 48-inch-diameter barrel for fiberglass manholes. Provide wall section thickness for depth of manhole according to ASTM D 3753, but not less than 0.48 inches in thickness.

E. Provide fabricated reducer bonded at factory to form one continuous unit at top of manhole barrel to accept concrete grade rings and cast iron frame and cover. Reducer design shall be of sufficient strength to safely support HL-93 loading in accordance with AASHTO.

F. Provide manhole base of precast concrete conforming to Section 02082 - Precast Concrete Manholes, unless cast-in-place base is indicated on Drawings. For concrete manhole bases, use an approved steel-reinforced design of sufficient strength to withstand imposed loads. Form cast-in-place base so that joint with fiberglass manhole barrel is sealed against leakage, as shown on Drawings. When precast bases are specified, it shall be the installers responsibility to ensure a sufficient seal against leakage.

2.02 CONCRETE

A. Conform to requirements of Section 03315 - Concrete for Utility Construction.

B. Channel Inverts: Use 5 sack premix (bag) concrete or Class A concrete for inverts not integrally formed with manhole base, with minimum compressive strength of 4000 psi.

C. Concrete Foundation: Use Class A concrete with minimum compressive strength of 4000 psi for cast-in-place base and for foundation slab under manhole base section where indicated on Drawings.

D. Cement Stabilized Sand Foundation: In lieu of foundation slab, provide cement stabilized sand foundation under base section, when shown on manhole Drawings, conforming to requirements of Section 02321 - Cement Stabilized Sand.

2.03 REINFORCING STEEL

A. Provide reinforcing steel conforming to requirements of Section 03315 - Concrete for Utility Construction.

2.04 MORTAR

A. Conform to requirements of Section 04061 - Mortar.

2.05 MISCELLANEOUS METALS

A. Provide cast-iron frames, rings, and covers conforming to requirements of Section 02090 - Frames, Grates, Rings, and Covers.

2.06 DROP CONNECTIONS AND STUBS

A. Provide drop connections and stubs conforming to same pipe material requirements used in main pipe, unless otherwise indicated on Drawings.

2.07 PIPE CONNECTIONS FOR SANITARY SEWERS

A. Provide pipe connections conforming to requirements of Section 02082 - Precast Concrete Manholes.

B. For drop, provide manufactured connector, such as Insert-a-Tee or equal, which provides positive seal between pipe and wall.

2.08 SEALANT MATERIALS

A. Sealing material between adjustment ring and manhole, between each adjustment ring, and between adjustment ring and manhole cover frame shall be a hydrophilic elastic sealant, which adheres to concrete, fiberglass and metal, or approved substitute.

B. Butyl Sealant: Provide Press-Seal EZ Stick, or equal, for HDPE rings.

C. Fiberglass manhole barrel may be bedded in a flexible joint material laid on the shoulder of the concrete base joint, or any other method approved by the Engineer. It will remain the installer’s responsibility to ensure the connection against leakage.

2.09 BACKFILL MATERIALS

A. Backfill materials shall conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

2.10 NON-SHRINK GROUT

A. Provide prepackaged, inorganic, flowable, non-gas-liberating, nonmetallic, cement-based grout requiring only addition of water.

B. Grout shall meet requirements of ASTM C 1107 and shall have minimum 28-day compressive strength of 7000 psi.

2.11 VENT PIPES

A. Provide external vent pipes for manholes, where indicated on Drawings.

B. Buried Vent Pipes: Provide 3-inch or 4-inch PVC DWV pipe conforming to ASTM D 2665. Alternatively, provide FRP pipe as specified for vent outlet assembly.

C. Vent Outlet Assembly: Provide vent outlet assembly as shown on Drawings, constructed of following specified materials:

1. Provide fiberglass reinforced pipe conforming to ASTM D 2997. Seal cut ends in accordance with manufacturer's recommendations

2. Joints and Fittings: Provide epoxy bodied fittings and join pipe to fittings with epoxy adhesive, according to pipe manufacturer's instructions

3. Flanges: Provide socket-flange fittings for epoxy adhesive bonding to pipe ends where shown on Drawings. Flanges shall meet bolt pattern and dimensions for ASME B16.l, 125-pound flanges. Flange bolts shall be hot-dip zinc coated, conforming to ASTM A 307, Class A or B.

4. Coating: Provide 2-component, aliphatic polyurethane coating using primer or tie coat recommended by manufacturer. Provide two or more coats to yield dry film thickness of at least 3 mils. Provide Amershield, Tnemec 74, or equal. Color shall be selected by Project Manager from manufacturer's standard colors.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that lines and grades are correct.

B. Determine if subgrade, when scarified and recompacted, can be compacted to 95 percent of maximum Standard Proctor Density at +- 3 percent moisture content, according to ASTM D 698 prior to placement of foundation material and base section. If it does not meet the moisture-density requirement, condition the subgrade or treat as an unstable subgrade.

C. Do not build manholes in ditches, swales, or drainage paths unless approved by Project Manager.

3.02 PLACEMENT

A. Install fiberglass manholes to conform to locations and dimensions shown on Drawings. Do not install underneath existing or proposed pavement.

B. Place sanitary sewer manholes at points of change of alignment, grade, size, pipe intersections, and end of sewer.

3.03 MANHOLE BASE SECTIONS AND FOUNDATIONS

A. Place base section and foundation as required in Section 02082 - Precast Concrete Manholes.

3.04 CAST-IN-PLACE FOUNDATION

A. Where Drawings indicate cast-in-place manhole base, place concrete as shown on Drawings on 4-inch (minimum) layer of either crushed stone, cement stabilized sand, or seal slab. When unstable subgrade is identified, over-excavate subgrade to allow for placement of 12-inch thick layer of crushed stone wrapped in filter fabric.

3.05 MANHOLE BARREL

A. Lower manhole barrel onto base section. Seal with manufacturer's gasket or approved sealant. Wrap joint with external sealing material, minimum 12-inch width.

B. Where cast-in-place base is used, support manhole barrel in place and brace it from sides of excavation to prevent any movement of barrel during concrete placement and while concrete is setting. Provide minimum clearance between reinforcing steel and manhole barrel bottom as shown on Drawings. Do not support manhole barrel on reinforcing steel. Place bead of water swelling sealant around inside of barrel near bottom, as shown on Drawings, to form seal.

3.06 PIPE CONNECTIONS AT PRECAST MANHOLE BASE

A. Install approved resilient connectors at each pipe entering and exiting sanitary sewer manholes in accordance with manufacturer's instructions.

B. Ensure that no concrete, cement stabilized sand, fill, or other solid material is allowed to enter space between pipe and edge of wall opening at and around resilient connector on either interior or exterior of manhole. When necessary, fill space with compressible material to ensure full flexibility provided by resilient connector.

C. Test connection for watertight seal before backfilling.

3.07 PIPE CONNECTIONS AT CAST-IN PLACE BASE

A. Cut manhole barrel for pipe penetrations following curvature of pipe and with maximum of 1-inch clearance. Seal cut edges with resin. Hole may be circular or cutout with semi-circular top which extends to bottom of barrel.

B. Place continuous bead of water swelling sealant, as shown on Drawings, around pipe penetrations on interior of manhole barrel. Roughen surface of fiberglass prior to placement to improve bond with sealant. Allow sealant to completely cure before placing concrete against it.

C. Extend pipe entering manhole at least 8 inches into manhole. Fit pipes with neoprene water-stop gasket seal placed tightly around pipe using stainless steel clamp. Alternately, pipes may have continuous bead of water swelling sealant, as detailed on Drawings, placed around pipe circumference.

D. When forming invert surface in bottom of manhole, mound concrete around pipe penetrations so that water swelling sealant beads and neoprene water-stop gasket have minimum 2 inches of concrete cover.

E. Test connection for watertight seal before backfilling.

3.08 INVERTS FOR SANITARY SEWERS

A. Construct invert channels as required in Section 02082 - Precast Concrete Manholes.

3.09 DROP CONNECTIONS FOR SANITARY SEWERS

A. Backfill drop assembly with crushed stone wrapped in filter fabric, cement stabilized sand, or Class A concrete to form solid mass. Extend cement stabilized sand or concrete outside of bells minimum 4 inches.

B. Install drop connection when sewer line enters manhole higher than 24 inches above invert of manhole.

C. At drop pipe connections through fiberglass barrel, cut circular hole sized to requirements of manufactured connector. Seal cut edge with resin. Install watertight connector according to manufacturer's recommendations.

3.10 STUBS FOR FUTURE CONNECTIONS

A. Where future connections are indicated on Drawings, install resilient connectors and pipe stubs with approved watertight plugs in manholes.

B. At cast-in-place base, where future connections are indicated on Drawings, install section of pipe extending no further than 12 inches from edge of foundation, ending in bell and provided with rubber-gasket watertight plug.

3.11 ADJUSTMENT RINGS AND FRAME

A. Combine precast concrete or HDPE adjustment rings so that elevation of installed casting cover matches pavement surface. Do not load manhole except on load bearing shoulder of manhole. Seal between adjustment ring and fiberglass manhole with approved sealant material. Apply a latex bonding agent to precast concrete surface and join with non-shrink grout. Set cast iron frame on adjustment ring in bed of approved sealant material. Install sealant bed consisting of two beads on sealant, each bead having minimum dimensions of 1/2-inch and 1/2-inch wide.

B. Wrap manhole frame and adjustment rings with external sealing material, minimum 3 inches beyond joint between ring and frame and ring and precast section.

C. Set cast iron frame on top of cone or adjustment rings using water swelling sealant materials and adjust elevation of casting cover to match pavement surface. For manholes in unpaved areas, set top frame minimum of 6 inches above existing ground line unless otherwise indicated on Drawings.

3.12 BACKFILL

A. After leakage testing, place and compact backfill material in area of excavation surrounding manholes in accordance with requirements of Section 02317- Excavation and Backfill for Utilities. Use embedment zone backfill material, as specified for adjacent utilities, from manhole foundation up to elevation 12-inches over each pipe connected to manhole. Provide trench zone backfill, as specified for adjacent utilities, above embedment zone backfill.

B. In unpaved areas, provide positive drainage away from manhole frame to natural grade. Provide minimum of 4-inches of topsoil conforming to requirements of Section 02911 - Topsoil and seed in accordance with Section 02921 - Hydro Mulch Seeding. When shown on Drawings, sod disturbed areas in accordance with Section 02922- Sodding.

3.13 FIELD QUALITY CONTROL

A. Conduct leakage testing of sanitary sewer manholes in accordance with requirements of Section 02533 - Acceptance Testing for Sanitary Sewers.

3.14 PROTECTION

A. Protect manholes from damage until work has been finally accepted. Repair damage to manholes at no additional cost to City.

END OF SECTION

SECTION 02085

VALVE BOXES, METER BOXES, AND METER VAULTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Valve boxes for water service.

B. Meter boxes for water service.

C. Meter vaults for water service.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02091 – Non-Metallic Frames, Grates, Rings, and Covers

D. Section 02317 – Excavation and Backfill for Utilities

E. Section 02320 – Utility Backfill Materials

F. Section 02501 – Ductile Iron Pipe and Fittings

G. Section 02506 – Polyvinyl Chloride Pipe

H. Section 02511 – Water Lines

I. Section 02512 – Water Tap and Service Line Installation

J. Section 02751 – Concrete Paving

K. Section 03315 – Concrete for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for valve boxes under this Section. Include payment in unit price for Section 02511 - Water Lines.

2. No separate payment will be made for meter boxes under this Section. Include payment in unit price for Section 02512 - Water Tap and Service Line Installation.

3. Payment for each size of meter vaults is on unit price basis per vault. Payment will be made for each vault installed, regardless of depth.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM A 48 - Standard Specification for Gray Iron Castings.

B. ASTM D 256 - Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.

C. ASTM D 638 - Standard Test Method for Tensile Properties of Plastics.

D. ASTM D 648 - Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.

E. ASTM D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

F. ASTM D 2240 - Standard Test Method for Rubber Property-Durometer Hardness.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturers' product data for following items for approval:

1. Each type of valve box and lid.

2. Each type of meter box and cover.

3. Each type of meter vault frame and cover.

C. Submit design calculations and shop drawings for precast vault elements, sealed by an Engineer registered in State of Texas.

D. Submit shop drawings for cast-in-place meter vaults for approval if proposed construction varies from City of Houston Detail Drawings.

E. Submit manufacturer's certification that plastic meter boxes meet requirements of Paragraph 2.05, Plastic Meter Boxes.

PART 2 PRODUCTS

2.01 VALVE BOXES

A. Provide approved Type A, cast-iron/ductile-iron, slide-type, valve boxes. Design of valve box shall minimize stresses on valve imposed by loads on box lid.

B. Cast letter “W” into lid, 1/2 inch in height and raised 3/32 inch, for valves serving potable water lines.

C. Unless otherwise specified, uncoated cast iron.

D. Riser Pipe.

1. Provide 6-inch PVC, DR 18, riser pipes in accordance with Section 02506 - Polyvinyl Chloride Pipe or

2. 6-inch ductile-iron, thickness Class 51 riser pipes in accordance with Section 02501 – Ductile Iron Pipe and Fittings.

3. Provide single section of pipe.

E. Concrete for valve box placement:

1. For locations in new concrete pavement, provide strength and mix design of new pavement.

2. For other locations, provide concrete for sidewalks conforming to requirements of Section 02751 - Concrete Paving.

2.02 METER BOXES

A. Provide meter boxes for 5/8-inch through 1-inch meters of the following materials:

1. Non-traffic bearing locations: Cast iron, concrete or plastic.

2. Traffic bearing locations: Cast iron.

B. Provide meter boxes for 1 1/2-inch and 2-inch meters of cast iron.

C. Provide meter box with reading lid. Provide lids with spring-type latching devices. Lids shall contain sufficient metal that meter box can be easily located with metal detector. Cast words “CITY OF HOUSTON” and "WATER METER" into lid with letters of 1/2-inch height and raised 3/32 inch.

D. Meter box dimensions shall conform to the following approximate dimensions:

1. Length: At top – 15 1/2 inches; at bottom 20 inches

2. Width: At top – 12 1/2 inches; at bottom 14 3/4 inches

3. Height: 12 inches

E. Extensions: Meter box extensions 3 inches and 6 inches in height shall be available from manufacturer as standard item.

2.03 CAST-IRON METER BOXES

A. Cast-Iron Boxes: Clean and free from sand blow-holes or other defects conforming to requirements of ASTM A 48, Class 30B. Bearing surfaces shall be machined so that covers seat evenly in frames.

B. Boxes and lids shall have dipped, coal-tar-pitch, varnish finish.

C. Provide lock-type meter boxes when required by Drawings. Lock mechanisms shall work with ease.

2.04 CONCRETE METER BOXES

A. Concrete Meter Boxes: Made of Class A concrete, with minimum 4000 psi compressive strength, conforming to requirements of Section 03315 - Concrete for Utility Construction. Construct to dimensions shown on Drawings.

B. Castings: Free from fractures, large or deep cracks, blisters or surface roughness or any other defects that may affect serviceability.

2.05 PLASTIC METER BOXES

A. Plastic Meter Boxes: Made of high density polyethylene conforming to the following ASTM standards:

ASTM	REQUIREMENT
D 256	Impact Strength = 1.9 ft.-lb./inch (Izod, Notched)
D 256	Impact Strength = 6.4 ft.-lb./inch (Izod, Un-Notched)
D 638	Tensile Strength (2.0 min.) = 3400 psi
D 648	Deflection Temperature = 170 degrees F
D 2240	Shore D, Hardness, 55-65 Impact Strength, Falling Dart Method, 160 inch-lb.
D 790	Flexural Modulus = 90,000 psi

B. Meter boxes shall meet the following test requirements:

1. Static Load: Not less than 2500 pounds using 6-inch disc with direct compression exerted at center of top of meter box with solid plastic lid.

2. Deflection: Not less than 1000 pounds load required to deflect top edge of meter box 1/8- inch.

C. Meter box body, without lid, shall weigh approximately 7 pounds.

2.06 METER VAULTS

A. Meter vaults may be constructed of precast concrete, cast-in-place concrete to the specified dimensions in the City of Houston Detail Drawings.

B. Concrete for Meter Vaults: Class A concrete, conforming to requirements of Section 03315 - Concrete for Utility Construction with minimum compressive strength of 4000 psi at 28 days.

C. Reinforcing steel for meter vaults: Conform to requirements of Section 03315 Concrete for Utility Construction.

D. Grates and Covers: Conform to requirements of Section 02091 – Non Metallic Frames, Grates, Rings, and Covers.

PART 3 EXECUTION

3.01 EXAMINATION

A. Obtain approval from Project Manager for location of meter vault.

B. Verify lines and grade are correct.

C. Verify compacted subgrade will support loads imposed by vaults.

3.02 VALVE BOXES

A. Install riser pipe with suitable length for depth of cover indicated on Drawings or to accommodate actual finish grade.

1. Install with bell on top of valve

2. Place riser pipe in plumb, vertical position

B. Install valve box and riser piping plumbed in a vertical position. Provide 6-inches telescoping freeboard space between riser pipe top butt end, and interior contact flange of valve box, for vertical movement damping. End of pipe resting on valve shall be notched out sufficiently to provide a snug fit around the valve bonnet and to center valve inside of pipe.

C. Set, align, and adjust valve box so that lid is level with final grade.

D. Paint covers of new valve boxes in fluorescent orange when installed. After completion and acceptance by City, repaint covers black.

3.03 METER BOXES

A. Install cast iron or plastic boxes in accordance with manufacturer's instructions.

B. Construct concrete meter boxes to dimensions shown on City of Houston Detail Drawings.

C. Adjust top of meter boxes to conform to cover elevations specified in Paragraph 3.05, Frame and Cover for Meter Vaults.

D. Do not locate under paved areas unless approved by Project Manager. Use approved traffic- type box with cast iron lid when meter must be located in paved areas.

3.04 METER VAULTS

A. Construct concrete meter vaults to dimensions shown on City of Houston Detail Drawings. Do not cast in presence of water. Make bottom uniform. Verify lines and grades are correct and compacted subgrade will support loads imposed by vaults. Interior meter vault depth is not allowed to exceed more than 4 feet unless approved by Office of the City Engineer.

B. Precast Meter Vaults:

1. Install precast vaults in accordance with manufacturer's recommendations. Set level on a minimum 3-inch-thick bed of sand conforming to requirements of Section 02320 - Utility Backfill Materials.

2. Seal lifting holes with cement-sand mortar or non-shrink grout.

C. Meter Vault Floor Slab:

1. Construct floor slabs of 6-inch-thick reinforced concrete. Slope floor 1/4 inch per foot toward sump. Make sump 12 inches in diameter, or 12 inches square, and 4 inches deep, unless other dimensions are required by Drawings. Install dowels at maximum of 18 inches, center-to-center for keying walls to floor slab.

2. Precast floor slab elements may be used for precast vault construction.

D. Cast-in-Place Meter Vault Walls:

1. Key walls to floor slab and form to dimensions shown on Drawings. Minimum wall thickness shall be 4 inches.

2. Cast walls monolithically. One cold joint will be allowed when vault depth exceeds 12 feet.

3. Set frame for cover in concrete.

3.05 FRAME AND COVER FOR METER VAULTS

A. Set cast iron frame in a mortar bed and adjust elevation of cover as follows:

1. In unpaved areas, set top of meter box or meter vault cover 2 to 3 inches above natural grade

2. In paved areas, set top of meter box or meter vault cover flush with adjacent concrete but no higher than 1/2-inch

3.06 BACKFILL

A. Provide bank run sand in accordance with Section 02320 - Utility Backfill Materials and backfill and compact in accordance with Section 02317 - Excavation and Backfill for Utilities.

B. In unpaved areas, slope backfill around meter boxes and vaults to provide a uniform slope 1- to-5 slope from top to natural grade.

C. In paved areas, slope concrete down from meter box or vault to meet adjacent paved area.

END OF SECTION

SECTION 02086

ADJUSTING MANHOLES, INLETS, AND VALVE BOXES TO GRADE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Adjusting elevation of manholes, inlets, and valve boxes to new grades.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 02081 – Cast-In-Place Concrete Manholes

C. Section 02082 – Precast Concrete Manholes

D. Section 02083 – Fiberglass Manholes

E. Section 02090 – Frames, Grates, Rings, And Covers

F. Section 02316 – Excavation and Backfill for Structures

G. Section 02501 – Ductile Iron Pipe and Fittings

H. Section 02528 – Polyethylene Encasement-Wrap

I. Section 02632 – Cast-In-Pace Inlets, Headwalls, And Wingwalls

J. Section 02633 – Precast Concrete Inlets, Headwalls, And Wingwalls

K. Section 02911 – Topsoil

L. Section 02921 – Hydro Mulch Seeding

M. Section 02922 – Sodding

N. Section 03315 – Concrete for Utility Construction

O. Section 04061 – Mortar

P. Section 04210 – Brick Masonry for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for adjusting manhole frames and covers, inlets, valve boxes, and meter boxes to grade for new construction under this Section. Include payment in unit price for related item.

2. Payment for adjusting existing manholes, frames and covers, inlets, valve boxes, and meter boxes to a new grade is on a unit price basis for each.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

PART 2 PRODUCTS

2.01 CONCRETE MATERIALS

A. Provide concrete, conforming to requirements of Section 03315 - Concrete for Utility Construction.

B. Provide precast concrete manhole sections and adjustment rings conforming to requirements of Section 02082 - Precast Concrete Manholes.

C. Provide mortar conforming to requirements of Section 04061 - Mortar.

2.02 CAST-IRON MATERIALS

A. Provide cast-iron materials conforming to requirements of Section 02090 - Frames, Grates, Rings, and Covers.

2.03 PIPING MATERIALS

A. For riser pipes and fittings, refer to Sections 02501 - Ductile-Iron Pipe and Fittings through 02528 - Polyethylene Encasement Wrap.

2.04 MASONRY MATERIALS FOR STORM SEWER MANHOLES AND INLETS

A. Provide brick masonry units conforming to the requirements of Section 04210 - Brick Masonry for Utility Construction.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine existing structure, valve box, frame and cover or inlet box, frame and cover or inlet, piping and connections for damage or defects affecting adjustment to grade. Report damage or defects to Project Manager.

3.02 ESTABLISHING GRADE

A. Coordinate grade related items with existing grade and finished grade or paving, and relate to established benchmark or reference line.

3.03 ADJUSTING MANHOLES AND INLETS

A. Rebuild adjustment portion of manhole or inlet by adding or removing Adjustments. Follow procedures for the type of structure being adjusted detailed in the following Sections:

1. Section 02081 - Cast-In-Place Concrete Manholes

2. Section 02082 - Precast Concrete Manholes

3. Section 02083 - Fiberglass Manholes

4. Section 02632 - Cast-In-Place Inlets, Headwalls and Wingwalls

5. Section 02633 - Precast Concrete Inlets, Headwalls and Wingwalls

B. Salvage and reuse cast-iron frame and cover or grate.

C. Protect or block off manhole or inlet bottom using wood forms shaped to fit so that no debris or soil falls to bottom during adjustment.

D. Verify that manholes and inlets are free of visible leaks as result of reconstruction. Repair leaks in manner subject to Project Manger's approval.

3.04 ADJUSTING VALVE BOXES

A. Salvage and reuse valve box and surrounding concrete block as approved by Project Manager. No separate pay.

B. Remove and replace 6 inch ductile iron riser pipe with suitable length for depth of cover required to establish adjusted elevation to accommodate actual finish grade.

C. Reinstall valve box and riser piping plumbed in vertical position. Provide minimum 6 inches telescoping freeboard space between riser pipe top butt end and interior contact flange of valve box for vertical movement damping.

D. After valve box has been set, aligned, and adjusted so that top lid is level with final grade.

3.05 BACKFILL AND GRADING

A. Backfill area of excavation surrounding each adjusted manhole, inlet, and valve box and compact according to requirements of Section 02316 - Excavation and Backfill for Structures.

B. Grade ground surface to drain away from each manhole and valve box. Place earth fill around manholes to level of upper rim of manhole frame. Place earth fill around valve box concrete slab.

C. In unpaved areas, grade surface at uniform slope of 1 to 5 from manhole frame to natural grade. Provide minimum of 4 inches of topsoil conforming to requirements of Section 02911 - Topsoil. Provide seeding in accordance with Section 02921 – Hydro Mulch Seeding, or if sodding in accordance with Section 02922 - Sodding.

END OF SECTION

SECTION 02088

PRECAST POLYMER CONCRETE MANHOLES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Precast polymer concrete manholes for sanitary sewers, force mains and where corrosion resistant manholes are specifically indicated on Drawings.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01630 – Product Substitution Procedures

D. Section 02090 – Frames, Grates, Rings, And Covers

E. Section 02091 – Non Metallic Frames, Grates, Rings, And Covers

F. Section 02317 – Excavation and Backfill for Utilities

G. Section 02321 – Cement Stabilized Sand

H. Section 02533 – Acceptance Testing for Sanitary Sewers

I. Section 02911 – Topsoil

J. Section 02921 – Hydro Mulch Seeding

K. Section 02922 – Sodding

L. Section 03315 – Concrete for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Payment for normal depth manholes, up to 8 feet deep, is on a unit price basis for each manhole installed. Manhole depth is measured from top of cover to sewer invert. Air release manhole depth is measured from top of cover to inside base for air release or vacuum release manholes. Manholes for water lines are measured from top of cover to inside base of manhole.

2. Payment for shallow depth manholes is on a unit price basis for each manhole installed. Shallow manholes have a depth of 5 feet or less measured from top of cover to sewer invert.

3. Payment for extra depth manholes is on a unit price basis per vertical foot for each foot of depth greater than 8 feet. Sewer manhole depth is measured from top of cover to sewer invert. Air release manhole depth is measured from top of cover to inside base for air release or vacuum release manholes. Manholes for water lines are measured from top of cover to inside base of manhole.

4. Payment for standard manhole drops is on a unit price basis for each drop installed. Standard manhole drops include both internal and external drops.

5. Payment for watertight manholes, including external vent pipe is on a unit price basis for each.

6. Payment for air-release manhole with valves and fittings installed is on a unit price basis for each manhole with air-release valves and fittings installed.

7. Pay estimates for partial payments will be made as measured above according to the following schedule for sanitary sewer manholes:

   a. Estimate for 90 percent payment will be authorized when the manhole is completely installed and surrounding soil backfilled

   b. Estimate for 100 percent payment will be authorized when manhole has been tested as specified in Section 02533 - Acceptance Testing for Sanitary Sewers

8. Refer to Section 01270 - Measurement and Payment for unit price procedures

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASME B 16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. ASTM C 33 - Standard Specification for Concrete Aggregates.

C. ASTM C 78 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).

D. ASTM A 307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength.

E. ASTM C 443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.

F. ASTM C 478 - Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.

G. ASTM C 497 - Standard Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile.

H. ASTM C 890 - Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.

I. ASTM C 913 - Standard Specification for Precast Concrete Water and Wastewater Structures

J. ASTM C 923 - Standard Specifications for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.

K. ASTM D 6783 - Standard Specification for Polymer Concrete Pipe.

L. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3 (600 kN-m/m3))

M. ASTM D 2665 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste and Vent Pipe and Fittings

N. ASTM D 2996 - Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber- Reinforced Thermosetting-Resin) Pipe

O. ASTM D 2997 - Standard Specification for Centrifugally Cast “Fiberglass” (Glass-Fiber- Reinforced Thermosetting Resin) Pipe

P. American Association of State Highway and Transportation Officials (AASHTO)

Q. AWWA C 213 - Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer's data and details of following items for approval:

1. Shop drawings of manhole sections, base units and construction details, including reinforcement, jointing methods, materials and dimensions.

2. Summary of criteria used in manhole design including, as minimum, material properties, loadings, load combinations, and dimensions assumed. Include certification from manufacturer that precast manhole design is in full accordance with ASTM C 478 and design criteria as established in Paragraph 2.01E of this Specification.

3. Frames, grates, rings, and covers

4. Materials to be used in fabricating drop connections

5. Materials to be used for pipe connections at manhole walls

6. Materials to be used for stubs and stub plugs, if required

7. Plugs to be used for sanitary sewer hydrostatic testing

C. Seal submittal drawings by Professional Engineer registered in State of Texas.

PART 2 PRODUCTS

2.01 PRECAST POLYMER CONCRETE MANHOLES

A. Provide manhole sections, base sections, and related components conforming to testing and tolerance requirements of ASTM C 478. Provide adjustment rings which are standard components of manufacturer of manhole sections. Mark date of manufacture and name or trademark of manufacturer on inside of barrel.

B. Construct barrels for precast polymer manholes from standard reinforced polymer manhole sections of diameter indicated on Drawings. Use various lengths of manhole sections in combination to provide correct height with fewest joints. Design wall sections for depth and loading conditions in Paragraph 2.01 E, with minimum thickness of 2” for 48” diameter and 3” for 72” and larger. Base sections shall have a minimum thickness of 6 inches under invert. Manhole components shall be dense, non-porous, corrosion-resistant, and homogeneous. Manholes shall be reinforced per ASTM C 478. Manholes shall have a monolithic base slab unless otherwise approved. All manhole lifting devices shall be cast into the product during manufacturing.

C. Provide tops to support AASHTO M-306 loading, and receive manhole frame & covers, as indicated on Drawings.

D. Where manholes larger than 48-inch diameter are indicated on Drawings, provide precast base sections with flat slab top precast sections used to transition to 48-inch diameter manhole access riser section s. Transition can be concentric or eccentric unless otherwise shown on Drawings. Locate transition to provide minimum of 7-foot head clearance from base to underside of transition unless otherwise approved by Project Manager.

E. Design Loading Criteria: Manhole walls, transition slabs, cone tops, and manhole base slab shall be designed, by manufacturer, to requirements of ASTM C 478 for depth as shown on Drawings and to resist following loads.

1. AASHTO M-306 H-20 / HS-20 design live loading loads as referred to in AASHTO M- 306 applied to manhole cover and transmitted down to transition and base slabs

2. Unit soil weight of 120 pcf located above portions of manhole, including base slab projections

3. Lateral soil pressure based on saturated soil conditions producing an at-rest equivalent fluid pressure of 100 pcf

4. Internal liquid pressure based on unit weight of 63 pcf

5. Dead load of manhole sections fully supported by transition and base slabs

F. Design: Manhole walls, transition slabs, cone tops, and manhole base slab shall be designed according to requirements of ASTM C 478, ASTM C 890 and/or ASTM C 913 and following:

1. Design additional reinforcing steel to transfer stresses at openings. Area of steel to be no less than shown on Drawings.

2. Wall loading conditions:

a. Saturated soil pressure acting on empty manhole

b. Manhole filled with liquid to a halfway depth as measured from invert to cover, with no balancing external soil pressure

3. Minimum clear distance between two wall penetrations shall be 12 inches or half diameter of smaller penetration, whichever is greater

G. Provide joints between sections with rubber gaskets conforming to ASTM C 443.

H. Monolithic base sections shall have vertical reinforcing extend into the base slab section.

2.02 POLYMER CONCRETE

A. Resin: The manufacturer shall use only polyester or vinyl ester resin systems designed for use with this particular application. Resin content shall be a minimum of 7% by weight.

B. Filler: All aggregate, sand and quartz powder shall meet the requirements of ASTM C 33, where applicable.

C. Additives: Resin additives, such as curing agents, pigments, dyes, fillers and thixotropic agents, when used, shall not be detrimental to the manhole.

D. Polymer concrete compressive strength shall be a minimum of 9000 psi per ASTM C 497

E. Flexural strength shall be a minimum of 1000 psi per ASTM C 78.

F. No Portland cement shall be permitted in the concrete mix and all aggregates shall have a minimum acid insoluble content of 95%

2.03 REINFORCING STEEL

A. If reinforcing steel is used, conform to requirements of Section 03315 - Concrete for Utility Construction.

2.04 MISCELLANEOUS METALS

A. Provide frames, rings, and covers conforming to requirements of Section 02090 - Frames, Grates, Rings and Covers or Section 02091 – Non-Metallic Frames, Grates, Rings and Covers

2.05 DROP CONNECTIONS AND STUBS

A. Provide drop connections and stubs conforming to same pipe material requirements used in main pipe, unless otherwise indicated on Drawings.

2.06 PIPE CONNECTIONS TO MANHOLE

A. Sanitary Sewers

1. Provide resilient connectors conforming to requirements of ASTM C 923. Use the following materials for metallic mechanical devices as defined in ASTM C 923:

a. External clamps: Type 304 stainless steel

b. Internal, expandable clamps on standard manholes: Type 304 stainless steel, 11 gauge minimum.

c. Internal, expandable clamps where corrosion-resistance is required:

(1) Type 316 stainless steel, 11 gauge minimum

(2) Type 304 stainless steel, 11 gauge minimum, coated with minimum 16 mil fusion-bonded epoxy conforming to AWWA C 213

2. Where rigid joints between pipe and cast-in-place manhole base are specified or shown on Drawings, provide polyethylene-isoprene water-stop meeting physical property requirements of ASTM C 923, such as Press-Seal WS Series, or approved equal.

2.07 SEALANT MATERIALS

A. Approved products in accordance with Section 01630 - Product Substitution Procedures.

B. Sealing material between precast concrete adjustment ring and manhole, between each adjustment ring, and between adjustment ring and manhole cover frame shall be a hydrophilic elastic sealant, which adheres to both concrete and metal, or approved substitute.

C. Provide approved external sealing material from Canusa Wrapid Seal manhole encapsulation system, or approved equal.

D. Provide Butyl Sealant: Provide Press-Seal EZ Stick, or equal, for HDPE rings.

2.08 BACKFILL MATERIALS

A. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

2.09 EPOXY GROUT

A. All grout materials shall not contain any Portland cement and shall be an epoxy based material. Grout materials shall be approved by Project Manager prior to use.

2.10 VENT PIPES

A. Provide external vent pipes for manholes where indicated on Drawings.

B. Buried Vent Pipes: Provide 3 inch or 4 inch PVC DWV pipe conforming to ASTM D2665. Alternatively, provide FRP pipe as specified for vent outlet assembly.

C. Vent Outlet Assembly: Provide vent outlet assembly as shown on Drawings, constructed of following specified materials:

1. FRP Pipe: Provide filament wound FRP conforming to ASTM D 2996 or centrifugally cast FRP conforming to ASTM D 2997. Seal cut ends in accordance with manufacturer's recommendations.

2. Joints and Fittings: Provide epoxy bodied fittings and join pipe to fittings with epoxy adhesive

3. Flanges: Provide socket-flange fittings for epoxy adhesive bonding to pipe ends where shown on Drawings. Meet bolt pattern and dimensions for ASME B 16.l, 125- pound flanges. Flange bolts shall be Type 304 stainless steel or hot-dip zinc coated, conforming to ASTM A 307, Class A or B.

4. Coating: Provide approved 2-component, aliphatic polyurethane coating using primer or tie coat recommended by manufacturer. Provide two or more coats to yield dry film thickness of at least 3 mils. Color shall be selected by Project Manager from manufacturer's standard colors.

2.11 PROHIBITED MATERIALS

A. Do not use brick masonry for construction of sanitary storm sewer manholes, including adjustment of manholes to grade. Use only specified materials listed above.

2.12 MANHOLE LADDER FOR WATERLINE MANHOLES

A. Manhole Ladder: Fiberglass with 300-lb rating at appropriate length; conform to requirements of Occupational Safety and Health Standards (OSHA), U.S. Department of Labor except where shown on Drawings:

1. Use components, including rungs, made of fiberglass, fabricated with nylon or aluminum rivets and/or epoxy. Apply non-skid coating to ladder rungs. Mount ladder using manufacturer's recommended hardware.

2. Provide ladder as manufactured by Saf-Rail or approved equal. Locate ladder as shown on Drawings.

3. Fiberglass: Premium type polyester resin, reinforced with fiberglass; constructed to provide complete wetting of glass by resin; resistant to rot, fungi, bacterial growth and adverse effects of acids, alkalis and residential and industrial waste; yellow in color.

B. Provide approved petroleum-based tape encapsulating bolts in access manhole.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that lines and grades are correct.

B. Determine if subgrade, when scarified and recompacted, can be compacted to 95 percent of maximum Standard Proctor Density, at ±3% optimum moisture content according to ASTM D 698 prior to placement of foundation material and base section. If it does not meet the moisture-density requirement, condition the subgrade until the required moisture-density requirement is met or treat as an unstable subgrade.

C. Do not build manholes within top banks of ditches, swales, or drainage paths unless approved by Project Manager.

3.02 PLACEMENT

A. Install polymer concrete manholes to conform to locations and dimensions shown on Drawings.

B. Place sanitary and storm manholes at points of change in alignment, grade, size, pipe intersections, and end of sewer unless otherwise shown on Drawings.

3.03 MANHOLE BASE SECTIONS AND FOUNDATIONS

A. Place precast base on 12 inch thick (minimum) foundation of crushed stone wrapped in filter fabric, cement stabilized sand, or concrete foundation slab. Compact cement-sand in accordance with requirements of Section 02321 - Cement Stabilized Sand.

B. Unstable Subgrade Treatment: When unstable subgrade is encountered, notify Project Manager for examination of subgrade to determine if subgrade has heaved upwards after being excavated. When heaving has not occurred, over-excavate subgrade to allow for 24- inch-thick layer of crushed stone wrapped in filter fabric as foundation material under manhole base. When there is evidence of heaving, provide pile-supported concrete foundation, as detailed on Drawings, under manhole base.

C. For manholes located over large diameter water lines, place precast base on a foundation of cement stabilized sand extending from bottom of manhole to bottom of trench. Manhole base is to be a minimum of 12-inches above water line.

3.04 PRECAST MANHOLE SECTIONS

A. Install sections, joints, and gaskets in accordance with manufacturer's printed recommendations.

B. Install adjustment rings above tops of cones or flat-top sections as required to adjust finished elevation and to support manhole frame.

C. Place at least two corrosion resistant precast concrete or polymer concrete grade rings with thickness of 12 inches or less, under casting.

3.05 PIPE CONNECTIONS AT MANHOLES

A. Install approved resilient connectors at each pipe entering and exiting manholes in accordance with manufacturer's instructions.

1. Where smooth exterior pipes, i.e. steel, ductile iron, or PVC pipes are connected to manhole base or barrel, space between pipe and manhole wall shall be sealed with an assembly consisting of rubber gaskets or links mechanically compressed to form watertight.

2. When connecting concrete or cement mortar coated steel pipes, or as an option for connecting smooth exterior pipes to manhole base or barrel, space between pipe and manhole wall may be sealed with an assembly consisting of stainless steel power sleeve, stainless steel take-up clamp. Provide PSX positive seal or Direct Drive by Press Seal Gasket Corporation or approved equal.

B. Ensure no concrete, cement stabilized sand, fill, or other rigid material is allowed to enter the space between pipe and edge of wall opening at and around resilient connector on either interior or exterior of manhole. If necessary, fill space with a compressible material to ensure full flexibility provided by the resilient connector.

C. Where new manhole constructed on existing sewer, rigid pipe joint may be used. Install waterstop gasket around existing pipe at center of cast-in-place wall. Join ends of spilt waterstop material at pipe springline using an adhesive recommended and supplied by waterstop manufacturer.

D. Test connection for watertight seal before backfilling.

3.06 INVERTS FOR SANITARY SEWERS

A. Construct invert channels to provide smooth flow transition waterway with no disruption of flow at pipe-manhole connections. Conform to following criteria:

1. Slope of invert bench: 1 inch per foot minimum; 1-1/2 inches per foot maximum

2. Depth of bench to invert shall be at least equal to the largest pipe diameter.

3. Invert slope through manhole: 0.10 foot drop across manhole with smooth transition of invert through manhole, unless otherwise indicated on Drawings.

B. Form invert channels with concrete if not integral with manhole base section. For direction changes of mains, construct channels tangent to mains with maximum possible radius of curvature. Provide curves for side inlets and smooth invert fillets for flow transition between pipe inverts.

3.07 DROP CONNECTIONS FOR SANITARY SEWERS

A. Backfill drop assembly with crushed stone wrapped in filter fabric, cement stabilized sand, or Class A concrete to form solid mass. Extend cement stabilized sand or concrete encasement minimum of 4 inches outside bells.

B. Install drop connection when sewer line enters manhole higher than 24 inches above invert of manhole.

3.08 STUBS FOR FUTURE CONNECTIONS

A. In manholes, where future connections are indicated on Drawings, install resilient connectors and pipe stubs with approved watertight plugs.

3.09 MANHOLE FRAME AND ADJUSTMENT RINGS

A. Combine precast concrete or HDPE adjustment rings so elevation of installed casting cover matches pavement surface. Seal between concrete adjustment ring and precast top section with non-shrink grout; do not use mortar between adjustment rings. Apply latex-based bonding agent to precast concrete surfaces joined with non-shrink grout. Set cast iron frame on adjustment ring in bed of approved sealant material. Install sealant bed consisting of two beads of sealant, each bead having minimum dimensions of 1/2-inch and 1/2-inch wide.

B. Wrap manhole frame and adjustment rings with external sealing material, minimum 3 inches beyond joint between ring and frame and adjustment rings and precast section.

C. For manholes in unpaved areas, set top of frame minimum of 6 inches above existing ground line unless otherwise indicated on Drawings. In unpaved areas, encase manhole frame in mortar or non-shrink grout placed flush with face of manhole ring and top edge of frame. Provide rounded corner around perimeter.

3.10 BACKFILL

A. Place and compact backfill materials in area of excavation surrounding manholes in accordance with requirements of Section 02317 - Excavation and Backfill for Utilities. Provide embedment zone backfill material, as specified for adjacent utilities, from manhole foundation up to an elevation 12 inches over each pipe connected to manhole. Provide trench zone backfill, as specified for adjacent utilities, above embedment zone backfill.

B. Where rigid joints are used for connecting existing sewers to manhole, backfill under existing sewer up to springline of pipe with Class B concrete or flowable fill.

C. In unpaved areas, provide positive drainage away from manhole frame to natural grade. Provide minimum of 4 inches of topsoil conforming to requirements of Section 02911 - Topsoil. Seed in accordance with Section 02921 - Hydromulch Seeding. When shown on Drawings, sod disturbed areas in accordance with Section 02922 - Sodding.

3.11 FIELD QUALITY CONTROL

A. Conduct leakage testing of sanitary sewer manholes in accordance with requirements of Section 02533 - Acceptance Testing for Sanitary Sewers.

3.12 PROTECTION

A. Protect manholes from damage until work has been accepted. Repair damage to manholes at no additional cost to City.

END OF SECTION

SECTION 02090

FRAMES, GRATES, RINGS, AND COVERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Iron castings for manhole frames and covers, inlet frames and grates, catch basin frames and grates, meter vault frames and covers, adjustment rings, and extensions.

B. Ring grates.

C. Trench Drainage.

D. Tree Grates.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for frames, grates, rings, covers, and seals under this Section. Include payment in unit price for related item.

2. Payment to rack over existing manhole is on a unit price basis for each manhole.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AASHTO Standard Specifications for Highway Bridges.

B. AASHTO M 306 - Standard Specification for Drainage, Sewer, Utility, and Related Castings.

C. AASHTO M 105 - Standard Specification for Gray Iron Castings.

D. ASTM A 536 - Standard Specification for Ductile Iron Castings.

E. ASTM A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

F. AWS - D 1.4 - Structural Welding Code – Steel Reinforcing Bars.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit copies of manufacturer's specifications, load tables, dimension diagrams, anchor details, and installation instructions.

C. Submit shop drawings for fabrication and installation of casting assemblies that are not included in Drawings or standard City of Houston details. Include plans, elevations, sections and connection details. Show anchorage and accessory items. Include setting drawings for location and installation of castings and anchorage devices.

PART 2 PRODUCTS

2.01 CASTINGS

A. All castings shall be made from gray cast iron conforming to the requirements of AASHTO M 105 class 35b or ductile iron conforming to the requirements ASTM A 536 70-50-05.

B. Castings intended for traffic service shall be clean castings capable of withstanding an application of 40,000 pound proof load as described in Section 5 of AASHTO M 306 (includes items such as frames, grates, rings, covers, trench drainage, etc.)

C. Fabricate castings to conform to shapes, dimensions, and with wording or logos shown on Drawings.

D. All castings shall be manufactured in accordance with the requirement of Section 4 of AASHTO M 306.

E. Unless otherwise indicated, all gray iron castings shall be provided uncoated.

F. Each individual casting shall include all markings as shown on the specification drawings and shall be identified by the producing foundry showing the following: Name of producing foundry; country of manufacturer preceded by the words "Made in," such as "Made in USA"; material designation, heat identification and cast date (MM/DD/YY), casting lettering as required by the purchaser. If a casting is melted and poured at one foundry and labeled with the name of another organization, manufacturer, or foundry the casting shall include the name of the producing foundry and the organization the casting is produced for. The name of the producing foundry and the organization the product is made for shall have lettering of equal size, be in close proximity to each other, and be easily identified from the same side of the casting. The casting shall also include any additional markings as required in Section 9 of AASHTO M 306 and Section 17 of AASHTO M 105.

2.02 TESTING REQUIREMENTS

A. Testing shall be performed in accordance with the following inspection criteria unless otherwise specified in the contract or purchase order. The manufacturer/supplier shall be responsible for carrying out all of the required tests and inspections. All testing shall be conducted in the United States using purchaser approved reliable facilities. The manufacturer/supplier shall maintain complete records of all such tests and inspections. All testing shall be paid for by the manufacturer/supplier.

B. The manufacturer shall report and certify material information obtained from separately cast test bars. If there are more than three test bar failures in a calendar year the manufacturer shall report this to the purchaser and shall discontinue supplying product. In order to resume supplying product, documentation that a new Quality System is in place to ensure material compliance must be submitted to and accepted by the purchaser.

2.03 SPECIAL FRAMES AND COVERS

A. Where indicated on Drawings, provide watertight manhole frames and covers with minimum of four bolts and gasket designed to seal cover to frame. Supply approved watertight manhole covers and frames.

B. Where shown on Drawing, provide manhole frames and covers with 48-inch diameter clear opening, with inner cover for 22-inch diameter clear opening. Provide approved inner cover with pattern shown on Drawings.

C. Where indicated on Drawings provide security enabled covers or grates, to be secured with the addition of Cam locks and lock lugs to inhibit opening and removal of cover or grate without proper authorized tool. Supply approved security feature Frames, Cover or Grates.

2.04 FABRICATED RING GRATES

A. Fabricate ring grates from reinforcing steel conforming to ASTM A 615.

B. Conform to welds connecting bars to AWS D 1.4.

C. Fabricate ring grates in accordance with City of Houston standard detail, “Ring Grate for Open End of 18 Inch to 72 Inch RCP Stubs to Ditch”.

2.05 ADJUSTMENT RINGS FOR ASPHALT OVERLAYS

A. Use castings conforming Paragraph 2.01.

B. One piece casting with dimensions to fit frame and cover.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install castings according to approved shop drawings, instructions in related specifications, and applicable directions from manufacturer's printed materials.

B. Set castings accurately at required locations to proper alignment and elevation. Keep castings plumb, level, true, and free of rack. Measure location accurately from established lines and grades. Brace or anchor frames temporarily in form work until permanently set.

C. Set in mortar in mouth of pipe bell.

D. Install adjustment rings in existing frames with clean bearing surfaces that are free from rocking.

END OF SECTION

SECTION 02091

NON METALLIC FRAMES, GRATES, RINGS, AND COVERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Manhole frames and covers, inlet frames and grates, catch basin frames and grates, meter vault frames and covers, adjustment rings, and extensions, ring grates, and trench drainage, for application in wastewater collection system and facilities.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for frames, grates, rings, covers, and seals under this Section. Include payment in unit price for related item.

2. Payment to rack over existing manhole is on a unit price basis for each manhole.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AASHTO M 306 – Standard Specification for Drainage, Sewer, Utility, and Related Castings

B. AASHTO - Standard Specifications for Highway Bridges

C. ASTM A 36 - Standard Specification for Carbon Structural Steel

D. ASTM A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

E. ASTM C 501 - Standard Test Method for Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser

F. ASTM D 2240 - Standard Test Method for Rubber Property—Durometer Hardness

G. ASTM G 154 - Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials.

H. ASTM E 303- Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester

I. AWS D1.1 - Structural Welding Code - Steel

J. TCEQ Chapter 217 Design Criteria for Domestic Wastewater Systems Section 217.55 Manhole Covers

K. OSHA Occupational Safety and Health Standards

L. EPA Environmental Protection Agency

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit copies of manufacturer's specifications, testing data, certifications, load tables, dimension diagrams, anchor details, and installation instructions.

C. Submit shop drawings for fabrication and installation of casting assemblies that are not included in Drawings or standard City of Houston details. Include plans, elevations, sections and connection details. Show anchorage and accessory items. Include setting drawings for location and installation of castings and anchorage devices.

PART 2 PRODUCTS

2.01 MANHOLE RING AND COVER

A. All rings and covers units shall be made from high strength nonmetallic fiber reinforced polymer /composite materials. The material shall be a resin thermoset matrix that can be reinforced with continuous filament engineered fabrics, fiber rovings, short fiber filaments, or equivalent nonmetallic reinforcing structure(s). Seatings shall be encapsulated or bonded with a continuous dampener to reduce wear, shock, noise, malodors and infiltration.

B. Rings and covers intended for traffic service shall be capable of withstanding AASHTO M 306: Proof Testing (includes items such as frames, grates, rings, covers, trench drainage, etc.).

C. Fabricate rings and covers to conform to shapes, dimensions, and with wording or logos shown on Drawings.

D. All rings and covers shall be manufactured in accordance with the requirements of AASHTO M 306.

E. Covers shall be provided with a positive lock mechanism as shown on City of Houston Standard Detail for Non-Metallic Covers. Lock will have indicators to show when Lock is fully engaged. Other equivalent locking mechanisms must be approved by the City of Houston.

2.02 TESTING AND PERFORMANCE REQUIREMENTS

A. Testing shall be performed in accordance with the following inspection criteria unless otherwise specified in the contract or purchase order. The manufacturer/supplier shall be responsible for carrying out all of the required tests and inspections. All testing shall be conducted in the United States using purchaser approved reliable facilities. The manufacturer/supplier shall maintain complete records of all such tests and inspections. All testing shall be paid for by the manufacturer/supplier.

B. Frames and Covers shall be "Proof Tested" in accordance with AASHTO M 306.

C. Heavy Duty: A load of 40,000 lbs shall be concentrated on a 9" x 9" block with rubber or fiber backing pad for one minute. During the load testing process visible cracks or delamination will be cause for rejection. When load is removed, Permanent Set (Deflection) of more than 1/8-inch (0.125-inch) measured at center of load area will be cause for rejection. All testing shall be conducted on a NIST calibrated and Certified load test machine.

D. Ultraviolet resistance: ASTM G 154 Cycle 1 for 1000 hrs. Specimens shall be tested for ultimate flexural strength, retaining at least 75% of control values for load and deflection at failure.

E. Skid resistance: Measure skid resistance in accordance with ASTM E 303. A pendulum test value of at least 50 is required.

F. Wear and Abrasion: Shall be tested in accordance with ASTM C 501, Test shall be 1000 cycles of a H22 wheel with 1000g load. Wear Index is calculated 88/ Weight Loss (grams). The average of four test cycles shall have a calculated wear index of >300.

G. At the request of the Project Manager, the quality process manual shall be available for review, manufacturing facility shall also be available for inspection to ensure quality standards are met along with EPA and OSHA standards.

2.03 FABRICATED RING GRATES

A. Fabricate ring grates from reinforcing steel conforming to ASTM A 36.

B. Conform to welds connecting bars to AWS D 1.1.

C. Fabricate ring grates in accordance with City of Houston standard detail, "Ring Grate for Open End of 18 Inch to 72 Inch RCP Stubs to Ditch".

2.04 GRADE ADJUSTMENT RINGS

A. Conform to Paragraph 2.01.

B. One piece unit with dimensions to fit frame and cover.

C. Physical properties shall comply with ASTM D 2240 with a Shore Durometer of 77A ±5.

D. Adjustment Risers shall be of uniform quality, free from cracks, holes, and any other surface debris. Riser rings shall be available in ½-inch height increments. Molded adjustment risers tolerance shall be ±1/16-inch (1.6mm) from required nominal dimensions. Adjustment Risers shall be designed for heavy duty street traffic, and meet or exceed minimum load capacity requirements of AASHTO M 306.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install castings according to approved shop drawings, instructions in related specifications, and applicable directions from manufacturer's printed materials.

B. Set units accurately at required locations to proper alignment and elevation. Keep units plumb, level, true, and free of rack. Measure location accurately from established lines and grades. Brace or anchor frames temporarily in form work until permanently set.

C. Set in mortar in mouth of pipe bell.

D. Install adjustment rings in existing frames with clean bearing surfaces that are free from rocking.

END OF SECTION

SECTION 02136

WASTE MATERIAL HANDLING, TESTING AND DISPOSAL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Handling, testing and disposal of hazardous and non-hazardous waste material.

B. Material present inside of existing tanks to be repaired or demolished, i.e., silt, sludge and other residue deposits generated by normal water production usage of the tanks.

C. Existing coatings removed from existing tanks.

D. Spent abrasives used and debris generated in the execution of the work.

E. All spent thinners, coating materials or other products brought on site for execution of work that require disposal as a hazardous or non-hazardous waste.

F. Soil that may be contaminated due to the execution of the work.

G. Petroleum soaked sand foundation material removed from demolished tank sites.

1.02 RELATED SECTIONS

A. Section 01110 – Summary of Work

B. Section 01270 – Measurement and Payment

C. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. No separate measurement and payment will be made for handling, testing or disposal of non- hazardous or hazardous material, debris or material identified as contaminated material on the site prior to the bid date except as indicated in section 1.03 B and 1.03 C. The Contractor shall include the cost for this work in the Contract bid price for work of which this is a component part.

B. Payment for hazardous waste material handling, removal, testing, transporting and disposal of material identified as hazardous after the bid date will be paid for at the unit price bid for "Hazardous Waste Handling, Removal, Transporting" if such an item is provided in the contract.

C. Removal and disposal of potentially petroleum soaked sand foundation material will be measured per cubic yard which shall include testing, removing, storing, transporting and disposing of material and will be paid for at the unit price bid for "Removal and Disposal of Potentially Petroleum Soaked Sand". Basis of payment will be Class I Industrial Waste having a Total Petroleum Hydrocarbon (TPH) level greater than 1500 ppm.

D. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

The following is a list of applicable requirements to this project. It is not intended to be a complete listing of all laws and regulations to which the Contractor must comply.

A. Environmental Protection Agency - Code of Federal Regulations

1. 40 CFR Part 261 - Identification and Listing of Hazardous Waste

2. 40 CFR 261, Appendix II EPA - Toxicity Characteristic Leaching Procedure

3. 40 CFR Part 262 - Standards Applicable to Generators of Hazardous Waste

4. 40 CFR Part 263 - Standards Applicable to Transporters of Hazardous Waste

5. 40 CFR Part 264 - Standards for Owner and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities

6. 40 CFR Part 265 - Interim Status for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities

7. 40 CFR 265, Subpart C EPA - Preparedness and Prevention

8. 40 CFR 265, Subpart D EPA - Contingency Plan and Emergency Procedures

9. 40 CFR 265.16 EPA - Personnel Training

10. 40 CFR Part 268 - Land Disposal Restrictions

11. 49 CFR Parts 173 – Shippers – General Requirements for Shipments and Packaging’s

12. 49 CFR Part 178 – Specifications for Packaging’s

13. 49 CFR Part 179 – Specifications for Tank Cars

14. 40 CFR Part 355 - Emergency Planning and Notification

B. EPA Methods

1. 3050 - Acid Digestion of Sediment, Sludge, and Soils

2. SW 846 - Test Methods for Evaluating Solid Waste - Physical/Chemical Methods

C. Texas Commission on Environmental Quality

1. TAC Title 30, Chapter 305 "Consolidated Permits"

2. TAC Title 30, Chapter 335 "Industrial Solid Waste and Municipal Hazardous Waste"

3. TAC Title 30, Chapter 343 "Oil and Hazardous Substances"

D. TWC Technical Guidelines

1. Document #1, Waste Evaluation/Classification

E. NIOSH Methods

1. 7082 LEAD by Flame AAS

F. Society for Protective Coatings

1. SSPC 91-18 - Industrial Lead Paint Removal Handbook

2. Guide 6 - Guide for Containing Surface Preparation Debris Generated During Paint Removal Operations

3. Guide 7 - Guide for the Disposal of Lead Contaminated Surface Preparation Debris

1.05 SUBMITTALS

A. Submittals shall conform to requirements of Section 01330 – Submittal Procedures.

B. Submittals shall conform to appropriate codes for regulatory requirements.

C. Obtain and submit disposal permits for proposed disposal sites, if required by local ordinances.

1.06 TESTING AND IDENTIFICATION

A. The Owner is the Generator of the debris for permitting purposes, and will obtain the EPA Identification number, but the Contractor is responsible for assuring that all testing, handling, storage, transportation, and disposal requirements are properly implemented, including satisfactory training of job site personnel and the cleaning of all reusable items and equipment prior to removal from the site.

B. Prior to the bid date, if testing has been performed by the City and if hazardous material has been identified in the debris material in an existing tank, the paint to be removed from an existing tank, the work site soil, or the foundation material, the material or test results will be indicated in Section 01110 – Summary of Work. It is the responsibility of the Contractor to properly test and to determine if any wastes generated as a result of this project are hazardous in accordance with 40 CFR Part 261.

1.07 DEFINITIONS

(Note Definitions applicable to this section are also presented elsewhere.)

A. Hazardous Waste (lead paint debris): Waste that is classified as hazardous due to its concentrations of regulated hazardous substances. Paint debris is classified as hazardous waste if, after testing by the Toxicity Characteristic Leaching Procedure (TCLP), the leachate contains any of the 8 metals or other substances in concentrations at or above limits established in 40 CFR 261.

B. Lead Containing Dust and Debris: Dust and debris generated during the project which contains lead in any amount, including but not limited to pulverized paint, spent abrasive, filters (wet and dry), and containment materials upon which lead is still present.

C. RCRA: Resource Conservation and Recovery Act. Federal law pertaining to hazardous waste management. EPA implementing regulations are contained in 40 CFR 240-280.

D. TACB: Texas Air Control Board. Texas State Agency joined into the TCEQ and responsible for writing and enforcement of rules and regulations relating to air quality.

E. TCEQ: Texas Commission on Environmental Quality. State of Texas Commission responsible for planning, oversight, monitoring and management of natural resources.

F. TCLP: Toxicity Characteristic Leaching Procedure. Laboratory tests conducted on wastes that determine the amount of hazardous materials that leach out into a test solution. The test is intended to simulate the properties of water as it leaches through a solid waste landfill. TCLP testing is defined in 40 CFR 261, Appendix II.

G. TWC: Texas Water Commission. Texas State Agency joined into the TCEQ and responsible for writing and enforcement of rules and regulations relating to water quality and solid waste programs.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 WASTE HANDLING AND STORAGE

A. All chemicals to be brought on site by the contractor must be stored and used in a safe and proper manner in accordance with all applicable Federal, State and local laws and regulations as well as the manufacturers recommendations. Material Safety Data Sheets (MSDSs) shall be maintained on-site for all hazardous chemicals used.

B. Hazardous wastes are to be handled and stored according to the requirements of TAC 30 Chapter 335 "Industrial Solid Waste and Municipal Hazardous Waste" and 40CFR Part 262, with regard to on-site storage, and 40CFR Part 264 with regard to required notices, site security, personnel training, contingency planning and emergency procedures, recordkeeping and reporting, time of storage, amount of material stored, and use of proper containers. Hazardous waste will be stored in covered containers in accordance with the requirements of 40 CFR 262 and 49 CFR 172,178 and 179.

C. The contractor shall provide proper, segregated storage for hazardous and non-hazardous materials to be used in the work area in order to ensure safe work conditions.

D. All material, waste and debris from removal of lead containing coatings, including those products and materials employed for chemical paint stripping, shall be considered hazardous waste and handled accordingly, until such time that testing and analysis indicates otherwise.

1. Sampling of materials for TCLP testing of initial containers of debris shall be completed prior to or during filling. Until the TCLP test results are received, the containers shall be labeled as lead-containing debris. Hazardous waste labels shall be applied after the test results are received, if the debris tests hazardous.

2. Hazardous waste shall not be stored at the project site for more than 90 days. Non- hazardous wastes shall be removed at a minimum of once per month (30 days).

3. Special attention shall be given to the time of storage, storage conditions, amount of material stored at any one time, use of proper containers, and personnel training.

E. Hazardous waste shall be placed on pallets over protected ground, be located in a secure area enclosed by a fence with signs around the perimeter, and be shielded adequately to prevent dispersion of the waste by wind or water. Under no circumstances shall the waste be stored within a flood plain area. Any evidence of improper storage shall be cause for immediate shutdown of the project until corrective action is taken. The storage area shall be within a security fence with a locked gate.

3.02 ENVIRONMENTAL CONTAMINATION

A. The contractor shall not contaminate the air, soils or surface and ground waters with any hazardous waste. Spills, releases and discharges of hazardous or toxic materials which inadvertently occur shall be reported in accordance with 40 CFR 265 and TAC 30 Chapter 343.

B. Contingency Plan and Training: The Contractor shall comply with TCEQ Title 30 Regulations and EPA 40 CFR 265, Subpart C in the event of a spill or release of waste, EPA 40 CFR 265 Subpart D, and TCEQ regulations.

C. All personnel associated with the handling of hazardous waste shall complete a formal training program in accordance with 40 CFR 265.16 and TCEQ Title 30 Regulations. Training records of all employees must be maintained and kept on file.

3.03 WASTE CLASSIFICATION

A. Testing

1. All solid waste generated by the paint removal activities shall be tested in accordance with 40 CFR 261, Appendix II, Method 1311 Toxicity Characteristic Leaching Procedure (TCLP), to determine if it is hazardous.

2. In the case of wet methods of preparation, the use of chemical strippers, or containerized hygiene water, all liquids and sludge shall also be tested. When chemical strippers are used, the testing shall include pH to determine corrosivity. All waste water shall be tested for total lead.

3. Representative samples of the debris for each waste stream generated from the work on this project shall be collected. A minimum of four of the samples representative of each waste stream shall be analyzed to establish a waste is non-hazardous. Note that more than four initial samples of each waste stream shall be collected in order to obtain the four representative samples for analysis. Results from one test sample are sufficient to identify a waste as hazardous.

4. The collection of the initial representative samples of each waste stream and selection of the minimum of four for testing shall be accomplished using a random sampling technique and shall comply with the following: a minimum of one representative sample for each 55 gallons of waste, or a minimum of four representative samples for each gondola or roll-off box of waste. Samples shall be collected in accordance with SW-846, "Test Methods for Evaluating Solid Waste - Physical/ Chemical Methods".

5. Sampling and testing shall be performed by a certified laboratory acceptable to the Owner. The name, address, and qualifications of the laboratory shall be provided for approval. The Owner shall be provided with copies of the test results as soon as they are received by the Contractor.

B. Classification

1. Lead paint debris is classified as hazardous waste if, after testing by TCLP, the leachate contains any of the 8 metals or other hazardous substances in concentrations at or above limits established in 40 CFR 261:

Arsenic -	5.0 mg/L
Barium -	100.0 mg/L
Cadmium -	1.0 mg/L
Chromium -	5.0 mg/L
Lead -	5.0 mg/L
Mercury -	0.2 mg/L
Selenium -	1.0 mg/L
Silver -	5.0 mg/L

2. The above includes only the eight (8) characteristic metals listed by EPA among which are elements typically associated with paints. Other substances may be present which may cause debris to be classified as hazardous waste as defined in 40 CFR 261 (such as a pH<=2.0 or >=12.5 resulting in corrosivity), and must be taken into account.

3.04 DISPOSAL

A. The contractor shall arrange to have wastes and debris transported from the site in accordance with all City Ordinances and State and Federal Laws. If wastes and/or debris is determined to be hazardous, transporting to be in accordance with TAC 30 Chapter 335 -Industrial Solid Waste and Municipal Hazardous Waste, 40CFR Part 263 - Standards Applicable to Transporters of Hazardous Waste and the applicable sections of 49 CFR Parts 171 through 179.

B. Manifest and Reporting: The Contractor shall comply with all of the manifesting, certification, and reporting requirements of EPA 40 CFR 262, 40 CFR 268, and Texas regulations, including certificates of final disposal for each shipment.

C. Copies of all records and reports, test sample chain of custody forms, TCLP and other test results shall be provided to the Owner.

D. The contractor shall dispose of wastes and debris at a licensed site acceptable to the Owner. Hazardous wastes and debris shall be disposed of in accordance with 40CFR Part 265 and 40CFR Part 268 Land Disposal Restrictions. Manifesting of hazardous wastes shall be in accordance with 40CFR Part 262, Subpart B.

E. Wastewater resulting from surface preparation, washing, personal hygiene or decontamination shall not be discharged without testing and through arrangement with the local Publicly Owned Treatment Works (POTW) or other approved means.

END OF SECTION

SECTION 02201

SITE PREPARATION, GRADING, RESTORATION AND CLEAN UP FOR WATER STORAGE TANKS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This Section covers the clearing, grubbing, grading, final clean-up, and restoration of the site in preparation for hydro mulch or sodding and move out.

1.02 RELATED SECTIONS

A. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. No separate measurement and payment for worked performed under this Section. The Contractor shall include the cost for this work in the contract bid price for work of which this is a component part.

1.04 REFERENCES

A. Federal Seed Act Regulations (Department of Agriculture)

1.05 SUBMITTALS

A. Submit product data in accordance with Section 01330 - Submittal Procedures.

B. Submit seed to engineer for approval. Submit certification from supplier that each type of seed conforms to these specifications and the requirements of the Texas Seed Law. Certification shall accompany seed delivery.

C. Submit a certificate stating that fertilizer complies with these specifications and the requirements of the Texas Fertilizer Law.

1.06 SEQUENCE OF WORK

A. Restoration of each site shall be completed immediately after all tank work is completed and the tank has been tested and returned to service.

B. After obtaining approval from the City Engineer of satisfactory site restoration, Contractor shall hydro mulch all areas disturbed during construction. The hydro mulch seeding requirements, together with other necessary related work, shall conform to the requirements of this Section.

C. All fences, walks, driveways or other permanent facilities are to be completed in place before the finished hydro mulch is applied.

PART 2 PRODUCTS

2.01 MATERIALS

A. All seed must meet the requirements of U.S. Department of Agriculture Rules and Regulations as set forth in Federal Seed Act and Texas Seed Law. Type of seed, purity and germination requirements, date of application and planting dates are as follows:

Type	Application Rate Pounds per Acre	Planting Date
Hulled Common Bermuda to Grass 98/88	40	January 1 April 15
Unhulled Common Bermuda Grass 98/88	40	
Annual Rye Grass (Gulf)	50	
Hulled Common Bermuda to Grass 98/88	40	April 15 October 1
Unhulled Common Bermuda Grass 98/88	40	
Annual Rye Grass	40	

B. Fertilizer:

1. Fertilizer shall be water soluble with analysis of 10% nitrogen, 20% phosphoric acid and 10% potash. Rate of application shall be 750 pounds per acre except during the period of April 15 through September 1, when the rate shall be reduced to 600 pounds per acre.

C. Mulch:

1. Mulch shall be virgin wood cellulose fiber made from whole wood chips.

2. Within the fiber material at least 20% of the fibers will be 10.7 mm in length and 0.27 mm in diameter. Rate of application shall be 2000 pounds per acre. Soil stabilizers such as Terra type III, (or approved equal) shall be applied at a rate of 40 pounds per acre in the flatter portions of the disturbed areas.

PART 3 EXECUTION

3.01 DESCRIPTION

A. The work covered by this Section consists of furnishing all labor, materials, equipment, supplies, supervision, tools, and performing all work necessary for clearing and protection of facilities during construction and top soiling, finish grading, seeding, fertilizing, watering, maintenance, and clean-up of disturbed areas within the individual water plant areas at the completion of work, in accordance with these specifications and as shown on drawings.

B. Fences shall be relocated or installed as shown on drawings. All damage to existing fencing occurring during construction activities shall be repaired or replaced at the Contractor's expense to a condition equal to or better than existing prior to such damage. Fencing relocated for the convenience of accommodating construction activities shall be returned to its original location at the completion of the work.

C. Silt fencing and four (4) foot safety fencing is to be installed as indicated on the plans.

D. All sites shall be restored to a condition equal to or better than that existing prior to construction activities. All holes and open excavations shall be filled and compacted to the density of the surrounding area. Level all washes, ruts, depressions, and mounds to provide a smooth finish with no large debris, dirt clods, or lumps of size that would interfere with the operation of a standard rotary lawnmower.

3.02 MAINTENANCE

A. The hydro mulch seeding shall be adequately watered until established. Any areas damaged by erosion or areas that do not have acceptable turfing shall be reapplied to the satisfaction of the Engineer.

END OF SECTION

SECTION 02221

REMOVING EXISTING PAVEMENTS, STRUCTURES, WOOD, AND DEMOLITION DEBRIS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Removing concrete paving, asphaltic concrete pavement, brick pavement and base courses.

B. Removing concrete curbs, concrete curbs and gutters, sidewalks and driveways.

C. Removing pipe culverts, sewers, and sewer leads.

D. Removing waterlines and water services lines including asbestos cement pipe per OSHA guidelines.

E. Removing existing inlets and manholes.

F. Removing and disposing of pre-stressed concrete beams and drill shafts.

G. Removing miscellaneous structures of concrete or masonry.

H. Removing existing bridge.

I. Removing existing wood and demolition debris.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01576 – Waste Material Disposal

C. Section 02316 – Excavation and Backfill for Structures

D. Section 02960 – Milling Pavement

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for removing and disposing of asphaltic surfacing with or without base, regardless of thickness encountered, is on square yard basis measured between lips of gutters.

2. Payment for removing and disposing of reinforced concrete pavement, with or without asphalt overlay, regardless of its thickness, is on square yard basis measured from back- to-back of curbs. Payment includes concrete pavement, esplanade curbs, curbs and gutters, and paving headers.

3. Payment for removing and disposing of curb or curb and gutter without removal of pavement is on a linear foot basis, if only curb or curb and gutter is being removed and disposed.

4. Payment for removing and disposing of cement stabilized shell base course, with or without asphaltic surfacing, is on square yard basis.

5. Payment for removing and disposing of concrete sidewalks and driveways is on square yard basis. Include removal and disposal of curb ramps in the cost for removal of sidewalks.

6. Payment for removing asphaltic pavement surface by milling shall be in accordance with Section 02960 – Milling Pavement.

7. Payment for removing and disposing of miscellaneous concrete and masonry is on cubic yard basis of structure in place.

8. Payment for removing and disposing of pipe culverts, sewers, and sewer leads, is on linear foot basis for each diameter and each material type of pipe removed.

9. Payment for removing and disposing of waterlines and water service lines including asbestos cement pipe is on linear foot basis for each diameter pipe and each material type of pipe removed.

10. Payment for removing and disposing of existing inlets is on unit price basis for each inlet removed.

11. Payment for removing and disposing of prestressed concrete piles and drill shafts is on linear foot basis.

12. Payment for removing and disposing of existing bridge, including piles and abutments to minimum of 4 feet below ground level, is on a lump sum basis.

13. Payment for removing existing pole foundations, including traffic signal pole foundations to minimum of 2 feet below grade, is on a unit price basis for each pole foundation removed.

14. Payment for removing and disposing of existing manholes is on unit price basis for each manhole removed.

15. Payment for removing and disposing of miscellaneous wood and demolition debris is on cubic yard basis.

16. Payment for removing and disposing of existing wheelchair ramps, except for concrete curb ramps, of any thickness is on square yard basis.

17. No payment for saw cutting of pavement, curbs, or curbs and gutters will be made under this section. Include cost of such work in unit prices for items listed in bid form requiring saw cutting.

18. No payment will be made for work outside maximum payment limits indicated on Drawings, or for pavements or structures removed for Contractor's convenience.

    a. For utility installations: Match actual pavement replaced but no greater than maximum pavement replacement limits shown on Drawings. Limits of measurement will be as shown on Street Cut Pavement Replacement Rules.

19. Refer to Section 01270 - Measurement and Payment for unit price procedures

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. EPA 40 CFR 763 – Asbestos

B. EPA 40 CFR 61, Subpart M – National Emission Standard for Asbestos

C. OSHA 29 CFR 1926.1101 – Asbestos

D. OSHA 29 CFR 1926.32 – General Safety and Health Provisions

E. OSHA 29 CFR 1910.134 – Respiratory Protection

F. National Institute of Occupational Safety and Health (NIOSH)

1.05 REGULATORY REQUIREMENTS

A. Conform to applicable codes for disposal of debris.

B. For removal of asbestos containing materials, or material that could potentially contain asbestos, comply with applicable provisions of OSHA 29 CFR 1926.1101 – Asbestos, OSHA 29 CFR 1926.32 – General Safety and Health Provisions, and EPA 40 CFR 61 Subpart M – National Emission Standard for Asbestos.

1.06 COORDINATION

A. Coordinate removal work with utility companies.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 PREPARATION

A. Obtain advance approval from Project Manager for dimensions and limits of removal work.

B. Identify known utilities below grade. Stake and flag locations.

C. For removal of asbestos-containing materials, or materials that could potentially contain asbestos, comply with the following:

1. Crew members must be trained in accordance with OSHA 29 CFR 1926.1101 – Asbestos.

2. Conduct negative exposure assessment to demonstrate asbestos exposure below permissible exposure limit (PEL) in accordance with OSHA 29 CFR 1926.1101 – Asbestos and EPA 40 CFR 763 – Asbestos

3. If negative exposure assessment not conducted, or if results are above PEL, provide respiratory protection in accordance with Paragraph 3.02 of this Section.

D. Removal of existing pole foundations:.

1. Unless otherwise specified on Drawings, the tops of unused foundations shall be removed to a depth of two feet (minimum) below grade and backfilled according to specifications.

3.02 PROTECTION

A. Protect following from damage or displacement:

1. Adjacent public and private property.

2. Trees, plants, and other landscape features designated to remain.

3. Utilities designated to remain.

4. Pavement and utility structures designated to remain.

5. Bench marks, monuments, and existing structures designated to remain.

B. When required, provide respiratory protection in accordance with OSHA 29 CFR 1910.134 – Respiratory Protection, and National Institute of Occupational Safety and Health (NIOSH).

3.03 REMOVALS

A. Remove pavements and structures by methods that will not damage underground utilities. Do not use drop hammer near existing underground utilities.

B. Minimize amount of earth loaded during removal operations.

C. Where existing pavement is to remain, make straight saw cuts in existing pavement to provide clean breaks prior to removal. Do not break concrete pavement or base with drop hammer unless concrete or base has been saw cut to minimum depth of 2 inches.

D. When street and driveway saw cut location is greater than one-half of pavement lane width, remove pavement for full lane width or to nearest longitudinal joint as directed by Project Manager.

E. Remove sidewalks and curbs to nearest existing dummy, expansion, or construction joint.

F. Where existing end of pipe culvert or end of sewer is to remain, install 8-inch-thick masonry plug in pipe end prior to backfill in accordance with requirements of Section 02316 - Excavation and Backfill for Structures.

G. Labeling of Asbestos Cement (AC) Pipe:

1. Label leak-tight container with warning statement of hazardous asbestos content in accordance with OSHA 29 CFR 1926.1101 and as noted below.

2. Label waste material with following warning:

DANGER
CONTAINS ASBESTOS FIBERS
MAY CAUSE CANCER
CAUSES DAMAGE TO LUNGS
DO NOT BREATHE DUST
AVOID CREATING DUST

3. Neatly print labels in letters of sufficient size and contrast so label is easily visible and legible.

3.04 BACKFILL

A. Backfill of removal areas shall be in accordance with requirements of Section 02316 - Excavation and Backfill for Structures.

3.05 DISPOSALS

A. Inlet frames, grates, and plates; and manhole frames and covers, may remain City property. Disposal shall be in accordance with requirements of Section 01576 - Waste Material Disposal.

B. Remove from site, debris resulting from work under this section in accordance with requirements of Section 01576 - Waste Material Disposal.

C. For asbestos-containing materials:

1. Comply with 40 CFR Part 61 and 30 TAC Sections 330.137(b) for Industrial Class 1 waste.

2. Inspect load to ensure correct packaging and labeling.

3. Line vehicles with two layers of 6-mil polyethylene sheeting.

4. Remove asbestos-containing waste from site daily.

END OF SECTION

SECTION 02222

ABANDONMENT OF SEWERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Abandonment in place of existing sewers, junction structures, manholes, and force mains.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01576 – Waste Material Disposal

D. Section 02317 – Excavation and Backfill for Utilities

E. Section 02431 – Tunnel Grout

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for grout fill and abandonment of existing sewers, including boxes and elliptical shaped sewers, is on linear foot basis for each diameter of sewer being abandoned. Measurement will be along centerline of sewer from centerline to centerline of manholes.

2. Payment for grout fill and abandonment of sewer manholes or junction structure is by each manhole or junction structure abandoned in conformance with this Section.

3. Payment will be full compensation for all material, equipment, and labor required for complete abandonment grouting, including air venting, testing, temporary plugs, fill lines, excavations, and incidentals.

4. No separate payment will be made for plugging and abandoning sewer force mains. Include cost of such abandonment in related work.

5. Refer to Section 01270 - Measurement and Payment for unit price procedures.

6. Acceptability of grout material is based on achieving average strength within range of 75 to 150 psi as defined in Paragraph 2.01B.1. Grout that is out of range after placement may be accepted with price adjustment of 1.0 percent price deduction for each psi average compressive strength below 75 psi and 0.5 percent price deduction for each psi average compressive strength above 150 psi, as applicable to material volume represented by test series. Shrinkage in grout material placements shall be remedied by Contractor according to Paragraph 3.04H without additional compensation.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

A. Abandonment. Sewer abandonment consists of demolition and removal of portion of manholes existing within specified depth of surface, and abandonment in place of sewer lines and manholes as specified in this Section.

B. Flowable Fill. Flowable fill (abandonment grout) shall be controlled low-strength material consisting of fluid mixture of cement, fly ash, aggregate, water and with admixtures as necessary to provide workable properties. Placement of flowable fill may be by grouting techniques in sewer pipes or other restricted areas, or as mass placement by chutes or tremie methods in unrestricted locations with open access. Long-term hardened strength shall be within specified range.

C. Ballast. Large aggregate either replaced with voids subsequently filled with flowable fill injected by grouting method; or in areas with open access, placed individually and sequentially at same time as flowable fill placement.

D. Backgrouting. Secondary stage pressure grouting to ensure that voids have been filled within abandoned sewer. Backgrouting will only be required at critical locations indicated on Drawings or if there is evidence of incomplete flowable fill placements.

1.05 REFERENCE STANDARDS

A. ASTM C 150 - Standard Specification for Portland Cement.

B. ASTM C 494 - Standard Specification for Chemical Admixtures for Concrete.

C. ASTM C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

D. ASTM C 937 - Standard Specification for Grout Fluidifier for Pre-placed Aggregate Concrete.

E. ASTM C 940 - Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory.

F. ASTM C 1017 - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.

G. ASTM C 1107 - Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink)

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Flowable fill mix design report:

1. Flowable fill type and production method. Describe if fill will be mixed to final proportions and consistency in batch plant or if constituents will be added in transit mixer at placement location.

2. Use of ballast. Provide percentage of ballast of total placement and size limits for ballast if fill is intended to be used with ballast.

3. Aggregate gradation of fill. Aggregate gradation of mix (excluding ballast) shall be used as pilot curve for quality control during production.

4. Fill mix constituents and proportions including materials by weight and volume, and air content but excluding ballast. Give types and amounts of admixtures including air entrainment or air generating compounds.

5. Fill densities and viscosities, including wet density at point of placement.

6. Initial time of set.

7. Bleeding and shrinkage.

8. Compressive strength.

C. Technical information for equipment and operational procedures including projected slurry injection rate, grout pressure, method of controlling grout pressure, bulkhead and vent design, and number of stages of grout application.

D. Experience record for proposed crew, showing minimum of 100 cubic yards of flowable fill placed using proposed or similar equipment and methods.

E. At least 60 days prior to commencing abandonment activities, submit plan for abandonment, describing proposed grouting sequence, bypass pumping requirements and plugging, if any, and other information pertinent to completion of work.

PART 2 PRODUCTS

2.01 FLOWABLE FILL

A. Design Mix Criteria. Provide design of one or more mixes to meet design criteria and conditions for placement. Present information required by Paragraph 1.06B in mix design report including following:

1. Cement: ASTM C 150 Type I or II. Volume and weight per cubic yard of fill. Provide minimum cement content of 100 pounds per cubic yard.

2. Fly ash: ASTM C 618 Class C or F. Volume and weight per cubic yard of fill. Provide minimum Fly ash content of 200 pounds per cubic yard.

3. Potable water: Volume and weight per cubic yard of fill. Amount of water determined by mix design testing.

4. Aggregate gradation: 100 percent passing 3/8-inch sieve and not more than 10 percent passing No. 200 sieve. Mix design report shall define pilot gradation based on following sieve sizes 3/8-inch, Nos. 4, 8, 16, 30, 50, 100, and 200. Do not deviate from pilot gradation by more than plus or minus 10 percentage points for any sieve for production material.

5. Aggregate source material: Screened or crushed aggregate, pit or bank run fine gravels or sand, or crushed concrete. If crushed concrete is used, add at least 30 percent of natural aggregate to provide workability.

6. Admixtures: Use admixtures meeting ASTM C 494 and ASTM C 1017 as needed to improve pumpability, to control time of set, and reduce bleeding.

7. Fluidifier: Use fluidifier meeting ASTM C 937 as necessary to hold solid constituents in suspension. Add shrinkage compensator if necessary.

8. Performance additive: Use flowable fill performance additive, such as Darafill or approved equal, to control fill properties.

B. Flowable Fill Requirements

1. Unconfined compressive strength: minimum 75 psi and maximum 150 psi at 56 days as determined based on an average of three tests for same placement. Present at least three acceptable strength tests for proposed mix design in mix design report.

2. Placement characteristics: self-leveling.

3. Shrinkage characteristics: non-shrink.

4. Water bleeding for fill to be placed by grouting method in sewers: not to exceed 2 percent according to ASTM C 940.

5. Minimum wet density: 90 pounds per cubic foot.

2.02 BALLAST

A. Ballast Material: Natural rock or concrete pieces with minimum size equal to at least 10 times maximum aggregate size of flowable fill and maximum size of 24 inches. Maximum dimension shall not be more than 20 percent of minimum dimension of space to be filled.

B. Ballast Composition: Free of regulated waste material.

2.03 PLUGS FOR FORCE MAINS

A. Grout Plugs: Cement-based dry-pack grout conforming to ASTM C 1107, Grade B or C.

B. Manufactured Plug: Commercially available plug or cap specifically designed and manufactured to be used with pipe being abandoned.

PART 3 EXECUTION

3.01 PREPARATION

A. Have fill mix design reports and other submittals required by Paragraph 1.06 accepted by Project Manager prior to start of placement. Notify Project Manager at least 24 hours in advance of grouting with flowable fill.

B. Select fill placement equipment and follow procedures with sufficient safety and care to avoid damage to existing underground utilities and structures. Operate equipment at pressure that will not distort or imperil portion of work, new or existing.

C. Clean sewer lines and video with closed circuit television to identify connections, locate obstructions, and assess condition of pipe. Locate previously unidentified connections, which have not been redirected and reconnected as part of this project, and report them to Project Manager. During placement of fill, compensate for irregularities in sewer pipe, such as obstructions, open joints, or broken pipe to ensure no voids remain unfilled.

D. Perform demolition work prior to starting fill placement. Clean placement areas of sewers and manholes of debris that may hinder fill placement. Remove excessive amounts of sludge and other substances that may degrade performance of fill. Do not leave sludge or other debris in place if filling more than 2 percent of placement volume. Dispose of waste material in compliance with Section 01576 - Waste Material Disposal.

E. Remove free water prior to starting fill placement.

3.02 EQUIPMENT

A. Mix flowable fill in automated batch plant and deliver it to site in ready-mix trucks. Performance additives may be added at placement site if required by mix design.

B. Use concrete or grout pumps capable of continuous delivery at planned placement rate.

3.03 DEMOLITION OF SEWER MANHOLES, PIPELINE STRUCTURES, AND FORCE MAINS PRIOR TO ABANDONMENT

A. Remove manhole frames and covers and castings from other existing pipeline structures. Deliver castings to nearest City of Houston maintenance facility for future use. Alternatively, salvaged castings may be used upon approval by Project Manager, for constructing new manholes on this project.

B. Demolish and remove precast concrete adjustment rings and corner section, or brick and mortar corbel and chimney, or other pipeline structure, to minimum depth of 4 feet below finished grade. Structure may be removed to greater depth, but not deeper than 18 inches above crown of abandoned sewer.

C. When adjacent sewer lines are not to be filled, place temporary plugs in each line connecting to manhole, in preparation for filling manhole.

D. Excavate overburden from force mains to be abandoned at locations indicated on Drawings, conforming to Section 02317 - Excavation and Backfill for Utilities. Cut existing force main, when necessary, to provide an end surface perpendicular to axis of pipe and suitable for plug to be installed. Remove force main piping material remaining outside of segment to be abandoned.

3.04 INSTALLATION

A. Abandon sewer lines by completely filling sewer line with flowable fill. Abandon manholes and other structures by filling with flowable fill, together with ballast as applicable, within depth of structures left in place.

B. Place flowable fill to fill volume between manholes. Continuously place flowable fill from manhole to manhole with no intermediate pour points, but not exceeding 500 feet in length.

C. Have filling operation performed by experienced crews with equipment to monitor density of flowable fill and to control pressure.

D. Temporarily plug sewer lines which are to remain in operation during pouring/pumping to keep lines free of flowable fill.

E. Pump flowable fill through bulkheads constructed for placement of two 2-inch PVC pipes or use other suitable construction methods to contain flowable fill in lines to be abandoned. These pipes will act as injection points or vents for placement of flowable fill.

F. Place flowable fill under pressure flow conditions into properly vented open system until flowable fill emerges from vent pipes. Pump flowable fill with sufficient pressure to overcome friction and to fill sewer from downstream end, to discharge at upstream end.

G. Inject flowable fill through replaced ballast using grouting equipment and series of grout pipes discharging at bottom of placement, allowing fill to rise through ballast effectively filling all voids. Alternatively, sequentially place individual pieces of ballast at same time as flowable fill is placed. Do not fill with ballast more than 50 percent of volume at any level, to prevent nesting and void formation.

H. Remediate placement of flowable fill which does not fill voids in sewer, in manhole or other structures, or where voids develop due to excessive shrinkage or bleeding of fill, by using pressure grouting either from inside sewer or from surface. Pressure grout shall conform to Section 02431 - Tunnel Grout.

I. Plug each end of force main being abandoned.

J. Force main abandonment

1. Clean inside surface of force main at least 12 inches from ends to achieve firm bond and seal grout plug or manufactured plug to pipe surface. Similarly, clean and prepare exterior pipe surface if manufactured cap is to be used.

2. When using grout plug, place temporary plug or bulkhead approximately 12 inches inside pipe. Fill pipe end completely with dry-pack grout mixture.

3. When using manufactured plug or cap, install fitting as recommended by manufacture's instructions, to form water tight seal.

K. Backfill to surface, above pipe or structures left in place, with flowable fill in restricted areas, compacted bank run sand in unrestricted areas to be paved or select fill in unrestricted areas outside of pavement. Place and compact backfill, other than flowable fill, in compliance with Section 02317 - Excavation and Backfill for Utilities.

L. Collect and dispose of excess flowable fill material and other debris in accordance with Section 01576 - Waste Material Disposal.

3.05 FIELD QUALITY CONTROL

A. Provide batch plant tickets for each truck delivery of flowable fill. Note on tickets addition of admixtures at site.

B. Check flow characteristics and workability of fill as placement proceeds.

C. Obtain at least three test cylinders for each placement area for determination of 56-day compressive strength and bleeding. Acceptance of placement will be based on average strength of three tests.

D. Record volume of ballast together with flowable fill placement for same space to demonstrate that voids have been filled.

3.06 PROTECTION OF PERSONS AND PROPERTY

A. Provide safe working conditions for employees throughout demolition and removal operations. Observe safety requirements for work below grade.

B. Maintain safe access to adjacent property and buildings. Do not obstruct roadways, sidewalks or passageways adjacent to work.

END OF SECTION

SECTION 02233

CLEARING AND GRUBBING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Removing surface debris and rubbish.

B. Clearing site of plant life and grass.

C. Removing trees and shrubs.

D. Removing root system of trees and shrubs.

E. Fence removal.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01576 – Waste Material Disposal

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for clearing and grubbing is on per acre basis.

2. No separate payment will be made for clearing and grubbing of wastewater projects, include payment in unit prices for related items.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REGULATORY REQUIREMENTS

A. Conform to applicable codes for disposal of debris.

B. Coordinate clearing work with utility companies.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that existing plant life and features designated to remain are identified and tagged.

3.02 PROTECTION

A. Protect following from damage or displacement:

1. Living trees located 3 feet or more outside of intersection of side slopes and original ground line.

2. Plants other than trees and landscape features designated to remain.

3. Utilities designated to remain.

4. Bench marks, monuments, and existing structures designated to remain.

3.03 CLEARING

A. Remove stumps, main root ball, and root system to:

1. Depth of 24 inches below finished subgrade elevation in area bounded by lines two feet behind back of curbs.

2. Depth of 24 inches below finished surface of required cross section for other areas.

B. Clear undergrowth and deadwood without disturbing subsoil.

C. Remove vegetation from top soil scheduled for reuse.

3.04 REMOVAL

A. Remove debris, rubbish, and extracted plant material life from site in accordance with requirements of Section 01576 - Waste Material Disposal.

B. Remove on site fences. Materials generated from removal of fences become property of Contractor. Properly dispose of in accordance with applicable local, state and federal laws.

END OF SECTION

SECTION 02260

TRENCH SAFETY SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Trench Safety System for the construction of trench excavations.

B. Trench Safety System for excavations which fall under provisions of State and Federal trench safety laws.

C. This Standard Specification Section replaces previously published Section 01561-Trench Safety System.

D. The Trench Safety System requirements will apply to larger open excavations if the erection of structures or other installations limits the space between the excavation slope and these installation to dimensions equivalent of a trench as defined.

1.02 RELATED SECTIONS

A. Document 00410 – Bid Form

B. Document 00830 – Trench Safety Geotechnical Information

C. Section 01270 – Measurement and Payment

D. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. Measurement for Trench Safety Systems used on trench excavations is on a linear foot basis measured along the centerline of the trench, including manholes and other line structures.

2. No payment will be made under this section for Trench Safety Systems for structural excavations, tunnel shafts, auger pits, or excavation for trenchless installations, and also for any necessary non trenchless installations included in the aforementioned methods of construction unless included as a bid item in Documents 00410 – Bid Form. Include payment for Trench Safety Systems in applicable structural or utility installation sections.

3. Refer to Section 01270 - Measurement and payment for unit price procedures.

B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 DEFINITIONS

A. A trench shall be defined as a narrow excavation (in relation to its depth) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet.

B. Trench Safety Systems include but are not limited to sloping, sheeting, trench boxes or trench shields, sheet piling, cribbing, bracing, shoring, dewatering or diversion of water to provide adequate drainage.

C. Trench Safety Program is the safety procedures governing the presence and activities of individuals working in and around trench excavations.

1.05 REFERENCES

A. Occupational Safety and Health Standards - OSHA 29CFR.

B. Occupational Safety and Health Standards - OSHA Sections 1926-650 through 1926-652.

C. Texas Health and Safety Code, §756, subchapter C.

1.06 SUBMITTALS

A. Submittals shall conform to requirements of Section 01330 - Submittal Procedures.

B. Submit a safety program specifically for the construction of trench excavation. Design the Trench Safety Program to be in accordance with OSHA 29CFR standards governing the presence and activities of individuals working in and around trench excavations.

C. Construction and shop drawings containing deviations from OSHA standards or special designs shall be sealed by a licensed Engineer retained and paid by Contractor.

D. Review of the safety program by the City Engineer will only be in regard to compliance with this specification and will not constitute approval by the City Engineer nor relieve Contractor of obligations under State and Federal trench safety laws.

E. Submit certification that Trench Safety System will not be subjected to loads exceeding those which the system was designed to withstand according to the available construction and geotechnical information.

1.07 REGULATORY REQUIREMENTS

A. Install and maintain Trench Safety Systems in accordance with the detail specifications set out in the provision of Excavations, Trenching, and Shoring, Federal Occupation Safety and Health Administration (OSHA) Standards, 29CFR, Part 1926, Subpart P, as amended, including Final Rule, published in the Federal Register Vol. 54, No. 209 on Tuesday, October 31, 1989. The sections that are incorporated into these specifications by reference include Sections 1926-650 through 1926-652.

B. A reproduction of the OSHA standards included in "Subpart P - Excavations" from the Federal Register Vol. 54, No. 209 is available upon request to Contractors bidding on City projects. The City assumes no responsibility for the accuracy of the reproduction. The Contractor is responsible for obtaining a copy of this section of the Federal Register.

C. Legislation that has been enacted by the Texas Legislature with regard to Trench Safety Systems, is hereby incorporated, by reference, into these specifications. Refer to Texas Health and Safety Code, §756, subchapter C.

D. Reference materials, if developed for a specific project, will be issued with the Bid Documents, including the following:

1. Document 00830 - Trench Safety Geotechnical Information: Geotechnical information obtained for use in design of the Trench Safety System.

1.08 INDEMNIFICATION

A. Contractor shall indemnify and hold harmless the City, its employees and agents, from any and all damages, costs (including, without limitation, legal fees, court costs, and the cost of investigation), judgements or claims by anyone for injury or death of persons resulting from the collapse or failure of trenches constructed under this Contract.

B. Contractor acknowledges and agrees that this indemnity provision provides indemnity for the City in case the City is negligent either by act or omission in providing for trench safety, including, but not limited to safety program and design reviews, inspections, failures to issue stop work orders, and the hiring of the Contractor.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 INSTALLATION

A. Install and maintain Trench Safety Systems in accordance with provisions of OSHA 29CFR.

B. Install specially designed Trench Safety Systems in accordance with the Contractor's trench excavation safety program for the locations and conditions identified in the program.

C. A competent person, as identified in the Contractor's Trench Safety Program, shall verify that trench boxes and other premanufactured systems are certified for the actual installation conditions.

3.02 INSPECTION

A. Contractor, or Contractor's independently retained consultant, shall make daily inspections of the Trench Safety Systems to ensure that the installed systems and operations meet OSHA 29CFR and other personnel protection regulations requirements.

B. If evidence of possible cave-ins or slides is apparent, Contractor shall immediately stop work in the trench and move personnel to safe locations until the necessary precautions have been taken by Contractor to safeguard personnel entering the trench.

C. Maintain a permanent record of daily inspections.

3.03 FIELD QUALITY CONTROL

A. Contractor shall verify specific applicability of the selected or specially designed Trench Safety Systems to each field condition encountered on the project.

END OF SECTION

SECTION 02315

ROADWAY EXCAVATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Excavation and compaction of materials for roadways and roadside ditches.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01454 – Testing Laboratory Services

C. Section 01576 – Waste Material Disposal

D. Section 01725 – Field Surveying

E. Section 02330 – Embankment

F. Section 02911 – Topsoil

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for roadway excavation, with or without subgrade, is on cubic yard basis. Unless specified otherwise under the borrow (off-site) material or embankment fill work item, measurement for payment shall be based on the cut quantity shown on the drawing.

2. No payment will be made for material excavated under the following conditions:

a. More than 2 feet outside of vertical planes behind back of curbs

b. For portion within limits of trench for utilities 24-inch and greater constructed by open-cut methods

c. As indicated otherwise on Drawings.

3. Measurement for the bid item “Regrade Ditches” is on a linear foot basis. No separate payment will be made for reshaping and regrading roadway ditch shoulder slope and side slope adjacent to installed temporary pavement upon removal of temporary pavement.

4. If specified, off-site borrow material including placement and compaction will be paid by final in-place quantity on cubic yard basis.

5. If specified and shown on the drawing, embankment fill including placement and compaction will be paid by final in-place quantity on cubic yard basis.

6. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400ft-lbf/ft3 (600 kN-m/m3)).

B. ASTM D 2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

C. ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

D. ASTM D 6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide topsoil conforming to requirements of Section 02911 - Topsoil.

B. Provide backfill which is excavated material, graded free of roots, lumps greater than 6 inches, rocks larger than 3 inches, organic material, and debris.

C. Provide structural backfill which is select material meeting following requirements:

1. Plasticity index: not less than 12 nor more than 20.

2. Maximum liquid limit: 45

PART 3 EXECUTION

3.01 PREPARATION

A. Identify required lines, levels, and datum. Coordinate with Section 01725 - Field Surveying.

B. Identify and flag surface and aerial utilities.

C. Notify utility companies to remove or relocate utilities.

D. Identify, stake, and flag known utility locations below grade. Make temporary or permanent relocation of underground pipes, ducts, or utilities where indicated on Drawings.

E. Upon discovery of unknown or badly deteriorated utilities, or concealed conditions, discontinue work. Notify Project Manager and obtain instructions before proceeding in such areas.

F. Obtain approval of top soil quality before excavating and stockpiling.

3.02 PROTECTION

A. Protect following from damage or displacement:

1. Trees, shrubs, lawns, existing structures, and other features outside of grading limits.

2. Utilities either above or below grade, which are to remain.

3.03 TOPSOIL REMOVAL

A. Strip off topsoil from area to be excavated to minimum depth of 6 inches, unless indicated otherwise on Drawings.

B. Stockpile topsoil in designated location for reuse. Stockpile topsoil to depth not

3.04 SOIL EXCAVATION

A. Excavate to lines and grades shown on Drawings.

B. Remove unsuitable material not meeting specifications. Backfill with embankment materials and compact to requirements of Section 02330 - Embankment.

C. Record location and plug and fill inactive water and oil wells. Conform to Texas Department of Health, Texas Natural Resource Conservation Commission, and Texas Railroad Commission requirements. Notify Project Manager prior to plugging wells.

D. At intersections, grade back at minimum slope of one inch per foot. Produce smooth riding junction with intersecting street. Maintain proper drainage.

E. When area is inadvertently over excavated, fill area in accordance with requirements of Section 02330 - Embankment at no additional cost to City.

F. Remove material not qualified for use and excess soil not being reused from site in accordance with requirements of Section 01576 - Waste Material Disposal.

3.05 COMPACTION

A. Maintain optimum moisture content of subgrade to attain required density.

B. Compact to following minimum densities at moisture content of optimum to 3 percent above optimum as determined by ASTM D 698, unless otherwise indicated on Drawings:

1. Areas under future paving and shoulders: Minimum density of 95 percent of maximum dry density.

2. Other areas: Minimum density of 90 percent of maximum dry density.

3.06 TOLERANCES

A. Top of Compacted Surface: Plus or minus 1/2 inch in cross section, or in 16-foot length.

3.07 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. Test and analysis of soil materials will be performed in accordance with ASTM D 4318, ASTM D 2216, and ASTM D 698.

C. Compaction testing will be performed in accordance with ASTM D 698 or ASTM D 6938.

D. A minimum of three tests will be taken for each 1000 linear feet per lane of roadway.

E. When tests indicate work does not meet specified compaction requirements, recondition, recompact, and retest at no additional cost to City.

3.08 PROTECTION

A. Prevent erosion at all times. Maintain ditches and cut temporary swales to allow natural drainage in order to avoid damage to roadway. Do not allow water to pond.

B. Distribute construction traffic evenly over compacted areas, where practical, to aid in obtaining uniform compaction. Protect exposed areas having high moisture content from wheel loads that cause rutting.

C. Maintain excavation and embankment areas until start of subsequent work. Repair and recompact slides, washouts, settlements, or areas with loss of density.

END OF SECTION

SECTION 02316

EXCAVATION AND BACKFILL FOR STRUCTURES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Excavation, backfilling, and compaction of Backfill for structures.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 01555 – Traffic Control and Regulation

E. Section 01562 – Tree and Plant Protection

F. Section 01576 – Waste Material Disposal

G. Section 01578 – Control of Ground and Surface Water

H. Section 01785 – Project Record Documents

I. Section 02221 – Removing Existing Pavements, Structures, Wood, and Demolition Debris

J. Section 02260 – Trench Safety System

K. Section 02319 – Borrow

L. Section 02320 – Utility Backfill Materials

M. Section 02321 – Cement Stabilized Sand

N. Section 02621 – Geotextile

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for structural excavation and Backfill under this Section. Include payment in unit price or lump sum for construction of structures.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

A. Unsuitable Material: Unsuitable soil materials are the following:

1. Materials that are classified as ML, CL-ML, MH, PT, OH, and OL according to ASTM D 2487.

2. Materials that cannot be compacted to required density due to gradation, plasticity, or moisture content.

3. Materials that contain large clods, aggregates, stones greater than 4 inches in any dimension, debris, vegetation, waste or any other deleterious materials.

4. Materials that are contaminated with hydrocarbons or other chemical contaminants.

B. Suitable Material: Suitable soil materials are those meeting specification requirements. Unsuitable soils meeting specification requirements for suitable soils after treatment with lime or cement shall be considered suitable, unless otherwise indicated.

C. Select Material: Material as defined in Section 02320 - Utility Backfill Materials.

D. Backfill: Material meeting specified quality requirements, placed and compacted under controlled conditions around structures.

E. Foundation Backfill Materials: Natural soil or manufactured aggregate meeting Class I requirements and geotextile filter fabrics as required, to control drainage and material separation. Foundation Backfill material is placed and compacted as Backfill where needed to provide stable support for structure Foundation Base. Foundation Backfill materials may include concrete fill and seal slabs.

F. Foundation Base: For Foundation Base material, use crushed stone aggregate with filter fabric as required, cement stabilized sand, or concrete seal slab. Foundation Base provides smooth, level working surface for construction of concrete foundation.

G. Foundation Subgrade: Foundation Subgrade is surface of natural soil which has been excavated and prepared to support Foundation Base or foundation Backfill, where needed.

H. Ground Water Control Systems: Installations external to excavation such as well points, eductors, or deep wells. Ground water control includes dewatering to lower ground water, intercepting seepage which would otherwise emerge from side or bottom of excavation, and depressurization to prevent failure or heaving of excavation bottom. Refer to Section 01578 - Control of Ground and Surface Water.

I. Surface Water Control: Diversion and drainage of surface water runoff and rain water away from excavation. Remove rain water and surface water which accidentally enters excavation as part of excavation drainage.

J. Excavation Drainage: Removal of surface and seepage water in excavation by sump pumping and using French drains surrounding foundation to intercept water.

K. Over-Excavation and Backfill: Excavation of subgrade soils with unsatisfactory bearing capacity or composed of otherwise Unsuitable Materials below foundation as shown on Drawings, and Backfilled with Foundation Backfill Material.

L. Shoring System: Structure that supports sides of an excavation to maintain stable soil conditions and prevent cave-ins.

1.05 REFERENCES

A. ASTM D 698 - Standard Test Methods for Laboratory Compaction of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600kN-m/m3)).

B. ASTM D 1556 - Standard Test Method for Density and Unit weight of Soil in Place by Sand-Cone Method.

C. ASTM D 2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

D. ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

E. ASTM D 6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

F. TxDOT Tex-101-E - Preparing and Testing Soils and Base Materials.

G. TxDOT Tex-110-E - Sieve Analysis of Soils and Base Materials.

H. Excavation, Occupational Safety and Health Administration (OSHA).

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit work plan for excavation and Backfill for each structure with complete written description which identifies details of proposed method of construction and sequence of operations for construction relative to excavation and Backfill activities. Use descriptions, with supporting illustrations, sufficiently detailed to demonstrate to Project Manager that procedures meet requirements of Specifications and Drawings.

C. Submit excavation safety system plan.

1. Submit excavation safety system plan in accordance with applicable OSHA requirements for excavations.

2. Submit excavation safety system plan in accordance with requirements of Section 02260 - Trench Safety System, for excavations that fall under State and Federal trench safety laws.

D. Submit ground and surface water control plan in accordance with requirements in this Section and Section 01578 - Control of Ground and Surface Water.

E. Submit Backfill material sources and product quality information in accordance with requirements of Section 02320 - Utility Backfill Materials.

F. Submit project record documents under provisions of Section 01785 - Project Record Documents. Record location of utilities, as installed, referenced to survey benchmarks. Include location of utilities encountered or rerouted. Give horizontal dimensions, elevations, inverts and gradients.

1.07 QUALITY ASSURANCE

A. Testing and analysis of Backfill materials for soil classification and compaction during construction will be performed by an independent laboratory provided by City in accordance with requirements of Section 01454 - Testing Laboratory Services and as specified in this Section.

B. Perform embedment and Backfill material source qualification testing in accordance with requirements of Section 02320 - Utility Backfill Materials.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Perform excavation with equipment suitable for achieving requirements of this Specification.

B. Use equipment which will produce degree of compaction specified. Compact Backfill within 3 feet of walls with hand operated equipment. Do not use equipment weighing more than 10,000 pounds closer to walls than a horizontal distance equal to depth of fill at that time. Use hand operated power compaction equipment where use of heavier equipment is impractical or restricted due to weight limitations.

2.02 MATERIAL CLASSIFICATIONS

A. Use Backfill materials conforming to classifications and product descriptions of Section 02320 - Utility Backfill Materials. Use classification or product description for Backfill applications as shown on Drawings and as specified.

PART 3 EXECUTION

3.01 PREPARATION

A. Conduct an inspection to determine condition of existing structures and other permanent installations.

B. Set up necessary street detours and barricades in preparation for excavation if construction will affect traffic. Conform to requirements of Section 01555 - Traffic Control and Regulation. Maintain barricades and warning devices at all times for streets and intersections where work is in progress, or where construction work is considered hazardous to traffic movements.

C. Perform work in accordance with OSHA standards. Employ an excavation safety system as specified in Section 02260 - Trench Safety Systems.

D. Remove existing pavements and structures, including sidewalks and driveways, in accordance with requirements of Section 02221 - Removing Existing Pavements, Structures, Wood, and Demolition Debris.

E. Install and operate necessary dewatering and surface water control measures in accordance with requirements of Section 01578 - Control of Ground and Surface Water.

3.02 PROTECTION

A. Protect trees, shrubs, lawns, existing structures, and other permanent objects outside of grading limits and within grading limits as designated on Drawings, and in accordance with requirements of Section 01562 - Tree and Plant Protection.

B. Protect and support above-grade and below-grade utilities which are to remain.

C. Restore damaged permanent facilities to pre-construction conditions unless replacement or abandonment of facilities is indicated on Drawings.

D. Prevent erosion of excavations and Backfill. Do not allow water to pond in excavations.

E. Maintain excavation and Backfill areas until start of subsequent work. Repair and recompact slides, washouts, settlements, or areas with loss of density at no additional cost to City.

3.03 EXCAVATION

A. Perform excavation work so that underground structure can be installed to depths and alignments shown on Drawings. Use caution during excavation work to avoid disturbing surrounding ground and existing facilities and improvements. Keep excavation to absolute minimum necessary. No additional payment will be made for excess excavation not authorized by Project Manager.

B. Upon discovery of unknown utilities, badly deteriorated utilities not designated for removal, or concealed conditions, discontinue work at that location. Notify Project Manager and obtain instructions before proceeding in such areas.

C. Immediately notify agency or company owning any line which is damaged, broken or disturbed. Obtain approval from Project Manager and agency for any repairs or relocations, either temporary or permanent.

D. Avoid settlement of surrounding soil due to equipment operations, excavation procedures, vibration, dewatering, or other construction methods.

E. Provide surface drainage during construction to protect work and to avoid nuisance to adjoining property. Where required, provide proper dewatering and piezometric pressure control during construction.

F. Conduct hauling operations so that trucks and other vehicles do not create dirt nuisance in streets. Verify that truck beds are sufficiently tight and loaded in such a manner such that objectionable materials will not spill onto streets. Promptly clear away any dirt, mud, or other materials that spill onto streets or are deposited onto streets by vehicle tires.

G. Maintain permanent benchmarks, monumentation, and other reference points. Unless otherwise directed, replace those which are damaged or destroyed by Work.

H. Provide sheeting, shoring, and bracing where required to safely complete Work, to prevent excavation from extending beyond limits indicated on Drawings, and to protect Work and adjacent structures or improvements. Use sheeting, shoring, and bracing to protect workmen and public conforming to requirements of Section 02260 - Trench Safety Systems.

I. Prevent voids from forming outside of sheeting. Immediately fill voids with grout, cement stabilized sand, or other material approved by Project Manager and compact to 95 percent standard density.

J. After completion of structure, remove sheeting, shoring, and bracing unless shown on Drawings to remain in place or directed by Project Manager in writing that such temporary structures may remain. Remove sheeting, shoring and bracing in such a manner as to maintain safety during backfilling operations and to prevent damage to Work and adjacent structures or improvements.

K. Immediately fill and compact voids left or caused by removal of sheeting with cement stabilized sand or other material approved by Project Manager and compact to 95 percent standard density.

3.04 HANDLING EXCAVATED MATERIALS

A. Classify excavated materials. Place material which is suitable for use as Backfill in orderly piles at sufficient distance from excavation to prevent slides or cave-ins.

B. Provide additional Backfill material in accordance with requirements of Section 02319 - Borrow, if adequate quantities of Suitable Material are not available from excavation and trenching operations at site.

3.05 DEWATERING

A. Provide ground water control per Section 01578 - Control of Ground and Surface Water.

B. Keep ground water surface elevation minimum of 2 feet below bottom of Foundation Base.

C. Maintain ground water control as directed by Section 01578 - Control of Ground and Surface Water and until structure is sufficiently complete to provide required weight to resist hydrostatic uplift with minimum safety factor of 1.2.

3.06 FOUNDATION EXCAVATION

A. Notify Project Manager at least 48 hours prior to planned completion of foundation excavations. Do not place Foundation Base until excavation is accepted by Project Manager.

B. Excavate to elevations shown on Drawings, as needed to provide space for Foundation Base, forming level undisturbed surface, free of mud or soft material. Remove pockets of soft or otherwise unstable soils and replace with Foundation Backfill Material or material as directed by Project Manager. Prior to placing material over it, recompact subgrade where indicated on Drawings, scarifying as needed, to 95 percent of maximum Standard Dry Density according to ASTM D 698. If specified level of compaction cannot be achieved, moisture condition subgrade and recompact until 95 percent is achieved, over-excavate to provide minimum layer of 24 inches of Foundation Backfill Material, or other means acceptable to Project Manager.

C. Fill unauthorized excessive excavation with Foundation Backfill Material or other material as directed by Project Manager.

D. Protect open excavations from rainfall, runoff, freezing groundwater, or excessive drying so as to maintain Foundation Subgrade in satisfactory, undisturbed condition. Keep excavations free of standing water and completely free of water during concrete placement.

E. Remove soils which become unsuitable due to inadequate dewatering or other causes, after initial excavation to required subgrade, and replace with Foundation Backfill Material, as directed by Project Manager, at no additional cost to City.

F. Place Foundation Base, or Foundation Backfill Material where needed, over subgrade on same day that excavation is completed to final grade. Where base of excavations is left open for longer periods, protect itwith seal slab or cement-stabilized sand.

G. Use filter fabric as specified in Section 02621 - Geotextile to separate crushed aggregate, and other free draining Class I materials from native soils or Select Material Backfill. Overlap fabric minimum of 12 inches beyond where another material stops contact with soil.

H. Place crushed aggregate, and other Class I materials, in uniform layers of 8-inch maximum thickness. Perform compaction by means of at least two passes of vibratory compactor.

3.07 FOUNDATION BASE.

A. Place Foundation Base after subgrade is properly prepared, including placement of Foundation Backfill where needed. Use Foundation Base consisting of 12-inch layer of crushed stone aggregate or cement stabilized sand. Alternately, seal slab with minimum thickness of 4 inches may be placed. Extend Foundation Base minimum of 12 inches beyond edge of structure foundation, unless shown otherwise on Drawings.

B. Where Foundation Base and Foundation Backfill are of same material, both can be placed in one operation.

3.08 BACKFILL

A. Complete Backfill to surface of natural ground or to lines and grades shown on Drawings. Remove forms, lumber, trash and debris from structures. Deposit Backfill in uniform layers and compact each layer as specified.

1. Unless otherwise shown on Drawings, for structures under pavement or within one foot back of curb, use cement stabilized sand up to the top of the proposed structure. Use suitable on-site material (random Backfill) up to 12 inches below pavement base or subgrade. Place minimum of 12 inches of select Backfill below pavement base or subgrade.

2. Unless otherwise shown on Drawings, for structures not under pavement, use random Backfill of Suitable Material up to the surface.

B. Do not place Backfill against concrete walls or similar structures until laboratory test breaks indicate that concrete has reached minimum of 85 percent of specified compressive strength. Where walls are supported by slabs or intermediate walls, do not begin Backfill operations until slab or intermediate walls have been placed and concrete has attained sufficient strength.

C. Remove concrete forms before starting Backfill and remove shoring and bracing as work progresses.

D. Maintain Backfill material at no less than 2 percent below nor more than 2 percent above optimum moisture content, unless otherwise approved by Project Manager. Place fill material in uniform 8-inch maximum loose layers. Compact fill to at least 95 percent of maximum Standard Proctor Density according to ASTM D 698 below paved areas. Compact fill to at least 90 percent around structures below unpaved areas.

E. Where Backfill is placed against sloped excavation surface, run compaction equipment across boundary of cut slope and Backfill to form compacted slope surface for placement of next layer of Backfill.

F. Place Backfill using cement stabilized sand in accordance with Section 02321 - Cement Stabilized Sand.

3.09 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. Tests will be performed initially on minimum of one different sample of each material type for plasticity characteristics, in accordance with ASTM D 4318, and for gradation characteristics, in accordance with Tex-101-E and Tex-110-E. Additional classification tests will be performed whenever there is noticeable change in material gradation or plasticity.

C. In-place density tests of compacted subgrade and Backfill will be performed according to ASTM D 1556, or ASTM D 6938, and at following frequencies and conditions:

1. Minimum of one test for every 50 to 100 cubic yards of compacted Backfill material as directed by Project Manager.

2. A minimum of three density tests for each full work shift.

3. Density tests will be performed in all placement areas.

4. Number of tests will be increased when inspection determines that soil types or moisture contents are not uniform or when compacting effort is variable and not considered sufficient to attain uniform density.

5. Identify elevation of test with respect to natural ground.

6. Record approximate depth of lift tested.

D. At least one test for moisture-density relationships will be initially performed for each type of Backfill material in accordance with ASTM D 698. Perform additional moisture-density relationship test once a month or whenever there is noticeable change in material gradation or plasticity.

E. When tests indicate work does not meet specified compaction requirements, recondition, recompact, and retest at Contractor's expense.

3.10 DISPOSAL OF EXCESS MATERIAL

A. Dispose of excess materials in accordance with requirements of Section 01576 - Waste Material Disposal.

END OF SECTION

SECTION 02317

EXCAVATION AND BACKFILL FOR UTILITIES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Excavation, trenching, foundation, embedment, and Backfill for installation of utilities, including manholes and other pipeline structures.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 01504 – Temporary Facilities and Controls

E. Section 01555 – Traffic Control and Regulation

F. Section 01562 – Tree and Plant Protection

G. Section 01576 – Waste Material Disposal

H. Section 01578 – Control of Ground and Surface Water

I. Section 01725 – Field Surveying

J. Section 02221 – Removing Existing Pavements, Structures, Wood, and Demolition Debris

K. Section 02260 – Trench Safety System

L. Section 02320 – Utility Backfill Materials

M. Section 02321 – Cement Stabilized Sand

N. Section 02322 – Flowable Fill

O. Section 02621 – Geotextile

P. Section 03315 – Concrete for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. No additional payment will be made for trench excavation, embedment and Backfill under this Section. Include cost in unit price for installed underground piping, sewer, conduit, or duct work.

2. When Project Manager directs Contractor to over excavate trench bottom, Contractor will be paid by unit price bid per linear foot under bid item -6-inches Over Excavation of Trench Bottom.

    a. No payment will be paid if Project Manager does not direct Contractor to over excavate trench bottom.

    b. No over excavation will be measured or paid when unsuitable conditions result from dewatering system not in conformance with Section 01578 - Control of Ground and Surface Water.

3. No additional payment will be made for performing Critical Location exploratory excavation. Include cost in unit price for installed underground piping, sewer, conduit, or duct work.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

A. Pipe Foundation: Suitable and stable native soils that are exposed at trench subgrade after excavation to depth of bottom of bedding as shown on Drawings, or foundation Backfill material placed and compacted in over-excavations.

B. Pipe Bedding: Portion of trench Backfill that extends vertically from top of foundation up to level line at bottom of pipe, and horizontally from one trench sidewall to opposite sidewall.

C. Haunching: Material placed on either side of pipe from top of bedding up to springline of pipe and horizontally from one trench sidewall to opposite sidewall.

D. Initial Backfill: Portion of trench Backfill that extends vertically from springline of pipe (top of Haunching) up to level line 12-inches above top of pipe, and horizontally from one trench sidewall to opposite sidewall.

E. Pipe Embedment: Portion of trench Backfill that consists of bedding, Haunching and Initial Backfill.

F. Trench Zone: Portion of trench Backfill that extends vertically from top of Pipe Embedment up to pavement subgrade or up to final grade when not beneath pavement.

G. Unsuitable Material: Unsuitable soil materials are the following:

1. Materials that are classified as ML, CL-ML, MH, PT, OH, and OL according to ASTM D 2487.

2. Materials that cannot be compacted to required density due to gradation, plasticity, or moisture content.

3. Materials that contain large clods, aggregates, stones greater than 4-inches in any dimension, debris, vegetation, waste or any other deleterious materials.

4. Materials that are contaminated with hydrocarbons or other chemical contaminants.

H. Suitable Material: Suitable soil materials are those meeting specification requirements. Materials mixed with lime, fly ash, or cement that can be compacted to required density and meeting requirements for Suitable Materials may be considered Suitable Materials, unless otherwise indicated.

I. Backfill: Suitable material meeting specified quality requirements placed and compacted under controlled conditions.

J. Ground Water Control Systems: Installations external to trench, such as well points, eductors, or deep wells. Ground water control includes dewatering to lower ground water, intercepting seepage which would otherwise emerge from side or bottom of trench excavation, and depressurization to prevent failure or heaving of excavation bottom. Refer to Section 01578 - Control of Ground Water and Surface Water.

K. Surface Water Control: Diversion and drainage of surface water runoff and rain water away from trench excavation. Rain water and surface water accidentally entering trench shall be controlled and removed as part of Excavation Drainage.

L. Excavation Drainage: Removal of surface and seepage water in trench by sump pumping and using drainage layer, as defined in ASTM D 2321, placed on foundation beneath Pipe Bedding or thickened bedding layer of Class I material.

M. Trench Conditions are defined with regard to stability of trench bottom and trench walls of Pipe Embedment zone. Maintain trench conditions that provide for effective placement and compaction of embedment material directly on or against undisturbed soils or foundation Backfill, except where structural trench support is necessary.

1. Dry Stable Trench: Stable and substantially dry trench conditions exist in Pipe Embedment zone as result of typically dry soils or achieved by ground water control (dewatering or depressurization) for trenches extending below ground water level.

2. Stable Trench with Seepage: Stable trench in which ground water seepage is controlled by Excavation Drainage.

a. Stable Trench with Seepage in Clayey Soils: Excavation Drainage is provided in lieu of or to supplement Ground Water Control Systems to control seepage and provide stable trench subgrade in predominately clayey soils prior to bedding placement.

b. Stable Wet Trench in Sandy Soils: Excavation Drainage is provided in embedment zone in combination with ground water control in predominately sandy or silty soils.

3. Unstable Trench: Unstable trench conditions exist in Pipe Embedment zone if ground water inflow or high water content causes soil disturbances, such as sloughing, sliding, boiling, heaving or loss of density.

N. Sub-trench: Sub-trench is special case of benched excavation. Sub-trench excavation below Trench Shields or shoring installations may be used to allow placement and compaction of foundation or embedment materials directly against undisturbed soils. Depth of sub-trench depends upon trench stability and safety as determined by Contractor.

O. Trench Dam: Placement of low permeability material in Pipe Embedment zone or foundation to prohibit ground water flow along trench.

P. Over-excavation and Backfill: Excavation of subgrade soils with unsatisfactory bearing capacity or composed of otherwise Unsuitable Materials below top of foundation as shown on Drawings, and Backfilled with foundation bedding.

Q. Foundation Bedding: Natural soil or manufactured aggregate of controlled gradation, and geotextile filter fabrics as required, to control drainage and material separation. Foundation Bedding is placed and compacted as Backfill to provide stable support for bedding. Foundation Bedding materials may include concrete seal slabs.

R. Trench Safety Systems include both protective systems and Shoring Systems as defined in Section 02260 - Trench Safety Systems.

S. Trench Shield (Trench Box): Portable worker safety structure moved along trench as work proceeds, used as protective system and designed to withstand forces imposed on it by cave in, thereby protecting persons within trench. Trench Shields may be stacked if so designed or placed in series depending on depth and length of excavation to be protected.

T. Shoring System: Structure that supports sides of an excavation to maintain stable soil conditions and prevent cave-ins, or to prevent movement of ground affecting adjacent installations or improvements.

U. Special Shoring: Shoring System meeting Special Shoring as specified in Paragraph1.09, Special Shoring Design Requirements, for locations identified on Drawings.

V. Vacuum Excavation: An excavation technique performed by an experienced subcontractor in which water or air jetting is used to slough off and vacuum away soil.

W. Large Diameter Water Line (LDWL): Water line that is 24-inches in diameter or larger. X. Emergency Action Plan (EAP): The EAP document should include a discussion of procedures for timely and reliable detection, classification (level of emergency) and response procedure to a potential emergency condition associated with a Large Diameter Water Line.

X. Subsurface Utility Exploration (SUE): Non-destructive excavation, unless otherwise approved by Project Manager.

1.05 REFERENCES

A. ASTM D 558 - Standard Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures.

B. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3 (600 kN-m/m3)).

C. ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method.

D. ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications.

E. ASTM D 2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classifications System).

F. ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

G. ASTM D 6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

H. TxDOT Tex-101-E - Preparing and Testing Soils and Base Materials.

I. TxDOT Tex-110-E - Sieve Analysis of Soils and Base Materials.

J. .

1.06 SCHEDULING

A. Schedule work so that Pipe Embedment can be completed on same day that acceptable foundation has been achieved for each section of pipe installation, manhole, or other structures.

B. For proposed utility adjacent to or across existing LDWL:

1. Conduct a meeting between Contractor, Drinking Water Operations and Utility Maintenance Branch prior to beginning excavation to coordinate the EAP in the event a water line shut down becomes necessary.

2. Notify Drinking Water Operations a minimum of 1 week prior to beginning construction activities.

3. Notify Drinking Water Operations a minimum of 48 hours prior to beginning SUE work near LDWL.

4. Unless otherwise approved by City Engineer, perform construction activities between 7 AM and 7 PM, Monday through Friday. No work permitted around a LDWL on weekends or City Holiday.

5. A City Inspector must be present during SUE or construction activities occurring within four feet or one diameter of the LDWL, whichever is greater, from a LDWL or appurtenance.

1.07 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit planned typical method of excavation, backfill placement and compaction including:

1. Trench widths.

2. Procedures for foundation and pipe zone bedding placement, and trench Backfill compaction.

3. Procedures for assuring compaction against undisturbed soil when pre-manufactured trench safety systems are proposed.

C. Submit Backfill material sources and product quality information in accordance with requirements of Section 02320 - Utility Backfill Materials.

D. Submit trench excavation safety program in accordance with requirements of Section 02260 - Trench Safety System. Include designs for Special Shoring meeting requirements defined in Paragraph 1.08, Special Shoring Design Requirements contained herein.

E. Submit record of location of utilities as installed, referenced to survey control points. Include locations of utilities encountered or rerouted. Give stations, horizontal dimensions, elevations, inverts, and gradients.

F. Submit 11-inch by 17-inch or 12-inch by 18-inch copy of Drawing with plotted utility or obstruction location titled "Critical Location Report" to Project Manager.

G. For installation of proposed utility adjacent to or across existing LDWL, prepare and submit the following to Drinking Water Operations prior to beginning construction activities. Obtain approval from Drinking Water Operations prior to commencing prelocate or utility work near LDWL.

1. Trench details, Shoring System designs, installation sequences, and flowable fill mix designs.

2. Emergency Action Plan (EAP) to address contingency plans in the event of damage to or failure of LDWL. Include the following:

a. Contact personnel and agencies including primary and secondary telephone numbers.

b. Contractor's hierarchy of responsible personnel.

c. Traffic control measures

d. Identification of resources to be available on or near Project site in event of damage to or failure of LDWL.

1.08 QUALITY ASSURANCE

A. Testing and analysis of Backfill materials for soil classification and compaction during construction will be performed by an independent laboratory provided by City in accordance with requirements of Section 01454 - Testing Laboratory Services and as specified in this Section.

B. Perform Backfill material source qualification testing in accordance with requirements of Section 02320 - Utility Backfill Materials.

1.09 SPECIAL SHORING DESIGN REQUIREMENTS

A. Have Special Shoring designed or selected by Contractor's Professional Engineer to provide support for sides of excavations, including soils and hydrostatic ground water pressures as applicable, and to prevent ground movements affecting adjacent installations or improvements such as structures, pavements and utilities. Special Shoring may be a premanufactured system selected by Contractor's Professional Engineer to meet project site requirements based on manufacturer's standard design.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Perform excavation with hydraulic excavator or other equipment suitable for achieving requirements of this Section.

B. Use only hand-operated tamping equipment until minimum cover of 12-inches is obtained over pipes, conduits, and ducts. Do not use heavy compacting equipment until adequate cover is attained to prevent damage to pipes, conduits, or ducts.

C. Use Trench Shields or other protective systems or Shoring Systems which are designed and operated to achieve placement and compaction of Backfill directly against undisturbed native soil.

D. Use special Shoring Systems where required which may consist of braced sheeting, braced soldier piles and lagging, slide rail systems, or other systems meeting requirements as specified in Paragraph 1.08, Special Shoring Design Requirements.

2.02 MATERIAL CLASSIFICATIONS

A. Embedment and Trench Zone Backfill Materials: Conform to classifications and product descriptions of Section 02320 - Utility Backfill Materials and Section 02321 – Cement Stabilized Sand.

B. Concrete Backfill: Conform to requirements for Class B concrete as specified in Section 03315 - Concrete for Utility Construction.

C. Geotextile (Filter Fabric): Conform to requirements of Section 02621 - Geotextile.

D. Concrete for Trench Dams: Concrete Backfill or 3 sack premixed (bag) concrete.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. In addition to requirements found in this Section, conform to requirements found in the applicable Sections for utility material/type. Where an apparent conflict occurs between the Sections, this Section governs.

3.02 PREPARATION

A. Establish traffic control to conform to requirements of Section 01555 - Traffic Control and Regulation. Maintain barricades and warning lights for streets and intersections affected by Work, and are considered hazardous to traffic movements.

B. Perform work to conform to applicable safety standards and regulations. Employ trench safety system as specified in Section 02260 - Trench Safety Systems.

C. Immediately notify agency or company owning any existing utility line which is damaged, broken, or disturbed. Obtain approval from Project Manager and agency for any repairs or relocations, either temporary or permanent.

D. Remove existing pavements and structures, including sidewalks and driveways, to conform to requirements of Section 02221 - Removing Existing Pavements, Structures, Wood and Demolition Debris, as applicable.

E. Install and operate necessary dewatering and surface-water control measures to conform to Section 01578 - Control of Ground and Surface Water. Provide stable trench to allow installation in accordance with Specifications.

F. Maintain permanent benchmarks, monumentation, and other reference points. Unless otherwise directed in writing, replace those which are damaged or destroyed in accordance with Section 01725 - Field Surveying.

3.03 CRITICAL LOCATION INVESTIGATION

A. Horizontal and vertical location of various underground lines shown on Drawings, including but not limited to water lines, gas lines, storm sewers, sanitary sewers, telecommunication lines, electric lines or power ducts, pipelines, concrete and debris, are based on best information available but are only approximate locations. Unless otherwise approved by Project Manager, at Critical Locations shown on Drawings, perform Vacuum Excavation to field verify horizontal and vertical locations of such lines within a zone 2 feet vertically and 4 feet horizontally of proposed work exclude water jetting at PCCP water line.

1. Verify location of existing utilities minimum of 7 working days in advance of pipe laying activities based on daily pipe laying rate or prior to beginning installation of auger pit or tunnel shaft. Use extreme caution and care when uncovering utilities designated by Critical Locate.

2. Notify Project Manager in writing immediately upon identification of obstruction. In event of failure to identify obstruction in minimum of 7 days, Contractor will not be entitled to extra cost for downtime including, but not limited to, payroll, equipment, overhead, demobilization and remobilization, until 7 days has passed from time Project Manager was notified of obstruction.

B. Notify involved utility companies of date and time that investigation excavation will occur and request that their respective utility lines be marked in field. Comply with utility or pipeline company requirements that their representative be present during excavation. Provide Project Manager with 48-hours notice prior to field excavation or related work.

C. Survey vertical and horizontal locations of obstructions relative to project baseline and datum and plot on 12-inch by 18-inch copy of Drawings. For Large diameter Water Lines, submit to Project Manager for approval, horizontal and vertical alignment dimensions for connections to existing lines, tied into Project baseline, signed and sealed by R.P.L.S.

D. LDWL Prelocate Requirements:

1. Field-locate LDWL, appurtenances and laterals connected directly to LDWL through use of non-probing method such as a vacuum truck (non-water jetting method) at no greater than 50-foot intervals. Locate upstream and downstream of proposed work or utility installation.

2. Record crown and side of LDWL adjacent to proposed work or utility installation. Record LDWL locations horizontally and vertically using same coordinate system employed on proposed utility drawings.

3. Tie horizontal and vertical coordinates into project baseline. Submit recordings performed by R.P.L.S to City a minimum of 14 days prior to mobilizing to site.

3.04 PROTECTION

A. Protect trees, shrubs, lawns, existing structures, and other permanent objects outside of grading limits and within grading limits as designated on Drawings, and in accordance with requirements of Section 01562 - Tree and Plant Protection.

B. Protect and support above-grade and below-grade utilities which are to remain.

C. Restore damaged permanent facilities to pre-construction conditions unless replacement or abandonment of facilities is indicated on Drawings.

D. Take measures to minimize erosion of trenches. Do not allow water to pond in trenches. Where slides, washouts, settlements, or areas with loss of density or pavement failures or potholes occur, repair, re-compact, and pave those areas at no additional cost to City.

E. Contingency plans for proposed work or utility installation adjacent to or across a LDWL:

1. Conduct on-site emergency drill prior to commencing proposed utility installation, and at three-month intervals to assure EAP is current.

2. In the event a LDWL shut down becomes necessary, secure site and provide assistance to City personnel to access pipe and isolation valves as needed.

3.05 EXCAVATION

A. Except as otherwise specified or shown on Drawings, install underground utilities in open cut trenches with vertical sides.

B. Perform excavation work so that pipe, conduit, and ducts can be installed to depths and alignments shown on Drawings. Avoid disturbing surrounding ground and existing facilities and improvements.

C. Determine trench excavation widths using following schedule as related to pipe outside diameter (O.D.). Excavate trench so that pipe is centered in trench.

Nominal Pipe Size, Inches	Minimum Trench Width, Inches
30 or less	O.D. + 24
36 to 42	O.D. + 36
Greater than 42	O.D. + 48

D. Do not obstruct sight distance for vehicles utilizing roadway or detours with stockpiled materials.

E. Use sufficient trench width or benches above embedment zone for installation of well point headers or manifolds and pumps where depth of trench makes it uneconomical or impractical to pump from surface elevation. Provide sufficient space between shoring cross braces to permit equipment operations and handling of forms, pipe, embedment and Backfill, and other materials.

F. Upon discovery of unknown utilities, badly deteriorated utilities not designated for removal, or concealed conditions, discontinue work at that location. Notify Project Manager and obtain instructions before proceeding.

G. Shoring of Trench Walls.

1. Install Special Shoring in advance of trench excavation or simultaneously with trench excavation, so that soils within full height of trench excavation walls will remain laterally supported at all times.

2. For all types of shoring, support trench walls in Pipe Embedment zone throughout installation. Provide trench wall supports sufficiently tight to prevent washing trench wall soil out from behind trench wall support.

3. Leave sheeting driven into or below Pipe Embedment zone in place to preclude loss of support of foundation and embedment materials, unless otherwise directed by Project Manager. Leave rangers, walers, and braces in place as long as required to support sheeting, which has been cut off, and trench wall in vicinity of pipe zone.

4. Employ special methods for maintaining integrity of embedment or foundation material. Before moving supports, place and compact embedment to sufficient depths to provide protection of pipe and stability of trench walls. As supports are moved, finish placing and compacting embedment.

5. If sheeting or other shoring is used below top of Pipe Embedment zone, do not disturb Pipe Foundation and embedment materials by subsequent removal. Maximum thickness of removable sheeting extending into embedment zone shall be equivalent of 1-inch-thick steel plate. As sheeting is removed, fill in voids left with grouting material.

H. Use of Trench Shields. When Trench Shield (Trench Box) is used as worker safety device, the following requirements apply:

1. Make trench excavations of sufficient width to allow shield to be lifted or pulled freely, without damage to trench sidewalls.

2. Move Trench Shields so that pipe, and Backfill materials, after placement and compaction, are not damaged nor disturbed, nor degree of compaction reduced. Re-compact after shield is moved if soil is disturbed.

3. When required, place, spread, and compact Pipe Foundation and bedding materials beneath shield. For backfill above bedding, lift shield as each layer of Backfill is placed and spread. Place and compact Backfill materials against undisturbed trench walls and foundation.

4. Maintain Trench Shield in position to allow sampling and testing to be performed in safe manner.

5. Conform to applicable Government regulations.

I. Voids under paving area outside shield caused by Contractor's work will require removal of pavement, consolidation and replacement of pavement in accordance with Contract Documents. Repair damage resulting from failure to provide adequate supports.

J. Place sand or soil behind shoring or Trench Shield to prevent soil outside shoring from collapsing and causing voids under pavement. Immediately pack Suitable Material in outside voids following excavation to avoid caving of trench walls.

K. Coordinate excavation within 15 feet of pipeline with company's representative. Support pipeline with methods agreed to by pipeline company's representative. Use small, rubber-tired excavator, such as backhoe, to do exploratory excavation. Bucket that is used to dig in close proximity to pipelines shall not have teeth or shall have guard installed over teeth to approximate bucket without teeth. Excavate by hand within 1 foot of Pipeline Company’s line. Do not use larger excavation equipment than normally used to dig trench in vicinity of pipeline until pipelines have been uncovered and fully exposed. Do not place large excavation and hauling equipment directly over pipelines unless approved by Pipeline Company’s representative.

L. When, during excavation to uncover pipeline company's pipelines, screwed collar or an oxy- acetylene weld is exposed, immediately notify Project Manager. Provide supports for collar or welds. Discuss with Pipeline Company’s representative and determine methods of supporting collar or weld during excavation and later backfilling operations. When collar is exposed, request Pipeline Company to provide welder in a timely manner to weld ends of collar prior to backfilling of excavation.

M. Excavation and shoring requirements for proposed work or utility installation adjacent to or across a LDWL:

1. Identify LDWL area in field and barricade off from construction activities. Allow no construction related activities including, but not limited to, loading of dump trucks and material staging or storage, on top of LDWL.

2. Employ a groundwater control system when performing excavation activities within ten feet of LDWL to:

   a. Effectively reduce hydrostatic pressure affecting excavations.

   b. Develop substantially dry and stable subgrade for subsequent construction operations.

   c. Prevent loss of fines, seepage, boils, quick condition or softening of foundation strata.

   d. Maintain stability of sides and bottom of excavations.

3. When edge of proposed trench or shoring is within a distance equal to one diameter of LDWL from outside of wall of LDWL, valve or appurtenance:

   a. Maintain minimum of four (4) feet horizontal clearance and minimum of two (2) feet vertical clearance between proposed utility and LDWL.

   b. Auger Construction.

      (1) Maintain minimum of four (4) feet horizontal clearance between proposed utility and LDWL.

      (2) Dry auger method required when auger hole is 12-inches and larger in diameter.

   c. Open Cut Construction and Auger pits

      (1) Perform hand excavation when within four (4) feet of LDWL.

      (2) Employ hydraulic or pneumatic Shoring System. Do not use vibratory or impact driven shoring or piling.

      (3) Expose no more than 30-feet of trench prior to backfilling.

      (4) A maximum of one (1) foot of vertical trench shall be un-braced at a time to maintain constant pressure on face of excavated soil.

      (5) Upon removal of Shoring System, inject flowable fill into void space left behind by Shoring System. Comply with Standard Specification 02322 - Flowable Fill.

   d. When edge of utility excavation is greater than one diameter of LDWL from outside wall of LDWL, use a shielding system as required by Project Manager and proposed utility standards and practices.

3.06 HANDLING EXCAVATED MATERIALS

A. Use only excavated materials, which are suitable as defined in this Section and conforming to Section 02320 - Utility Backfill Materials. Place material suitable for backfilling in stockpiles at distance from trench to prevent slides or cave-ins.

B. When required, provide additional Backfill material conforming to requirements of Section 02320 - Utility Backfill Materials.

C. Do not place stockpiles of excess excavated materials on streets and adjacent properties. Protect Backfill material to be used on site. Maintain site conditions in accordance with Section 01504 - Temporary Facilities and Controls. Excavate trench so that pipe is centered in trench. Do not obstruct sight distance for vehicles utilizing roadway or detours with stockpiled materials.

3.07 TRENCH FOUNDATION

A. Excavate bottom of trench to uniform grade to achieve stable trench conditions and satisfactory compaction of foundation or bedding materials.

B. When wet soil is encountered on trench bottom and dewatering system is not required, over excavate an additional 6-inches with approval by Project Manager. Place non-woven geotextile fabric and then compact 12-inches of crushed stone in one lift on top of fabric. Compact crushed stone with four passes of vibratory-type compaction equipment.

C. Perform over excavation, when directed by Project Manager, in accordance with Paragraph 3.07.B above. Removal of unstable or Unsuitable Material may be required if approved by Project Manager.

1. Even though Contractor has not determined material to be unsuitable, or

2. If unstable trench bottom is encountered and an adequate ground water control system is installed and operating according to Section 01578 - Control of Ground and Surface Water.

D. Place Trench Dams in Class I foundations in line segments longer than 100 feet between manholes and not less than one in every 500 feet of pipe placed. Install additional dams as needed to achieve workable construction conditions. Do not place Trench Dams closer than 5 feet from manholes.

3.08 PIPE EMBEDMENT, PLACEMENT, AND COMPACTION

A. Remove loose, sloughing, caving, or otherwise unsuitable soil from bottoms and sidewalls of trenches immediately prior to placement of embedment materials.

B. Place embedment including bedding, Haunching, and Initial Backfill as shown on Drawings.

C. For pipe installation, manually spread embedment materials around pipe to provide uniform bearing and side support when compacted. Protect flexible pipe from damage during placing of pipe zone bedding material. Perform placement and compaction directly against undisturbed soils in trench sidewalls, or against sheeting which is to remain in place.

D. Do not place Trench Shields or shoring within height of Embedment Zone unless means to maintain density of compacted embedment material are used. If moveable supports are used in Embedment Zone, lift supports incrementally to allow placement and compaction of material against undisturbed soil.

E. Place geotextile to prevent particle migration from in-situ soil into open-graded (Class I) embedment materials or drainage layers.

F. Do not damage coatings or wrappings of pipes during backfilling and compacting operations. When embedding coated or wrapped pipes, do not use crushed stone or other sharp, angular aggregates.

G. Place Haunching material manually around pipe and compact it to provide uniform bearing and side support. If necessary, hold small-diameter or lightweight pipe in place during compaction of haunch areas and placement beside pipe with sand bags or other suitable means.

H. Place electrical conduit, if used, directly on foundation without bedding.

I. Shovel in-place and compact embedment material using pneumatic tampers in restricted areas, and vibratory-plate compactors or engine-powered jumping jacks in unrestricted areas. Compact each lift before proceeding with placement of next lift. Water tamping is not allowed.

J. For water lines construction embedment, use bank run sand, concrete sand, gem sand, pea gravel, or crushed limestone as specified in Section 02320 - Utility Backfill Material. Adhere to the following subparagraph numbers 1 and 2.

1. Class I, II and III Embedment Materials:

    a. Maximum 6-inches compacted lift thickness.

    b. Compact to achieve minimum of 95 percent of maximum dry density as determined according to ASTM D 698.

    c. Moisture content to be within -3 percent to +5 percent of optimum as determined according to ASTM D 698, unless otherwise approved by Project Manager.

2. Cement Stabilized Sand (where required for special installations):

    a. Maximum 6-inches compacted thickness.

b. Compact to achieve minimum of 95 percent of maximum dry density as determined according to ASTM D 698.

c. Moisture content to be on dry side of optimum as determined according to ASTM D 698 but sufficient for effective hydration.

K. For Sanitary Sewers adhere to subparagraph number 1 and 2. For Storm Sewers provide cement stabilized sand Embedment per paragraph 2.

1. Class I Embedment Materials.

a. Maximum 6-inches compacted lift thickness.

b. Systematic compaction by at least two passes of vibrating equipment. Increase compaction effort as necessary to effectively embed pipe to meet deflection test criteria.

c. Moisture content as determined by Contractor for effective compaction without softening soil of trench bottom, foundation or trench walls.

2. Class II Embedment and Cement Stabilized Sand.

a. Maximum 6-inches compacted thickness.

b. Compaction by methods determined by Contractor to achieve minimum of 95 percent of maximum dry density as determined according to ASTM D 698 for Class II materials and according to ASTM D 558 for cement stabilized materials.

c. Moisture content of Class II materials within 3 percent of optimum as determined according to ASTM D 698. Moisture content of cement stabilized sands on dry side of optimum as determined according to ASTM D 558 but sufficient for effective hydration

L. Place Trench Dams in Class I embedment in line segments longer than 100 feet between manholes, and not less than one in every 500 feet of pipe placed. Install additional dams as needed to achieve workable construction conditions. Do not place Trench Dams closer than 5 feet from manholes.

3.09 TRENCH ZONE BACKFILL PLACEMENT AND COMPACTION

A. Place Backfill for pipe or conduits and restore surface as soon as practicable. Leave only minimum length of trench open as necessary for construction.

B. For water lines, under pavement and to within one foot back of curb, use Backfill materials described below:

1. For water lines 20-inches in diameter and smaller, use bank run sand or select Backfill materials up to pavement base or subgrade.

2. For water lines 24-inches in diameter and larger, Backfill with suitable on-site material (random Backfill) up to 12-inches below pavement base or subgrade. Place minimum of 12-inches of select Backfill below pavement base or subgrade.

C. For sewer pipes (Storm and Sanitary), use Backfill materials described by trench limits. For "Trench Zone Backfill" under pavement and to within one foot back of curb, use cement stabilized sand for pipes of nominal sizes 36-inches in diameter and smaller to level 12 inches below the pavement. For sewer pipes 42-inches in diameter and larger, under pavement or natural ground, backfill from 12-inches above top of pipe to 120 inches below pavement with suitable on-site material or Select Backfill. Use select Backfill for rigid pavements or flexible base material for asphalt pavements for 12-inch Backfill directly under pavement. For Backfill Materials reference Section 02320 - Utility Backfill Materials.

D. For Storm Sewers constructed of thermoplastic pipe Backfill shall not exceed 20 ft. in depth from the top of pipe to the pavement surface/ground surface.

E. Unless otherwise shown in the plans or permitted in writing, do not use heavy earth-moving equipment over the structure until a minimum of 4 ft. of permanent or temporary compacted fill is placed over the top of the structure.

F. Where damage to completed pipe installation work is likely to result from withdrawal of sheeting, leave sheeting in place. Cut off sheeting 1.5 feet or more above crown of pipe. Remove trench supports within 5 feet from ground surface.

G. Compaction: Unless otherwise shown on Drawings, use Trench Zone Backfills under pavement and to within one foot of edge of pavement as required in 3.09. B, 3.09.C and 3.09.D. Place Trench Zone Backfill in lifts and compact. Fully compact each lift before placement of next lift.

1. Class I, II, or III or combination thereof:

   a. Place in maximum 12-inch thick loose layers.

   b. Compact by vibratory equipment to minimum of 95 percent of maximum dry density determined according to ASTM D 698.

   c. Moisture content within zero percent to 5 percent above optimum determined according to ASTM D 698, unless otherwise approved by Project Manager.

2. Cement-Stabilized Sand:

   a. Maximum lift thickness determined by Contractor to achieve uniform placement and required compaction, but do not exceed 12-inches.

   b. Compact by vibratory equipment to minimum of 95 percent of maximum dry density determined according to ASTM D 558.

c. Moisture content on dry side of optimum determined according to ASTM D 558 but sufficient for cement hydration.

3. Class IVA and IVB (Clay Soils):

a. Place in maximum 8-inch thick loose lifts.

b. Compaction by vibratory Sheepfoot roller to minimum of 95 percent of maximum dry density determined according to ASTM D 698.

c. Moisture content within zero percent to 5 percent above optimum determined according to ASTM D 698, unless approved by Project Manager.

H. Unless otherwise shown on Drawings, for trench excavations not under pavement, random backfill of Suitable Material may be used in Trench Zone. This provision does not apply to flexible pipe used for storm sewers.

1. Fat clays (CH) may be used as Trench Zone Backfill outside paved areas at Contractor's option. When required density is not achieved, at any additional cost to City, rework, dry out, use lime stabilization or other approved methods to achieve compaction requirements, or use different Suitable Material.

2. Maximum 9-inch compacted lift thickness for clayey soils and maximum 12-inch lift thickness for granular soils.

3. Compact to minimum of 90 percent of maximum dry density determined according to ASTM D 698.

4. Moisture content as necessary to achieve density.

I. For electric conduits, remove form work used for construction of conduits before placing Trench Zone Backfill.

3.10 MANHOLES, JUNCTION BOXES AND OTHER PIPELINE STRUCTURES

A. Below paved areas or where shown on Drawings, encapsulate manhole with cement stabilized sand; minimum of 2 foot below base, minimum 2 foot around walls, up to pavement subgrade or natural ground. Compact in accordance with Paragraph 3.09.F.2 of this Section.

B. In unpaved areas, use select fill for backfill. Existing material that qualifies as select material may be used, unless indicated otherwise on Drawings. Deposit Backfill in uniform layers and compact each layer as specified. Maintain Backfill Material at no less than 2 percent below nor more than 5 percent above optimum moisture content, unless otherwise approved by Project Manager. Place fill material in uniform 8-inch maximum loose layers. Compact fill to at least 95 percent of maximum Standard Proctor Density according to ASTM D 698.

C. For LDWL projects, encapsulate manhole with cement stabilized sand; minimum of 1 foot below base, minimum of 2 feet around walls, up to within 12 inches of pavement subgrade or natural ground. For manholes over water line, extend encapsulation to bottom of trench. Compact in accordance with Paragraph 3.09 F.2 of this Section.

3.11 FIELD QUALITY CONTROL

A. Test for material source qualifications as defined in Section 02320 - Utility Backfill Materials.

B. Provide excavation and trench safety systems at locations and to depths required for testing and retesting during construction at no additional cost to City.

C. Tests will be performed on minimum of three different samples of each material type for plasticity characteristics, in accordance with ASTM D 4318, and for gradation characteristics, in accordance with Tex-101-E and Tex-110-E. Additional classification tests will be performed whenever there is noticeable change in material gradation or plasticity, or when requested by Project Manager.

D. At least three tests for moisture-density relationships will be performed initially for Backfill materials in accordance with ASTM D 698, and for cement-stabilized sand in accordance with ASTM D 558. Perform additional moisture-density relationship tests once a month or whenever there is noticeable change in material gradation or plasticity.

E. In-place density tests of compacted Pipe Foundation, embedment and Trench Zone Backfill soil materials will be performed according to ASTM D 1556 or ASTM D 6938, and at following frequencies and conditions:

1. For open cut construction projects and auger pits: Unless otherwise approved by Project Manager, successful compaction to be measured by one test per 40 linear feet measured along pipe for compacted embedment and two tests per 40 linear feet measured along pipe for compacted Trench Zone Backfill material. Length of auger pits to be measured to arrive at 40 linear feet.

2. A minimum of three density tests for each full shift of Work.

3. Density tests will be distributed among placement areas. Placement areas are: foundation, outer bedding, Haunching, Initial Backfill and Trench Zone.

4. The number of tests will be increased if inspection determines that soil type or moisture content are not uniform or if compacting effort is variable and not considered sufficient to attain uniform density, as specified.

5. Density tests may be performed at various depths below fill surface by pit excavation. Material in previously placed lifts may therefore be subject to acceptance/rejection.

6. Two verification tests will be performed adjacent to in-place tests showing density less than acceptance criteria. Placement will be rejected unless both verification tests show acceptable results.

7. Recompacted placement will be retested at same frequency as first test series, including verification tests.

8. Identify elevation of test with respect to natural ground or pavement.

F. Recondition, recompact, and retest at Contractor's expense if tests indicate Work does not meet specified compaction requirements. For hardened soil cement with nonconforming density, core and test for compressive strength at Contractor's expense.

G. Acceptability of crushed rock compaction will be determined by inspection.

3.12 DISPOSAL OF EXCESS MATERIAL

A. Dispose of excess materials in accordance with requirements of Section 01576 – Waste Material Disposal.

END OF SECTION

SECTION 02318

EXTRA UNIT PRICE WORK FOR EXCAVATION AND BACKFILL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Measurement and payment applicable to extra unit price work items for excavation and backfill made necessary by unusual or unforeseen circumstances encountered during utility installations.

B. Extra unit price work for excavation and backfill is paid only when authorized in advance by Project Manager.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 02316 – Excavation and Backfill for Structures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02320 – Utility Backfill Materials

1.03 MEASUREMENT AND PAYMENT

A. UNIT PRICES

1. Excavation Around Obstructions: Payment for Excavation Around Obstructions is on cubic yard basis, measured in place, without deduction for volume occupied by portions of pipes, ducts, or other structures left in place across trenches excavated under this item.

2. Extra Hand Excavation: Payment for Extra Hand Excavation is on cubic yard basis, measured in place.

3. Extra Machine Excavation: Payment for Extra Machine Excavation is on cubic yard basis, measured in place.

4. Extra Placement of Backfill Material: Payment for Extra Placement of Backfill Material is on cubic yard basis, measured in place, for material installed as part of Work. At discretion of Project Manager, measurement of cubic yards may be calculated from volume of Extra Hand Excavation or Extra Machine Excavation for which replacement is made, minus volume of any Extra Placement of Granular Backfill authorized in conjunction with Work.

5. Extra Placement of Granular Backfill: Payment for Extra Placement of Granular Backfill material is on cubic yard basis, measured in place.

6. Extra Select Backfill: Payment for Extra Select Backfill is on cubic yard basis, measured in place for a theoretical minimum trench width. The Project Manager may authorize Extra Select Backfill when soil from the excavation work does not include adequate quantities for placement of suitable on-site material (random backfill).

7. Refer to Section 01270 – Measurement and payment for unit price procedures.

1.04 DEFINITIONS

A. Excavation Around Obstructions: Excavation necessitated by obstruction of pipes (other than service connections 3 inches in diameter or less), ducts, or other structures, not shown on Drawings, and of an unusual or unforeseen nature which interfere with installation of utility piping by normal methods of excavation or auguring.

B. Extra Hand Excavation: Excavation by manual labor made necessary by unusual or unforeseen circumstances at locations approved in advance by Project Manager.

C. Extra Machine Excavation: Excavation by machine at or near project site to perform related work not included in original project scope but added for convenience of City, as approved in advance by Project Manager.

D. Extra Replacement of Backfill Material: Handling, backfill, and compaction of excavated material authorized under extra work bid items for Extra Hand Excavation or Extra Machine Excavation. Placement and compaction shall conform to requirements specified for excavation and backfill in Sections 02316 – Excavation and Backfill for Structures and 02317 – Excavation and Backfill for Utilities.

E. Extra Placement of Granular Backfill: Hauling, placing, and compacting granular backfill materials as approved by Project Manager in conjunction with Extra Replacement of Backfill Material. Materials placed under this item shall conform to requirements for Bank Run Sand, Cement Stabilized Sand, Concrete Sand, Gem Sand, Crushed Stone, or Crushed Concrete specified for backfill material in Sections 02316 – Excavation and Backfill for Structures and 02317 – Excavation and Backfill for Utilities.

F. Extra Select Backfill: Unsuitable material removed from the project and select backfill material hauled to the project, or conditioning unsuitable material on the site to make it select backfill. Provide select backfill material specified in Section 02320 – Utility Backfill Materials.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION - NOT USED

END OF SECTION

SECTION 02319

BORROW

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Soil materials for embankment or backfill.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 01555 – Traffic Control and Regulation

E. Section 02330 – Embankment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for borrow is on cubic yard basis calculated by theoretical quantities using average end area method based on Drawings.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM D 2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

B. ASTM D 4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit location and description of proposed borrow area for approval.

C. Submit material samples for testing.

PART 2 PRODUCTS

2.01 SOIL MATERIAL

A. Grade borrow material used for embankment or backfill free of lumps greater than 6 inches, rocks larger than 3 inches, organic material, chemical waste or other contamination, and debris. Take borrow material from sources approved by Project Manager.

B. Use material with plasticity index not less than 12, nor more than 20 when tested in accordance with ASTM D 4318. Maximum liquid limit shall be 45, unless approved by Project Manager. Do not use blend of cohesive and granular soils to achieve required plasticity index

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Project Manager and testing laboratory 5 days in advance of opening borrow source to permit obtaining samples for qualification testing. When material does not meet specification requirements, locate another source of borrow.

B. Clear approved source area of trees, stumps, brush, roots, vegetation, organic matter, and other unacceptable material before excavation.

3.02 TESTS

A. Test and analyze soil materials in accordance with ASTM D 4318 and ASTM D 2216 under provisions of Section 01454 - Testing Laboratory Services.

3.03 EXCAVATION

A. Provide adequate drainage of surface water so that surface water run off does not enter borrow pit excavation.

3.04 HAULING

A. Use covered trucks. Conform to requirements of Section 01555 - Traffic Control and Regulation.

3.05 EMBANKMENT

A. Conform to requirements of Section 02330 - Embankment.

END OF SECTION

SECTION 02320

UTILITY BACKFILL MATERIALS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Material Classifications.

B. Utility Backfill Materials:

1. Concrete sand
2. Gem sand
3. Pea gravel
4. Crushed stone
5. Crushed concrete
6. Bank run sand
7. Select backfill
8. Random backfill
9. Cement stabilized sand

C. Material Handling and Quality Control Requirements.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 02316 – Excavation and Backfill for Structures

E. Section 02317 – Excavation and Backfill for Utilities

F. Section 02318 – Extra Unit Price Work Price Work for Excavation and Backfill

G. Section 02321 – Cement Stabilized Sand

H. Section 02711 – Hot Mix Asphalt Base Course

I. Section 02712 – Cement Stabilized Base Course

J. Section 02713 – Recycled Crushed Concrete Base Course

K. Section 02951 – Pavement Repair and Restoration

L. Section 03315 – Concrete for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for backfill material. Include payment in unit price for applicable utility installation.

2. Payment for backfill material, when included as separate pay item or when directed by Project Manager, is on cubic yard basis for material placed and compacted within theoretical trench width limits and thickness of material according to Drawings, or as directed by Project Manager.

3. Payment for backfill of authorized over-excavation is in accordance with Section 02318 - Extra Unit Price Work for Excavation and Backfill.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

A. Unsuitable Material:

1. Materials classified as ML, CL-ML, MH, PT, OH, and OL according to ASTM D 2487.

2. Materials that cannot be compacted to required density due to gradation, plasticity, or moisture content.

3. Materials containing large clods, aggregates, or stones greater than 4 inches in any dimension; debris, vegetation, or waste; or any other deleterious materials.

4. Materials contaminated with hydrocarbons or other chemical contaminants.

B. Suitable Material:

1. Materials meeting specification requirements.

2. Unsuitable materials meeting specification requirements for suitable soils after treatment with lime or cement.

C. Foundation Backfill Materials: Natural soil or manufactured aggregate meeting Class I requirements and geotextile filter fabrics as required, to control drainage and material separation. Foundation backfill material is placed and compacted as backfill where needed to provide stable support for structure Foundation Base. Foundation Backfill Materials may include concrete fill and seal slabs.

D. Foundation Base: Crushed stone aggregate with filter fabric as required, cement stabilized sand, or concrete seal slab. Foundation Base provides smooth, level working surface for construction of concrete Foundation.

E. Backfill Material: Classified soil material meeting specified quality requirements for designated application as embedment or Trench Zone Backfill.

F. Embedment Material: Soil material placed under controlled conditions within embedment zone extending vertically upward from top of Foundation to an elevation 12 inches above top of pipe, and including pipe bedding, haunching and initial backfill.

G. Trench Zone Backfill: Classified soil material meeting specified quality requirements and placed under controlled conditions in trench zone from top of embedment zone to base course in paved areas or to surface grading material in unpaved areas.

H. Foundation: Either suitable soil of trench bottom or material placed as backfill of over- excavation for removal and replacement of unsuitable or otherwise unstable soils.

I. Source: Source selected by Contractor for supply of embedment or trench zone Backfill Material. Selected Source may be Project excavation, off-site borrow pits, commercial borrow pits, or sand and aggregate production or manufacturing plants.

J. Refer to Section 02317 - Excavation and Backfill for Utilities for other definitions regarding utility installation by trench construction.

1.05 REFERENCES

A. ASTM C 33 - Standard Specification for Concrete Aggregates.

B. ASTM C 40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.

C. ASTM C 123 - Standard Test Method for Lightweight Particles in Aggregate.

D. ASTM C 131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in Los Angeles Machine.

E. ASTM C 136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

F. ASTM C 142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregates.

G. ASTM D 1140 - Standard Test Methods for Determining the Amount of Material Finer Than 75-µm (No. 200) Sieve in soils by Washing.

H. ASTM D 2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

I. ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

J. TxDOT Tex-110-E - Sieve Analysis of Soils and Base Materials

K. TxDOT Tex-460-A - Determining Crushed Face Particle count

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit description of Source, material classification and product description, production method, and application of Backfill Materials.

C. Submit test results for samples of off-site Backfill Materials. Comply with Paragraph 2.03, Material Testing.

D. Before stockpiling materials, submit copy of approval from landowner for stockpiling Backfill Material on private property.

E. Provide delivery ticket which includes Source location for each delivery of material that is obtained from off-site Sources or is being paid as specific bid item.

1.07 QUALITY ASSURANCE

A. Perform tests of Sources for Backfill Material in accordance with Paragraph 2.03B.

B. Verification tests of Backfill Materials may be performed by City in accordance with Section 01454 - Testing Laboratory Services and in accordance with Paragraph 3.03.

PART 2 PRODUCTS

2.01 MATERIAL CLASSIFICATIONS

A. Classify materials for backfill for purpose of quality control in accordance with Unified Soil Classification Symbols as defined in ASTM D 2487. Material use and application is defined in utility installation specifications and Drawings either by class, as described in Paragraph 2.01B, or by product descriptions, as given in Paragraph 2.02.

B. Class Designations Based on Laboratory Testing:

1. Class I: Well-graded gravels and sands, gravel-sand mixtures, crushed well-graded rock, little or no fines (GW, SW):

   a. Plasticity index: non-plastic.

   b. Gradation: D60/D10 - greater than 4 percent; amount passing No. 200 sieve - less than or equal to 5 percent.

2. Class II: Poorly graded gravels and sands, silty gravels and sands, little to moderate fines (GM, GP, SP, SM):

   a. Plasticity index: non-plastic to 4.

   b. Gradations:

      (1) Gradation (GP, SP): amount passing No. 200 sieve - less than 5 percent.

      (2) Gradation (GM, SM): amount passing No. 200 sieve - between 12 percent and 50 percent.

      (3) Borderline gradations with dual classifications (e.g., SP-SM): amount passing No. 200 sieve - between 5 percent and 12 percent.

3. Class III: Clayey gravels and sands, poorly graded mixtures of gravel, sand, silt, and clay (GC, SC, and dual classifications, e.g., SP-SC):

   a. Plasticity index: greater than 7.

   b. Gradation: amount passing No. 200 sieve - between 12 percent and 50 percent.

4. Class IVA: Lean clays (CL).

   a. Plasticity Indexes:

      (1) Plasticity index: greater than 7, and above A line.

      (2) Borderline plasticity with dual classifications (CL-ML): PI between 4 and 7.

   b. Liquid limit: less than 50.

   c. Gradation: amount passing No. 200 sieve - greater than 50 percent.

   d. Inorganic.

5. Class IVB: Fat clays (CH)

   a. Plasticity index: above A line.

   b. Liquid limit: 50 or greater.

   c. Gradation: amount passing No. 200 sieve - greater than 50 percent.

   d. Inorganic.

6. Use soils with dual class designation according to ASTM D 2487, and which are not defined above, according to more restrictive class.

2.02 PRODUCT DESCRIPTIONS

A. Soils classified as silt (ML) silty clay (CL-ML with PI of 4 to 7), elastic silt (MH), organic clay and organic silt (OL, OH), and organic matter (PT) are not acceptable as Backfill Materials. These soils may be used for site grading and restoration in unimproved areas as approved by Project Manager. Soils in Class IVB, fat clay (CH) may be used as Backfill Materials where allowed by applicable backfill installation specification. Refer to Section 02316 - Excavation and Backfill for Structures and Section 02317 - Excavation and Backfill for Utilities.

B. Provide Backfill Material that is free of stones greater than 6 inches, free of roots, waste, debris, trash, organic material, unstable material, non-soil matter, hydrocarbon or other contamination, conforming to following limits for deleterious materials:

   1. Clay lumps: Less than 0.5 percent for Class I, and less than 2.0 percent for Class II, when tested in accordance with ASTM C 142.

   2. Lightweight pieces: Less than 5 percent when tested in accordance with ASTM C 123.

   3. Organic impurities: No color darker than standard color when tested in accordance with ASTM C 40.

C. Manufactured materials, such as crushed concrete, may be substituted for natural soil or rock products where indicated in product specification, and approved by Project Manager, provided that physical property criteria are determined to be satisfactory by testing.

D. Bank Run Sand: Durable bank run sand classified as SP, SW, or SM by Unified Soil Classification System (ASTM D 2487) meeting following requirements:

   1. Less than 15 percent passing number 200 sieve when tested in accordance with ASTM D 1140. Amount of clay lumps or balls may not exceed 2 percent.

   2. Material passing number 40 sieve shall meet the following requirements when tested in accordance with ASTM D 4318: Plasticity index: not exceeding 7.

E. Concrete Sand: Natural sand, manufactured sand, or combination of natural and manufactured sand conforming to requirements of ASTM C 33 and graded within following limits when tested in accordance with ASTM C 136:

Sieve	Percent Passing
3/8"	100
No. 4	95 to 100
No. 8	80 to 100
No. 16	50 to 85
No. 30	25 to 60
No. 50	10 to 30
No. 100	2 to 10

F. Gem Sand: Sand conforming to requirements of ASTM C 33 for course aggregates specified for number 8 size and graded within the following limits when tested in accordance with ASTM C 136:

Sieve	Percent Passing
3/8”	95 to 100
No. 4	60 to 80
No. 8	15 to 40

G. Pea Gravel: Durable particles composed of small, smooth, rounded stones or pebbles and graded within the following limits when tested in accordance with ASTM C 136:

Sieve	Percent Passing
1/2”	100
3/8”	85 to 100
No. 4	10 to 30
No. 8	0 to 10
No. 16	0 to 5

H. Crushed Aggregates: Crushed aggregates consist of durable particles obtained from an approved Source and meeting the following requirements:

1. Materials of one product delivered for same construction activity from single Source, unless otherwise approved by Project Manager.

2. Non-plastic fines.

3. Los Angeles abrasion test wear not exceeding 45 percent when tested in accordance with ASTM C 131.

4. Crushed aggregate shall have minimum of 90 percent of particles retained on No. 4 sieve with 2 or more crushed faces as determined by Tex-460-A, Part I.

5. Crushed stone: Produced from oversize plant processed stone or gravel, sized by crushing to predominantly angular particles from naturally occurring single Source. Uncrushed gravel is not acceptable materials for embedment where crushed stone is shown on applicable utility embedment drawing details.

6. Crushed Concrete: Crushed concrete is an acceptable substitute for crushed stone as utility backfill. Gradation and quality control test requirements are same as crushed stone. Provide crushed concrete produced from normal weight concrete of uniform quality; containing particles of aggregate and cement material, free from other substances such as asphalt, reinforcing steel fragments, soil, waste gypsum (calcium sulfate), or debris.

7. Gradations, as determined in accordance with Tex-110-E.

Sieve	Percent Passing by Weight for Pipe Embedment by Ranges of Nominal Pipes Sizes		
	>15"	15" - 8"	<8"
1"	95 - 100	100	-
3/4"	60 - 90	90 - 100	100
1/2"	25 - 60	-	90 - 100
3/8"	-	20 - 55	40 - 70
No. 4	0 - 5	0 - 10	0 - 15
No. 8	-	0 - 5	0 - 5

I. Select Backfill: Class III clayey gravel or sand or Class IV lean clay with plasticity index between 7 and 20 or clayey soils treated with lime in accordance with Section 02951 - Pavement Repair and Restoration to meet plasticity criteria.

J. Random Backfill: Any suitable soil or mixture of soils within Classes I, II, III and IV; or fat clay (CH) where allowed by applicable backfill installation specification. Refer to Section 02316 - Excavation and Backfill for Structures and Section 02317 - Excavation and Backfill for Utilities.

K. Cement Stabilized Sand: Conform to requirements of Section 02321 - Cement Stabilized Sand.

L. Concrete Backfill: Conform to Class B concrete as specified in Section 03315 - Concrete for Utility Construction.

M. Flexible Base Course Material: Conform to requirements of applicable portions of Section 02711 - Hot Mix Asphaltic Base Course, Section 02712 - Cement Stabilized Base Course, and Section 02713 - Recycled Crushed Concrete Base Course.

2.03 MATERIAL TESTING

A. Source Qualification. Perform testing to obtain tests by suppliers for selection of material Sources and products not from the Project site. Test samples of processed materials from current production representing material to be delivered. Use tests to verify that materials meet specification requirements. Repeat qualification test procedures each time Source characteristics change or there is planned change in Source location or supplier. Include the following qualification tests, as applicable:

1. Gradation. Report complete sieve analyses regardless of specified control sieves from largest particle through No. 200 sieve.

2. Plasticity of material passing No. 40 sieve

3. Los Angeles abrasion wear of material retained on No. 4 sieve

4. Clay lumps

5. Lightweight pieces

6. Organic impurities

B. Production Testing. Provide reports to Project Manager from an independent testing laboratory that Backfill Materials to be placed in Work meet applicable specification requirements.

C. Assist Project Manager in obtaining material samples for verification testing at Source or at production plant.

PART 3 EXECUTION

3.01 SOURCES

A. Use of existing material in trench excavations is acceptable, provided applicable specification requirements are satisfied.

B. Identify off-site Sources for Backfill Materials at least 14 days ahead of intended use so that Project Manager may obtain samples for verification testing.

C. Materials may be subjected to inspection or additional verification testing after delivery. Materials which do not meet requirements of specifications will be rejected. Do not use material which, after approval, has become unsuitable for use due to segregation, mixing with other materials, or by contamination. Once material is approved by Project Manager, expense for sampling and testing required to change to different material will be credited to City through change order.

D. Bank run sand, select backfill, and random backfill, if available in Project excavation, may be obtained by selective excavation and acceptance testing. Obtain additional quantities of these materials and other materials required to complete Work from off-site Sources.

E. City does not represent or guarantee that any soil found in excavation work will be suitable and acceptable as Backfill Material.

3.02 MATERIAL HANDLING

A. When Backfill Material is obtained from either commercial or non-commercial borrow pit, open pit to expose vertical faces of various strata for identification and selection of approved material to be used. Excavate selected material by vertical cuts extending through exposed strata to achieve uniformity in product.

B. Establish temporary stockpile locations for practical material handling, control, and verification testing by Project Manager in advance of final placement. Obtain approval from landowner for storage of Backfill Material on adjacent private property.

C. When stockpiling Backfill Material near Project site, use appropriate covers to eliminate blowing of materials into adjacent areas and prevent runoff containing sediments from entering drainage system.

D. Place stockpiles in layers to avoid segregation of processed materials. Load material by making successive vertical cuts through entire depth of stockpile.

3.03 FIELD QUALITY CONTROL

A. Quality Control

1. The Project Manager may sample and test backfill at:

   a. Sources including borrow pits, production plants and Contractor's designated off-site stockpiles.

   b. On-site stockpiles.

   c. Materials placed in Work.

2. The Project Manager may re-sample material at any stage of Work or location if changes in characteristics are apparent.

B. Production Verification Testing: City's testing laboratory will provide verification testing on Backfill Materials, as directed by Project Manager. Samples may be taken at Source or at production plant, as applicable.

END OF SECTION

SECTION 02321

CEMENT STABILIZED SAND

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Cement stabilized sand.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 - Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 02320 – Utility Backfill Materials

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for work performed under this Section. Include cost of such work in Contract unit prices for items listed in bid form requiring cement stabilized sand.

2. Refer to Paragraph 3.04 for material credit.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 33 - Standard Specification for Concrete Aggregates.

B. ASTM C 40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.

C. ASTM C 42 - Standard Test Methods for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

D. ASTM C 94 - Standard Specification for Ready-Mixed Concrete.

E. ASTM C 123 - Standard Test Method for Lightweight Particles in Aggregate.

F. ASTM C 142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregates.

G. ASTM C 150 - Standard Specification for Portland Cement.

H. ASTM D 558 - Standard Test Method for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures.

I. ASTM D 1632 - Standard Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory.

J. ASTM D 1633 - Standard Test Method for Compressive Strength of Molded Soil-Cement Cylinders.

K. ASTM D 2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

L. ASTM D 3665 - Standard Practice for Random Sampling of Construction Materials.

M. ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit proposed target cement content and production data for sand-cement mixture in accordance with requirements of Paragraph 2.03, Materials Qualifications.

1.06 DESIGN REQUIREMENTS

A. Use sand-cement mixture producing minimum unconfined compressive strength of 100 pounds per square inch (psi) in 48 hours.

1. Design will be based on strength specimens molded in accordance with ASTM D 558 at moisture content within 3 percent of optimum and within 4 hours of batching.

2. Determine minimum cement content from production data and statistical history. Provide no less than 1.1 sacks of cement per ton of dry sand.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cement: Type I Portland cement conforming to ASTM C 150.

B. Sand: Clean, durable sand meeting grading requirements for fine aggregates of ASTM C 33, or requirements for bank run sand of Section 02320 - Utility Backfill Materials, and the following requirements:

1. Classified as SW, SP, SW-SM, SP-SM, or SM by Unified Soil Classification System of ASTM D 2487.

2. Deleterious materials:

a. Clay lumps, ASTM C 142 - less than 0.5 percent.

b. Lightweight pieces, ASTM C 123; less than 5.0 percent.

c. Organic impurities, ASTM C 40, color no darker than standard color.

3. Plasticity index of 4 or less when tested in accordance with ASTM D 4318.

C. Water: Potable water, free of oils, acids, alkalies, organic matter or other deleterious substances, meeting requirements of ASTM C 94.

2.02 MIXING MATERIALS

A. Add required amount of water and mix thoroughly in pugmill-type mixer.

B. Stamp batch ticket at plant with time of loading. Reject material not placed and compacted within 4 hours after mixing.

2.03 SOURCE QUALITY CONTROL

A. Determine target cement content of material as follows:

1. Obtain samples of sand-cement mixtures at production facility representing range of cement content consisting of at least three points.

2. Complete molding of samples within 4 hours after addition of water.

3. Perform compressive strength tests (average of two specimens) at 48 hours and 7 days.

4. Perform cement content tests on each sample.

5. Perform moisture content tests on each sample.

6. Plot average 48-hour strength vs. cement content.

7. Record scale calibration date, sample date, sample time, molding time, cement feed dial settings, and silo pressure (if applicable).

B. Test raw sand for following properties at point of entry into pug-mill:

1. Gradation
2. Plasticity index
3. Organic impurities
4. Clay lumps and friable particles
5. Lightweight pieces
6. Moisture content
7. Classification

C. Present data obtained in format similar to that provided in sample data form attached to this Section.

D. The target content may be adjusted when statistical history so indicates. For determination of minimum product performance use formula:

f'c% 1/2 standard deviation

PART 3 EXECUTION

3.01 PLACING

A. Place sand-cement mixture in maximum 12-inch-thick loose lifts and compact to 95 percent of maximum density as determined in accordance with ASTM D 558, unless otherwise specified. Refer to related specifications for thickness of lifts in other applications. Target moisture content during compaction is +3 percent of optimum. Perform and complete compaction of sand-cement mixture within 4 hours after addition of water to mix at plant.

B. Do not place or compact sand-cement mixture in standing or free water.

C. Where potable water lines cross wastewater line, embed wastewater line with cement stabilized sand in accordance with Texas Administrative Code §290.44(e)(4)(B):

1. Provide minimum of 10% cement per cubic yard of cement stabilized sand mixture, based on loose dry weight volume. Use at least 2.5 bags of cement per cubic yard of mixture (2 sacks per ton of dry sand).
2. Unless otherwise shown on Drawings, embed wastewater main or lateral minimum of six inches above and below.
3. Use brown coloring in cement stabilized sand for wastewater main or lateral bedding for identification of pressure rated wastewater mains during future construction.

3.02 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. One sample of cement stabilized sand shall be obtained for each 150 tons of material placed per day with no less than one sample per day of production. Random samples of delivered cement stabilized sand shall be taken in the field at point of delivery in accordance with ASTM 3665. Obtain three individual samples of approximately 12 to 15 lb each from the first, middle, and last third of the truck and composite them into one sample for test purpose.

C. Prepare and mold four specimens (for each sample obtained) in accordance with ASTM D 558, Method A, without adjusting moisture content. Samples will be molded at approximately same time material is being used, but no later than 4 hours after water is added to mix.

D. After molding, specimens will be removed from molds and cured in accordance with ASTM D 1632.

E. Specimens will be tested for compressive strength in accordance with ASTM D 1633, Method A. Two specimens will be tested at 48 hours plus or minus 2 hours and two specimens will be tested at 7 days plus or minus 4 hours.

F. A strength test will be average of strengths of two specimens molded from same sample of material and tested at same age. Average daily strength will be average of strengths of all specimens molded during one day's production and tested at same age.

G. Precision and Bias: Test results shall meet recommended guideline for precision in ASTM D 1633.

H. Reporting: Test reports shall contain, as a minimum, the following information:

1. Supplier and plant number
2. Time material was batched
3. Time material was sampled
4. Test age (exact hours)
5. Average 48-hour strength
6. Average 7-day strength
7. Specification section number
8. Indication of compliance / non-compliance
9. Mixture identification

10. Truck and ticket numbers

11. The time of molding

12. Moisture content at time of molding

13. Required strength

14. Test method designations

15. Compressive strength data as required by ASTM D 1633

16. Supplier mixture identification

17. Specimen diameter and height, in.

18. Specimen cross-sectional area, sq. in.

3.03 ACCEPTANCE

A. Strength level of material will be considered satisfactory if:

1. The average 48-hour strength is greater than 100 psi with no individual strength test below 70 psi.

2. All 7-day individual strength tests (average of two specimens) are greater than or equal to 100 psi.

B. Material will be considered deficient when 7-day individual strength test (average of two specimens) is less than 100 psi but greater than 70 psi. See Paragraph 3.04 Adjustment for Deficient Strength.

C. The material will be considered unacceptable and subject to removal and replacement at Contractor's expense when individual strength test (average of two specimens) has 7-day strength less than 70 psi.

D. When moving average of three daily 48-hour averages falls below 100 psi, discontinue shipment to Project until plant is capable of producing material, which exceeds 100 psi at 48 hours. Five 48-hour strength tests shall be made in this determination with no individual strength tests less than 100 psi.

E. Testing laboratory shall notify Contractor, Project Manager, and material supplier by facsimile of tests indicating results falling below specified strength requirements within 24 hours.

F. If any strength test of laboratory cured specimens falls below the specified strength, Contractor may, at Contractor's own expense, request test of cores drilled from the area in question in accordance with ASTM C42. In such cases, three (3) cores shall be taken for each strength test that falls below the values given in 3.03.A.

G. Cement stabilized sand in an area represented by core tests shall be considered satisfactory if the average of three (3) cores is equal to at least 100 psi and if no single core is less than 70 psi. Additional testing of cores extracted from locations represented by erratic core strength results will be permitted.

3.04 ADJUSTMENT FOR DEFICIENT STRENGTH

A. When mixture produces 7-day compressive strength greater than or equal to 100 psi, then material will be considered satisfactory and bid price will be paid in full.

B. When mixture produces 7-day compressive strength less than 100 psi and greater than or equal to 70 psi, material shall be accepted contingent on credit in payment. Compute credit by the following formula:

$$\text{Credit per Cubic Yard} = \frac{\$30.00 \times 2\ (100\ \text{psi} - \text{Actual psi})}{100}$$

C. When mixture produces 7-day compressive strength less than 70 pounds per square inch, then remove and replace cement-sand mixture and paving and other necessary work at no cost to City.

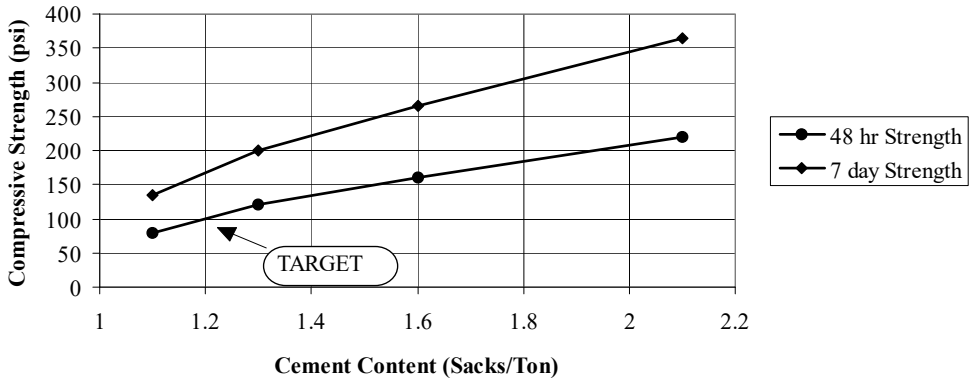
Supplier: City Stabilized Sand	Plant No: 1 - Main Street	Date of Tests: January 1, 1997

Item	Raw Sand	1.1 Sack	100 psi	1.5 Sack	2.0 Sack
Moisture Content	10.9	15.7	14.0	13.8	13.7
Cement Feed Dial Setting	--	2.25	2.5	2.75	3.75
Silo Pressure (psi)	--	4	4	4	4
Batch Time	10:00	10:10	10:15	10:20	10:25
Sample Time	--	10:10	10:15	10:20	10:25
Molding Time	--	12:30	12:45	1:00	1:15
Cement Content (sacks/ton)	--	1.1	1.3	1.6	2.1
Compressive Strength at 48 hrs. (avg of 2)	--	80	120	160	220
Compressive Strength at 7 days (avg of 2)	--	135	200	265	365

Sieve size	Percent Passing	COH Spec. Section 02320
3/8 Inch	100	--
No. 16	100	--
No. 40	100	--
No. 50	99	--
No. 100	41	--
No. 200	11	0 to 15

Raw Sand Tests	Result	City of Houston
Plasticity Index	Non-Plastic	4 Maximum
Organic Impurities	Passing	No Darker Than
Clay Lumps & Friable Parts (%)	0.0	0.5 % Maximum
Lightweight Pieces (%)	0.0	5.0 % Maximum
Classification	SP-SM	SW, SP, SW-SM, SP-SM, SM

Compressive Strength vs Cement Content



END OF SECTION

SECTION 02322

FLOWABLE FILL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnishing, mixing, transporting and placing flowable fill.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 02120 – Off-Site Transportation and Disposal

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for flowable fill under this Section. Include cost in unit prices for work, as specified in Section 01270 – Measurement and Payment.

1.04 REFERENCES

A. ASTM C 31 – Standard Practice for Making and Curing Concrete Test Specimens in the Field.

B. ASTM C 39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

C. ASTM C 40 – Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.

D. ASTM C 94 - Standard Specification for Ready-Mixed Concrete.

E. ASTM C 150 - Standard Specification for Portland Cement.

F. ASTM C 260 – Standard Specification for Air-Entraining Admixtures for Concrete.

G. ASTM C 494 - Standard Specification for Chemical Admixtures for Concrete.

H. ASTM C 618 – Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

I. ASTM D 4318 – Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures

B. Submit proposed mix design

C. Submit a copy of delivery tickets accompanied by batch tickets, providing the information required by ASTM C 94 to Project Manager in the field at time of delivery.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide material conforming to:

1. Cement- ASTM C 150, Type I.

2. Fly Ash – ASTM C 618, Class C, with a minimum CaO content of 20 percent.

3. Water- ASTM C 94.

4. Fine Aggregate – Natural or manufactured fine aggregate, or a combination there of, free from deleterious amounts of salt, alkali, vegetable matter or other objectionable material. The plasticity index shall be 4 or less when tested in accordance with ASTM D 4318. Organic impurities, when tested in accordance with ASTM C 40, shall not show a color darker than the standard color. It is intended that the fine aggregate be fine enough to stay in suspension in the mortar to the extent required for proper flow. The fine aggregate shall conform to the following gradation:

Sieve Size	Percent Passing
3/8 inch	100
No. 200	0-10

5. If flowable mixture cannot be produced, the fine aggregate may not be approved.

6. Admixtures – ASTM C 260 and /or C 494.

2.02 MIX DESIGN

A. Mix design shall state the following information:

1. Mix design number or code designation to order the concrete from the supplier.

2. Design strength at 7 days (unless otherwise noted on the Plans).

3. Cement type and brand.

4. Fly ash type and brand.

5. Admixtures type and brand.

6. Proportions of each material used.

B. Minimum strength requirement is 100 psi in 7 days unless otherwise noted on the Plans.

PART 3 EXECUTION

3.01 BATCHING, MIXING AND TRANSPORTATION

A. Batch, mix and transport flowable fill in accordance with ASTM C 94, except when directed otherwise by the Project Manager.

B. Mix flowable fill in quantities required for immediate use. Do not use portions which have developed initial set or which are not in place within 90 minutes after the initial water has been added.

C. Do not mix flowable fill while the air temperature is at or below 35 degrees F. without prior approval of the Project Manager.

3.02 PLACEMENT

A. Seal off the area to be repaired.

B. Monitor and control the fluid pressure during placement of flowable fill prior to set. Take appropriate measures to avoid excessive pressure that may damage or displace structures or cause flotation. Cease operations if flowable fill is observed leaking from the repair area. Repair or replace damaged or displaced structures at no additional cost.

3.03 TESTING AND INSPECTION

A. Refer to Section 01454 – Testing Laboratory Services.

3.04 CLEAN UP

A. Clean up excess flowable fill discharged from the work area and remove excess flowable fill from pipes at no additional cost.

B. Refer to Section 02120 – Off-Site Transportation and Disposal.

END OF SECTION

SECTION 02330

EMBANKMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Construction of embankments with excess excavated material and borrow.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01454 – Testing Laboratory Services

C. Section 01576 – Waste Material Disposal

D. Section 02315 – Roadway Excavation

E. Section 02316 – Excavation and Backfill for Structures

F. Section 02317 – Excavation and Backfill for Utilities

G. Section 02319 – Borrow

H. Section 02320 – Utility Backfill Materials

I. Section 02511 – Water Lines

J. Section 02531 – Gravity Sanitary Sewers

K. Section 02532 – Sanitary Sewer Force Mains

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for embankment under this section. Include payment in unit price for excavation or borrow.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soils Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).

B. ASTM D 6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

PART 2 PRODUCTS`

2.01 MATERIALS

A. Refer to Section 02315 - Roadway Excavation for acceptable excess materials from roadway excavation.

B. Refer to Section 02317 - Excavation and Backfill for Utilities for acceptable excess materials from utility excavation and trenching.

C. Refer to Section 02319 - Borrow for acceptable borrow materials.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify borrow and excess excavated materials to be reused are approved.

B. Verify removals and clearing and grubbing operations have been completed.

3.02 PREPARATION

A. Backfill test pits, stump holes, small swales and other surface irregularities. Backfill and compact in designated lift depths to requirements for embankment compaction.

B. Record location and plug and fill inactive water and oil wells. Conform to Texas State Health Department, Texas Commission on Environmental Quality and Texas Railroad Commission requirements. Notify City Engineer prior to plugging wells.

C. Excavate and dispose of unsuitable soil and other unsuitable materials which will not consolidate. Backfill and compact to requirements for embankment. Unsuitable soil is defined in Section 02316 - Excavation and Backfill for Structures and Section 02320 - Utility Backfill Materials.

D. Backfill new utilities below future grade. Conform to requirements of Sections 02317 - Excavation and Backfill For Utilities, 02511 - Water Lines, 02531 - Gravity Sanitary Sewers, and 02532 - Sanitary Sewer Force Mains.

3.03 PROTECTION

A. Protect trees, shrubs, lawns, existing structures, and other features outside of embankment limits.

B. Protect utilities above and below grade, which are to remain.

C. Conform to protection requirements of Section 02315 - Roadway Excavation.

3.04 PLACING EMBANKMENT

A. Do not conduct placement operations during inclement weather or when existing ground or fill materials exceed 3 percent of optimum moisture content. Contractor may manipulate wet material to facilitate drying, by disking or windrowing.

B. Do not place embankment fill until density and moisture content of previously placed material comply with specified requirements.

C. Scarify areas to be filled to minimum depth of 4 inches to bond existing and new materials. Mix with first fill layer.

D. Spread fill material evenly, from dumped piles or windrows, into horizontal layers approximately parallel to finished grade. Place to meet specified compacted thickness. Break clods and lumps and mix materials by blading, harrowing, disking or other approved method. Extend each layer across full width of fill.

E. Each layer shall be homogeneous and contain uniform moisture content before compaction. Mix dissimilar abutting materials to prevent abrupt changes in composition of fill.

F. Layers shall not exceed the following compacted thickness:

1. Areas indicated to be under future paving or shoulders, to be constructed within 6 months: 6 inches when compacted with pneumatic rollers, or 8 inches when compacted with other rollers.

2. Other areas: 12 inches

G. For steep slopes, cut benches into slope and scarify before placing fill. Place increasingly wider horizontal layers of specified depth to level of each bench.

H. Build embankment layers on back slopes, adjacent to existing roadbeds, to level of old roadbed. Scarify top of old roadbed to minimum depth of 4 inches and recompact with next fill layer.

I. Construct to lines and grades shown on Drawings.

J. Remove unsuitable material and excess soil not being used for embankment from site in accordance with requirements of Section 01576 - Waste Material Disposal.

K. Maintain moisture content of embankment materials to attain required density.

L. Compact to following minimum densities at moisture content of optimum to 3 percent above optimum as determined by ASTM D 698, unless otherwise indicated on Drawings:

1. Areas under future paving and shoulders: Minimum density of 95 percent of maximum dry density.

2. Other areas: Minimum density of 90 percent of maximum dry density.

3.05 TOLERANCES

A. Top of compacted surface: Plus or minus 1/2 inch in cross section or 16 foot length.

3.06 FIELD QUALITY CONTROL

A. Compaction Testing will be performed in accordance with ASTM D 698 or ASTM D 6938 under provisions of Section 01454 - Testing Laboratory Services.

B. A minimum of three tests will be taken for each 1000 linear feet per lane of roadway or 500 square yards of embankment per lift.

C. If tests indicate work does not meet specified compaction requirements, recondition, recompact, and retest at no cost to City.

END OF SECTION

SECTION 02336

LIME STABILIZED SUBGRADE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Foundation course of lime stabilized subgrade material.

1. Application of lime slurry to subgrade.

2. Mixing, compaction, and curing of lime slurry, water, and subgrade into a stabilized foundation.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Measurement and payment for lime stabilized subgrade is on a square yard basis compacted in place to proper density. Separate measurement will be made for each required thickness of subgrade course.

a. Limits of measurement shall match actual pavement replaced, but no greater than maximum pavement replacement limits shown on Drawings. Limits for measurement will be extended to include installed lime stabilized subgrade material that extends 2 feet beyond outside edge of pavement to be replaced, except where proposed pavement section shares common longitudinal or transverse edge with existing pavement section. No payment will be made for lime stabilized subgrade in areas beyond these limits.

b. Limits of measurement and payment shall match pavement replacement limits shown on Drawings, except as noted in Paragraph 1.03.A.1.a, or as approved by Project Manager.

2. Measurement and payment for lime is by ton of 2000 pounds dry weight basis. Calculate weight of dry solids for lime slurry based on percentage by dry weight solids.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 DEFINITION

A. Moist Cure: Curing soil and lime to obtain optimum hydration.

B. 1000-Foot Roadway Section: 1000 feet per lane width or approximately 500 square yards of compacted subgrade for other than full-lane-width roadway sections.

1.05 REFERENCES

A. ASTM D 698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3).

B. ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

C. ASTM D 6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

D. TxDOT Tex-101-E (Part III) - Preparing and Testing Soils and Base Materials.

E. TxDOT Tex-140-E - Measuring Depth of Compacted Base and Treated Materials.

F. TxDOT Tex-600-J - Sampling and Testing Hydrated Lime, Quicklime, and Commercial Lime Slurry.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certification that hydrated lime, quicklime, or commercial lime slurry complies with specifications.

C. Submit weight tickets, certified by supplier, with each bulk delivery of lime to work site.

1.07 DELIVERY, STORAGE AND HANDLING

A. Bagged lime shall bear manufacturer's name, product identification, and certified weight. Bags varying more than 5 percent of certified weight may be rejected; average weight of 50 random bags in each shipment shall not be less than certified weight.

B. Store lime in weatherproof enclosures. Protect lime from ground dampness.

PART 2 PRODUCTS

2.01 WATER

A. Use clean, clear water, free from oil, acids, alkali, or vegetation.

2.02 LIME

A. Type A - Hydrated Lime: Dry material consisting essentially of calcium hydroxide or mixture of calcium hydroxide and an allowable percentage of calcium oxide as listed in chemical composition chart.

B. Type B - Commercial Lime Slurry: Liquid mixture consisting essentially of lime solids and water in slurry form. Water or liquid portion shall not contain dissolved material in sufficient quantity to be injurious or objectionable for purpose intended.

C. Type C - Quicklime: Dry material consisting essentially of calcium oxide. Furnish quicklime in either of the following grades:

1. Grade DS: Pebble quicklime of gradation suitable for use in preparation of slurry for wet placing.

2. Grade S: Finely-graded quicklime for use in preparation of slurry for wet placing. Donor use grade S quicklime for dry placing.

D. Conform to the following requirements:

CHEMICAL COMPOSITION	TYPE		
	A	B	C
Active lime content, % by weight Ca(OH)2+CaO	90.0 min[1]	87.0 min[2]	-
Unhydrated lime content, % by weight CaO	5.0 max	-	87.0 min
Free water content, % by weight H2O :	5.0 max	-	-
SIZING			
Wet Sieve, as % by weight residue retained:			
No. 6	0.2 max	0.2 max[2]	8.0 max[3]
No. 30	4.0 max	4.0 max[2]	-
Dry sieve, as % by weight residue retained:			
1-inch	-	-	0.0
1/2-inch	-	-	10.0 max

Notes:
1. Maximum 5.0% by weight CaO shall be allowed in determining total active lime content.
2. Maximum solids content of slurry.
3. Total active lime content, as CaO, in material retained on No. 6 sieve shall not exceed 2.0% by weight of original Type C lime.

E. Deliver lime slurry to job site as commercial lime, or prepare at job site by using hydrated lime or quicklime. Provide slurry free of liquids other than water and of consistency that can be handled and uniformly applied without difficulty.

F. Lime containing magnesium hydroxide is prohibited.

2.03 SOIL.

A. Soil to receive lime treatment may include borrow or existing subgrade material, existing pavement structure, or combination of all three. Where existing pavement or base material is encountered, pulverized or scarify material so that 100 percent of sampled material passes 2- inch sieve.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify compacted subgrade will support imposed loads.

B. Verify subgrade lines and grades.

3.02 PREPARATION

A. Complete backfill of utilities prior to stabilization.

B. Cut material to bottom of subgrade using an approved cutting and pulverizing machine meeting following requirements:

1. Cutters accurately provide smooth surface over entire width of cut to plane of secondary grade.

2. Provide cut to depth as specified or shown in the Drawings.

C. Alternatively, scarify or excavate to bottom of stabilized subgrade. Remove material or windrow to expose secondary grade. Obtain uniform stability.

D. Correct wet or unstable material below secondary grade by scarifying, adding lime, and compacting as directed by Project Manager.

E. Pulverize existing material so that 100 percent passes a 1-3/4-inch sieve.

3.03 LIME SLURRY APPLICATION

A. Apply slurry with distributor truck equipped with an agitator to keep lime and water in consistent mixture. Make successive passes over measured section of roadway to attain proper moisture and lime content. Limit spreading to an area where preliminary mixing operations can be completed on same working day.

B. Minimum lime content shall be 5 percent of dry unit weight of subgrade as determined by ASTM D 698

3.04 PRELIMINARY MIXING

A. Use approved single-pass or multiple-pass rotary speed mixers to mix soil, lime, and water to required depth. Obtain homogeneous friable mixture free of clods and lumps.

B. Shape mixed subgrade to final lines and grades.

C. Eliminate following operations and final mixing if pulverization requirements of Paragraph 3.05C can be met during preliminary mixing:

1. Seal subgrade as precaution against heavy rainfall by rolling lightly with light pneumatic rollers

2. Cure soil lime material for 24 to 72 hours or as required to obtain optimum hydration. Keep subgrade moist during cure.

3.05 FINAL MIXING

A. Use approved single-pass or multiple-pass rotary speed mixers to uniformly mix cured soil and lime to required depth.

B. Add water to bring moisture content of soil mixture to optimum or above.

C. Mix and pulverize until all material passes 1-3/4-inch sieve; minimum of 85 percent, excluding non-slacking fractions, passes 3/4-inch sieve; and minimum of 60 percent excluding non-slacking fractions passes No. 4 sieve. Test according to TxDOT Tex-101-E, Part III using dry method.

D. Shape mixed subgrade to final lines and grades.

E. Do not expose hydrated lime to open air for 6 hours or more during interval between application and mixing. Avoid excessive hydrated lime loss due to washing or blowing.

3.06 COMPACTION

A. Aerate or sprinkle to attain optimum moisture content to 3 percent above optimum, as determined by ASTM D 698 on material sample from roadway after final mix with lime.

B. Start compaction immediately after final mixing.

C. Spread and compact in two or more equal layers where total compacted thickness is greater than equipment manufacturer's recommended range of mixing and compaction.

D. Compact with approved heavy pneumatic or vibrating rollers, or combination of tamping rollers and light pneumatic rollers. Begin compaction at bottom and continue until entire depth is uniformly compacted.

E. Do not allow stabilized subgrade to mix with underlying material. Correct irregularities or weak spots immediately by replacing material and recompacting.

F. Compact subgrade to minimum density of 95 percent of maximum dry density, according to ASTM D 698, at moisture content of optimum to 3 percent above optimum, unless otherwise indicated on Drawings.

G. Seal with approved light pneumatic tired rollers. Prevent surface hair line cracking. Rework and recompact at areas where hairline cracking develops.

3.07 CURING

A. Moist Cure for minimum of 3 days before placing base or surface course, or opening to traffic. Subgrade may be opened to traffic after 2 days when adequate strength has been attained to prevent damage. Restrict traffic to light pneumatic rollers or vehicles weighing less than 10 tons.

B. Keep subgrade surface damp by sprinkling. Roll with light pneumatic roller to keep surface knit together.

C. Place base or surface within 14 days after final mixing and compaction. Restart compaction and moisture content of base material when time is exceeded.

3.08 TOLERANCES

A. Completed surface: smooth and conforming to typical section and established lines and grades.

B. Top of compacted surface: Plus or minus 1/4 inch in cross section or in 16-foot length.

C. Depth of lime stabilization shall be plus or minus one inch of specified depth for each 1000- Foot Roadway Section.

3.09 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. Test soils, lime, and mixtures as follows:

1. Tests and analysis of soil materials will be performed in accordance with ASTM D 4318, using the wet preparation method.

2. Sampling and testing of lime slurry shall be in accordance with TxDOT Tex-600-J, except using a lime slurry cup.

3. Sample mixtures of hydrated lime or quicklime in slurry form will be tested to establish compliance with specifications.

4. Moisture-density relationship will be established on material sampled from roadway, after stabilization with lime and final mixing, in accordance with ASTM 698, Moist preparation Method.

C. In-place depth will be evaluated for each 1000-Foot Roadway Section and determined in accordance with TxDOT Tex-140-E in hand excavated holes. For each 1000-foot section, 3 phenolphthalein tests will be performed. Average stabilization depth for 1000-foot section will be based on average depth for three tests.

D. Perform compaction testing in accordance with ASTM D 6938. Three tests will be performed for each 1000-Foot Roadway Section.

E. Pulverization analysis will be performed as required by Paragraph 3.05C on material sampled during mixing of each production area. Three tests will be performed per 1000-Foot Roadway Section or a minimum of once daily.

3.10 REWORK OF FAILED SECTIONS

A. Rework sections that do not meet specified thickness.

B. Perform the following steps when more than 72 hours have lapsed since completion of compaction.

1. Moist Cure for minimum of 3 days after compaction to required density.

2. Add lime at rate of 25 percent of specified rate at no additional cost to City.

3. Moisture density test of reworked material must be completed by laboratory before field compaction testing can be completed.

3.11 PROTECTION

A. Maintain stabilized subgrade to lines and grades and in good condition until placement of base or surface course. Protect asphalt membrane from being picked up by traffic.

B. Repair defects immediately by replacing material to full depth.

END OF SECTION

SECTION 02337

LIME/FLY ASH STABILIZED SUBGRADE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Foundation course of lime/fly ash stabilized subgrade material.

1. Application of lime slurry and fly ash to subgrade.

2. Mixing, compaction, and curing of lime, slurry, fly ash, water and subgrade into a stabilized foundation.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 02336 – Lime Stabilized Subgrade

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Measurement and payment for lime/fly ash stabilized subgrade is on a square yard basis compacted in place to proper density. Separate measurement will be made for each required thickness of subgrade course.

a. Limits of measurement shall match actual pavement replaced, but no greater than the maximum pavement replacement limits shown on Drawings. Limits for measurement will be extended to include installed lime/fly ash stabilized subgrade material that extends 2-foot beyond outside edge of pavement to be replaced, except where proposed pavement section shares a common longitudinal or transverse edge with existing pavement section. No payment will be made for lime/fly ash stabilized subgrade in areas beyond these limits.

b. Limits of measurement and payment shall match pavement replacement limits shown on Drawings, except as noted in Paragraph 1.03.A.1.a, or as approved by Project Manager.

2. Payment for hydrated lime and quicklime is by ton of 2000 pounds dry-weight basis.

3. Payment for commercial lime slurry is by ton of 2000 pounds of lime calculated on percentage by weight of dry solids for grade of slurry.

4. Payment for fly ash is on unit price basis per ton.

5. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

A. Moist Cure: Curing soil lime/fly ash material to obtain optimum hydration.

B. 1000-Foot Roadway Section: 1000 feet per lane width or approximately 500 square yards of compacted subgrade for other than full-lane-width roadway sections.

1.05 REFERENCES

A. ASTM C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certification that fly ash, hydrated lime, quicklime, or commercial lime slurry complies with these specifications.

C. Submit weight tickets, certified by supplier, with each bulk delivery of materials to work site.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Conform to requirements of Section 02336 - Lime Stabilized Subgrade.

B. Quicklime can be dangerous; exercise extreme caution if used for Work. Become informed about recommended precautions in handling, storage and use of quicklime.

PART 2 PRODUCTS

2.01 MATERIALS

A. Water: clean, clear and free from oil, acids, alkali, or vegetable matter.

B. Lime: Conform to requirements of Section 02336 - Lime Stabilized Subgrade for Type A hydrated lime, Type C quicklime, and Type B commercial lime slurry.

C. Fly ash: Residue or ash remaining after burning finely pulverized coal at high temperatures conforming to requirements of ASTM C 618, Type ‘C” or “F” and following:

1. Minimum CaO content of 20 percent.

2. Loss on ignition not to exceed 3 percent.

3. Contain no lignite ash.

D. Asphaltic Seal Cure: Conform to requirements of Section 02336 - Lime Stabilized Subgrade.

PART 3 EXECUTION

3.01 INSTALLATION

A. Conform to Part 3 of Section 02336 - Lime Stabilized Subgrade with following exceptions:

1. Include fly ash in percentage amounts in lime or lime slurry as established from geotechnical evaluation for application, mixing, and compaction.

2. Apply lime/fly ash as single mix, single pass over lower PI soils.

3. Conduct operations to minimize elapsed time between mixing and compacting lime/fly ash stabilized subgrade in order to take advantage of rapid initial set characteristics. Complete compaction within 2 hours of commencing compaction and not more than 6 hours after adding and mixing last stabilizing agent.

3.02 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. Soil will be sampled to establish percent of fly ash and hydrated lime, quicklime, or lime slurry to be applied to subgrade material.

C. Testing will be in accordance with Part 3 of Section 02336-Lime-Stabilized Subgrade.

END OF SECTION

SECTION 02338

PORTLAND CEMENT STABILIZED SUBGRADE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Foundation course of Portland cement stabilized natural subgrade material.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for Portland cement stabilized subgrade is on a square yard basis compacted in place to proper density. Separate measurement will be made for each different required thickness of subgrade course.

   a. Limits of measurement shall match actual pavement replaced, but no greater than maximum pavement replacement limits shown on Drawings. Limits for measurement will be extended to include installed Portland cement stabilized subgrade material that extends 2-foot beyond outside edge of pavement to be replaced, except where proposed pavement section shares common longitudinal or transverse edge with existing pavement section. No payment will be made for Portland cement stabilized subgrade in areas beyond these limits.

   b. Limits of measurement and payment shall match pavement replacement limits shown on Drawings, except as noted in Paragraph 1.03.A.1.a, or as approved by Project Manager

2. Payment for Portland cement is by ton of 2000 pounds dry-weight basis.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 150 - Standard Specification for Portland Cement.

B. ASTM D 558 - Standard Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement- Mixtures.

C. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3 (600 kN-m/m3).

D. ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

E. ASTM D 6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certification that Portland cement complies with these specifications.

PART 2 PRODUCTS

2.01 WATER

A. Water: clean, clear and free from oil, acids, alkali, or organic matter.

2.02 PORTLAND CEMENT

A. ASTM C 150 Type I; bulk or sacked.

2.03 SOIL

A. Provide soil consisting of approved material free from vegetation or other objectionable matter encountered in existing roadbed.

2.04 TESTS

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. Tests and analysis of soil materials will be performed in accordance with ASTM D 4318.

C. Soil will be evaluated to establish ratio of cement to soil to obtain desired stability. Normal range is 6 percent to 10 percent by weight.

D. The percentage of moisture in soil, at time of cement application, will be determined by ASTM D 558. Moisture will not be allowed to exceed quantity that will permit uniform, complete mixture of soil and cement during dry mixing operations nor specified optimum moisture content for soil cement mixture, as determined.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify compacted subgrade is ready to support imposed loads.

B. Verify subgrade lines and grades are correct.

3.02 EQUIPMENT

A. Apply Portland cement treatment with machine or combination of machines and auxiliary equipment to produce specified results. Mixing may be accomplished by multiple-pass traveling mixing plant or single-pass traveling mixing plant. Provide sufficient equipment to enable continuous prosecution of work

3.03 PREPARATION

A. Backfill for utilities below future grade.

B. Verify subgrade is firm and able to support, without displacement, construction equipment at specified density. Correct soft or yielding subgrade and stabilize by scarifying and aerating or by adding cement and compacting to uniform stability.

C. Grade, shape, and compact, as required, to allow construction of Portland cement treatment for in-place materials to lines, grades, thickness, and typical cross section shown on Drawings. Remove unsuitable soil or material and replace with acceptable material.

D. Pulverize soil so that at completion of moist-mixing, 100 percent by dry weight passes 1-inch sieve, and minimum of 80 percent passes No. 4 sieve, exclusive of gravel or stone retained on these sieves. Pulverize existing bituminous wearing surfaces so that 100 percent will pass 2-inch sieve.

3.04 MIXING

A. Do not place and mix cement when temperature is below 40 degrees F and falling. Place base when temperature taken in shade and away from artificial heat is above 35 degrees F and rising.

B. Spread cement uniformly on soil at rate specified by laboratory. When bulk cement spreader is used, position it by string lines or other approved method to ensure uniform distribution of cement. Apply cement only to area where operations can be continuous and completed in daylight, within 1 hour of application. Amount of moisture in soil at time of cement placement shall not exceed quantity that will permit uniform mixture of soil and cement during dry mixing operations. Do not exceed specified optimum moisture content for soil cement mixture.

C. Do not allow equipment other than that used in spreading and mixing, to pass over freshly spread cement until it is mixed with soil.

D. Dry mix cement with soil after cement application. Continue mixing until cement has been sufficiently blended with soil to prevent formation of cement balls when water is applied. Mixture of soil and cement that has not been compacted and finished shall not remain undisturbed for more than 30 minutes.

E. Immediately after dry mixing is complete, uniformly apply water as necessary and incorporate it into mixture. Pressurized equipment must provide adequate supply to ensure continuous application of required amount of water to sections being processed within 3 hours of cement application. Ensure proper moisture distribution at all times. After last increment of water has been added, continue mixing until thorough and uniform mix has been obtained.

F. Ensure percentage of moisture in mixture, based on dry weights, is within 2 percentage points of specified optimum moisture content prior to compaction. When uncompacted soil cement mixture is wetted by rain indicating that average moisture content exceeds tolerance given at time of final compaction, reconstruct entire section in accordance with this Section at no additional cost to City.

3.05 COMPACTION

A. Prior to beginning compaction, ensure mixture is in loose condition for its full depth. Uniformly compact the loose mixture to specified density, lines, and grades.

B. After soil and cement mixture is compacted, apply water uniformly as needed and mix thoroughly. Then reshape surface to required lines, grades, and cross section and lightly scarify to loosen imprints left by compacting or shaping equipment.

C. Roll resulting surface with pneumatic-tired roller and "skin" surface with power grader. Thoroughly compact mixture with pneumatic roller, adding small increments of moisture, as needed. When aggregate larger than No. 4 sieve is present in mixture, make one complete coverage of section with flat-wheel roller immediately after skinning operation. When approved by Project Manager, surface finishing methods may be varied from this procedure, provided dense uniform surface, free of surface compaction planes, is produced. Maintain moisture content of surface material at its specified optimum during finishing operations. Compact and finish surface within period not to exceed 2 hours, to produce smooth, closely knit surface, free of cracks, ridges, or loose material, conforming to crown, grade, and line shown on Drawings within period not to exceed 2-hours.

3.06 CONSTRUCTION JOINTS

A. At end of each day's construction, form straight transverse construction joint by cutting back into total width of completed work to form true 2-inch depth vertical face free of loose and shattered material. Construct cement treatment for large wide areas in series of parallel lanes of convenient length and width approved in advance by Project Manager.

3.07 CURING

A. Moist cure for minimum of 3 days before placing base or surface course, or opening to traffic. When open, restrict traffic to light pneumatic rollers or vehicles weighing less than 10 tons.

B. Keep subgrade surface damp by sprinkling. Roll with light pneumatic roller to keep surface knit together.

C. Place base and surface within 14 days after final mixing and compaction, unless prior approval is obtained from Project Manager.

3.08 TOLERANCES

A. Completed surface: smooth and conforming to typical section and established lines and grades.

B. Top of compacted surface: Plus or minus 1/4 inch in cross section or in 16-foot length.

3.09 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. In-place density will be determined in accordance with ASTM D 6938 or ASTM D 698. Minimum of three tests will be taken for each 1000 feet per lane of roadway or 500 square yards of embankment.

3.10 PROTECTION

A. Maintain stabilized subgrade to lines and grades and in good condition until placement of base or surface course.

B. Repair defects immediately by replacing material to full depth.

END OF SECTION

SECTION 02340

COMPACTED SAND FILL UNDER TANK FLOOR PLATE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Excavation, sand fill and compaction under structures within limits shown on plans.

1.02 RELATED SECTIONS

A. Section 01330 – Submittal Procedures

B. Section 02336 – Lime Stabilized Subgrade

1.03 MEASUREMENT AND PAYMENT

A. No separate measurement and payment for work performed under this Section except as indicated in section 1.03 B and 1.03 C. The Contractor shall include the cost for this work in the contract bid price for work of which this is a component part.

B. Extra excavation ordered by the Engineer for removing weak areas in the subgrade, as determined by proof rolling procedures, will be measured per cubic yard and paid at the unit price bid for "Extra Excavation".

C. Extra select fill ordered by the Engineer for replacing weak areas in the subgrade will be measured per cubic yard and paid at the unit price bid for "Extra Select Fill".

1.04 REFERENCES

A. AWWA D 100 – Standard for Welded Steel Tank for Water Storage.

B. ASTM C 33 - Standard Specification for Concrete Aggregates.

C. ASTM C 117 – Standard Test Method for Material Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by washing.

D. ASTM D 698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3 (600 kN-m/m3)).

E. ASTM D 1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

F. ASTM D 4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.05 SUBMITTALS

A. Submittals shall conform to requirements of Section 01330 - Submittal Procedures.

B. Submit proposed materials and sequence of operations for compacting sand. Describe proposed equipment.

C. Submit sand fill to Engineer for approval.

PART 2 PRODUCTS

2.01 MATERIALS

A. Clean sand or clean bank sand free from clay and clay lumps, shale, loam, organic matter, salt or chlorides, and other deleterious materials in accordance with ASTM C33 shall be used. Water soluble ionic (salt) contamination of the sand shall be determined and limited in accordance with AWWA D100, Section 12.6, Note 3. Maximum chloride level not to exceed 100 ppm, maximum sulfate level not to exceed 200 ppm.

B. Sand to have a maximum plasticity index of 7 in accordance with ASTM D-4318 and not more than 15% passing a No. 200 sieve, in accordance with ASTM C117.

C. Water, if used to obtain moisture content, to be clean and fresh.

D. Hydrated lime for soil stabilization shall comply with Section 02336 – Lime-Stabilized Subgrade.

E. Select fill shall be silty or sandy clay with liquid limit of less than 40 and plasticity index between 7 and 20.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. Excavate or strip to depth as indicated on Drawings or as directed by the Engineer to effectively remove all vegetation, topsoil and debris, if present.

B. Limit of excavation and stripping to be defined by a radius equal to the tank ring foundation wall outer radius plus 5 feet.

C. Existing trees are to be grubbed to a minimum depth of 3 feet to remove stumps.

D. Following stripping, the exposed subgrades are to be proof-rolled with a minimum 20 ton pneumatic roller to detect any soft or poorly compacted areas.

E. All weak areas in the subgrade are to be removed and replaced with select fill. Where indicated on the Drawings, scarify upper 6-inches of soil and stabilize with 5% hydrated lime and compact to 95% of maximum density as determined by ASTM D698.

F. Shape surface to receive sand fill as shown on Plans.

G. Fill for grade adjustments (below clean sand) is to be select soil, free of organic and deleterious material and have a plasticity index between 7 and 20.

H. Fill for grade adjustments is to be placed in lifts not exceeding 8 inches loose measure and compacted to at least 95% of the standard Proctor maximum dry density within ±2 percentage points of the optimum moisture content in accordance with ASTM D1557.

I. Place clean sand or clean bank sand base under floor plate in 4-inch maximum lifts, measured loose, and compact with pneumatic, vibratory or mechanical tamps. Compact to 95% standard Proctor maximum dry density with ±2 percentage points of the optimum moisture content in accordance with ASTM D698.

J. After compaction, shape surface area to grade indicated.

K. The Owner shall provide for density testing and will be performed on each lift of fill for grade adjustments and fill under tank floor as directed by the Engineer.

L. Contractor shall notify the Engineer at least twenty-four (24) hours prior to proof rolling and density testing.

END OF SECTION

SECTION 02400

TUNNEL SHAFTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Construction, maintenance, and backfilling requirements of tunnel shafts.

1.02 RELATED SECTIONS

A. Document 00410 – Bid Form

B. Section 01292 – Schedule of Values

C. Section 01330 – Submittal Procedures

D. Section 01504 – Temporary Facilities and Controls

E. Section 01555 – Traffic Control and Regulation

F. Section 01576 – Waste Material Disposal

G. Section 01578 – Control of Ground and Surface Water

H. Section 02081 – Cast-In-Place Concrete Manholes

I. Section 02082 – Precast Concrete Manholes

J. Section 02316 – Excavation and Backfill for Structures

K. Section 02317 – Excavation and Backfill for Utilities

L. Section 02321 – Cement Stabilized Sand

M. Section 02401 – Common Tunnel Shafts

N. Section 02431 – Tunnel Grout

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Tunnel shafts, both those shown on Drawings and those additional ones needed for Contractor's operations, are bid as lump sum for all shafts, collectively. Prior to construction, provide schedule of values as specified in Section 01292 - Schedule of Values. Itemize cost by station for each shaft designated on Drawings and additionally required for construction operations. 75 percent of itemized amount will be submitted on pay estimate upon completion for each shaft installed; 25 percent will be submitted on pay estimate upon completion of backfill and site restoration (including topsoil, sodding and hydro-mulching) for each shaft. Payment will include excavation, disposal of excavated materials, ground support systems, backfilling, and cleanup. Manholes constructed in tunnel shafts are to be paid separately at contract unit price as specified in Section 02081 - Cast-In-Place Concrete Manholes or Section 02082 - Precast Concrete Manholes.

2. Removal and replacement of surface improvements necessary for shaft construction, including but not limited to sidewalks, asphaltic or concrete pavement, base and subbase, curbs, curb and gutter, driveways, topsoil, sodding, and hydro-mulch shall be included in lump sum for tunnel shafts.

3. Pay for relocation of City-owned utilities at contract unit price, only when included in Document 00410 - Bid Form.

4. If Contractor’s alternative construction method or alignment is approved by the City, the Contractor shall resubmit the schedule of values per the alternative alignment for approval. Itemize cost by station for each shaft designated on the revised plan and any additional shaft required for construction operations. If a portion of the Work requiring tunnel shafts is removed by the City from the project scope, the Contractor will be compensated by a deduction from the original lump sum bid price based on the fair market value of the portion of the Work removed (e.g. bid price for removal of one tunnel shaft from project scope will result in deduction from the original lump sum bid price by fair market value of one tunnel shaft).

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

C. Unit Prices for water main Projects.

1. Payment will be made for construction of tunnel shafts and related work on a lump sum basis only if include on Document 00410 – Bid Form. If work is not included on Document 00410 – Bid Form, include the cost for construction of tunnel shafts in unit price for related items.

2. Unless otherwise shown on Drawings removal and replacement of surfaces necessary for shaft construction, including but not limited to sidewalks, asphaltic and correct pavement, base and sub-base shall be paid to limits no further than 5 feet from shaft wall.

1.04 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO), AASHTO LRFD Bridge Design Specifications, current edition.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Shaft design submittals by Contractor shall be signed and sealed by Professional Engineer registered in State of Texas. If trench box is used in tunnel shaft and such utilization is in a manner other than what is indicated and certified in manufacturer's technical data, submit trench box manufacturer certification of proposed usage.

C. Submit shaft construction drawings and seal slabs. Clearly indicate allowable surcharge loads and restrictions on surcharge capacity, including live loads, on shaft construction drawings. Indicate thrust blocks or other reactions required for pipe jacking, when applicable.

1. Location of shafts by station and limits of working sites.

2. Description of site security arrangements in conformance with Paragraph 3.03, Shaft Construction.

3. Description of method of extending shaft above flood level in conformance with Paragraph 3.03, Shaft Construction.

4. Any geotechnical / boring undertaken by Contractor for whatever purpose connected to Work.

D. Shaft Monitoring Plan: Submit for review prior to construction, shaft monitoring plan that includes schedule of instrumentation design, layout of instrumentation parts, equipment installation details, manufacturer's catalog literature, and monitoring report forms.

E. Structures Assessment: Provide preconstruction and post-construction assessment reports for critical structures located within radius of shaft center equal to shaft depth plus shaft radius, measured in plan. Include photographs or video of any existing damage to structures in vicinity of shafts in assessment reports.

F. Submit shaft surface settlement monitoring plan for review prior to construction. Identify location of settlement monitoring points, reference benchmarks, survey frequency and procedures, and reporting formats on plan.

G. Submit readings of monitoring plans to Project Manager as soon as readings have been taken.

H. Submit shaft temporary deck drawings and calculations to Project Manager, signed and sealed by Contractor's Professional Engineer in event that shaft is not needed for immediate construction activity, in conformance with Paragraph 3.03, Shaft Construction.

1.06 PERFORMANCE REQUIREMENTS

A. Shaft design must include allowance for contractor's equipment and stored material and spoil stockpile as appropriate. Design must also allow for HL-93 highway loading if located in the vicinity of a paved area.

B. Design shaft to withstand full hydrostatic head without failure. In case of common shaft in conformance to Section 02401- Common Tunnel Shafts, design shaft with adequate factor of safety for full hydrostatic head.

C. Design shaft located within 50-year flood plain with water retaining liner extending 2 feet above 50-year flood elevation. It is acceptable when liner is stored at site for immediate installation in lieu of it being installed at shaft, provided that shaft liner extends at least 2 feet above existing ground elevation.

D. Design shaft cover for minimum 25 pounds per square foot distributed load plus 300-pound point load.

E. Design steel plate deck, if such is required, for HL-93 loading.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 LOCATION OF ACCESS SHAFTS

A. Contractor has sole responsibility for selection of shaft sites needed for construction operations unless otherwise indicated on Drawings. Location will be subject to the approval of the Project Manager.

B. Locate shafts and associated work areas to avoid blocking driveways and cross streets, and to minimize disruption to business and commercial interests. Avoid shaft locations near areas identified as residential or potentially contaminated.

C. Plan shaft locations to minimize interference with storm drainage channels, ditches, water lines, sanitary sewers, storm water sewers or culverts, which, when damaged, could result in ground washout or flooding of shafts and tunnels.

3.02 UTILITY RELOCATION

A. Relocate utilities as shown on Drawings. Utility relocations required by Contractor for shaft construction shall take into account zone of potential settlement in vicinity of shaft.

B. Obtain approval from Project Manager for permanent relocations prior to relocating.

3.03 SHAFT CONSTRUCTION

A. Conform to the following for ground support systems:

1. Install liner elements, bracing and shoring structural members at locations and in method sequence and tolerances defined on shaft construction drawings as excavation progresses.

2. Ensure bracing and shoring are in contact with liner to provide full support as shown in shaft construction drawings. Evaluate and check modifications to liner, bracing and shoring. Obtain approval from Contractor's Professional Engineer and submit to Project Manager.

3. Install seal slab as soon as final depth and stable bottom conditions have been reached and accepted by Project Manager. Construct seal slab capable of withstanding full piezometric pressure, either by pressure relief using under drains, or in case of more permeable ground condition, by use of structural reinforced slab. Construct seal slab in accordance with design provided by Contractor's Professional Engineer.

4. Design and construct entire shaft to appropriate factors of safety against yield, deformation, or instability as determined by Contractor's Professional Engineer. Shaft must withstand full hydrostatic head without failure.

5. Special framing, bracing or shoring required around tunnel "eyes" or other penetrations shall be in place according to shaft construction drawings before liner or any bracing or shoring at penetration is cut or removed.

6. Securely breast and shore face of starter or back tunnels to resist both soil and hydrostatic pressure.

7. When applicable, pressure grout voids or seepage paths around shafts and adjoining tunnels in accordance with Section 02431- Tunnel Grout. Pressure grout bolted steel liner plates as they are installed, unless otherwise approved by Project Manager. Perform secondary or 'back grouting' as ground measurement, voids or deformation of shaft liner are detected.

B. Install suitable thrust or reaction blocks as required for pipe jacking equipment.

C. Provide drainage from shafts while work is in progress and until adjacent pipe joints have been sealed and shaft is backfilled. Conform to requirements of Section 01578 - Control of Ground and Surface Water.

D. Surface Water Control. Divert surface water runoff and discharge from dewatering system away from shaft. Protect shafts from infiltration or flooding.

E. Each surface work site is to be surrounded by security fence meeting requirements of Section 01504 - Temporary Facilities and Controls, which shall be secure any time site is unattended by Contractor's personnel.

F. Protect shaft, when not in use by second security fence at perimeter of shaft, or alternatively by cover designed in accordance with Paragraph 1.06, Performance Requirements.

G. Provide portable concrete traffic barriers at locations where work site is situated adjacent to highway, road, driveway, or parking lot. Angle traffic barriers in direction of lane flow. Do not place perpendicular to on-coming traffic.

H. Provide and maintain traffic control system in accordance with provision of Section 01555 - Traffic Control and Regulation.

I. Cover shaft which is constructed more than 60 days in advance of its intended use by steel plate deck designed by Contractor's Professional Engineer, and restore surface to permit full traffic flow during time shaft is not in use. Remove from site other material and equipment used by Contractor including portable concrete traffic barriers, traffic control system, fencing and reinstall at time shaft is re-opened for use.

J. Construct suitable guardrail barrier around periphery of shaft, meeting applicable safety standards. Properly maintain barrier throughout period shaft remains open. Repair broken boards, supports, and structural members. Provide ladder with safety cage, when required by OSHA, in each shaft. Provide security barrier for each access shaft in which there is no construction activity or which is unattended by Contractor's personnel.

K. Size of Shafts: Make size adequate for construction of permanent structures indicated on Drawings and to provide adequate room to meet operational requirements for tunnel construction and backfill.

3.04 BACKFILL

A. Provide cement-stabilized sand to minimum depth of 10 feet above crown of sanitary sewer, but where shaft is located in paved area, cement-stabilized sand shall be used to within one foot of pavement subgrade elevation. Provide cement-stabilized sand in accordance with Section 02321 – Cement Stabilized Sand. Compact cement stabilized sand in accordance with Section 02317 - Excavation and Backfill for Utilities. In locations where backfill is not subject to traffic loading, depth above initial cement-stabilized sand may be backfilled with select backfill in accordance with Section 02316 - Excavation and Backfill of Structures. When insufficient work space exists, grout manhole or structure annular space in accordance with Section 02431 - Tunnel Grout.

B. Remove shaft liner above level of 8 feet below ground surface, unless otherwise indicated on Drawings. Maintain sufficient ground support to meet excavation safety requirements while removing shaft structure.

C. Where common shafts are indicated, refer to Section 02401 - Common Tunnel Shafts.

3.05 MONITORING

A. Monitoring Instrumentation. Instrumentation specified and readings shall be accessible at all times to Project Manager.

1. Install and maintain instrumentation system to monitor and detect movement of ground surface and adjacent structures. Establish vertical survey control points at distance from construction area that avoids disturbance due to ground settlement.

2. Project Manager may through independent contractor or consultant, from installing instrumentation in, on, near, or adjacent to construction work. Provide access to work for such independent installations.

3. Install instruments in accordance with Drawings and manufacturer's recommendations.

B. Surface Settlement Monitoring

1. Establish monitoring points on all critical structures.

2. Record location of settlement monitoring points with respect to construction baselines and elevations. Record elevations to an accuracy of 0.01 feet for each monitoring point location. Establish monitoring points at locations and by methods that protect them from damage by construction operations, tampering, or other external influences.

3. Monitoring points to measure ground elevation are required at distance of 10 feet and 20 feet from perimeter of shaft on each of four radial lines, at 90 degrees to each other.

4. Railroads. Monitor ground settlement of track subbase at centerline of each track when within zone of potential settlement.

C. Reading Frequency and Reporting. Submit to Project Manager, records of readings from various instruments and survey points.

1. Record all shaft monitoring readings at least once per week starting prior to shaft construction and continuing until shaft has been backfilled and until no more detectable movement occurs.

2. Immediately report to Project Manager any movement, cracking, or settlement which is detected.

3. Following substantial completion but prior to final completion, make final survey of all shaft related monitoring points.

3.06 DISPOSAL OF EXCESS MATERIAL

A. Remove spoil in accordance with Section 01576 - Waste Material Disposal.

END OF SECTION

SECTION 02401

COMMON TUNNEL SHAFTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for design and construction of common tunnel shaft used for tunnel construction by Contractor (First Contractor) followed by transfer of shaft and work site to separate Contractor (Second Contractor) for use in completing interconnecting tunneling operations and permanent work within shaft.

1.02 RELATED SECTIONS

A. Document 00800 – Supplementary Conditions

B. Section 01110 – Summary of Work

C. Section 01292 – Schedule of Values

D. Section 01330 – Submittal Procedures

E. Section 01555 – Traffic Control and Regulation

F. Section 02400 – Tunnel Shafts

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Common Shafts are bid as part of Work defined in Section 02400 - Tunnel Shafts, except as modified in this Section.

2. Construction of Common Shaft includes installation of site security, removal of affected site improvements, shaft excavation, disposal of excess material, sheeting, shoring or bracing, seal slab, ground water control, and installation of temporary plug in pipe. Payment is made in accordance with Section 02400 - Tunnel Shafts and as specified in Section 01292 - Schedule of Values.

3. Work within Common Shaft, previously constructed by First Contractor, and transferred to Second Contractor includes maintaining site, security, groundwater control, permanent backfilling, replacement of permanent site improvements, such as sidewalks, asphaltic and concrete pavement, pavement base and subbase, curbs, curb and gutter, driveways, topsoil, sodding, and hydro-mulch. Payment is made in accordance with Section 02400 - Tunnel Shafts and as specified in Section 01292 - Schedule of Values.

4. Traffic control and regulation, including flagmen are paid under Section 01555 - Traffic Control and Regulation.

5. Agreement which may be reached between two Contractors involving common tunnel shaft which results in departure from or omits element of Common Shaft concept specified in this Section will not result in an adjustment in Contract Price by City for either Contractor.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

A. Common Shaft. Shaft that First Contractor constructs under one contract and then is transferred as responsibility of Second Contractor, under separate contract, who completes interconnected tunneling operations, permanent work, backfill, and restoration of site improvements.

B. First Contractor. Contractor responsible for design and construction of Common Shaft. First Contractor uses shaft for tunneling and installing permanent sewer line, and then relinquishes responsibility at time of transfer to Second Contractor.

C. Second Contractor. Contractor who takes responsibility for shaft constructed by First Contractor and uses it to complete interconnected tunneling and to complete permanent work at that location.

D. Starter Shaft. Generally, downstream shaft of First Contractor; shaft from which First Contractor begins tunnel work. This shaft, when common, becomes Receiving Shaft for Second Contractor.

E. Receiving Shaft. Generally, shaft at upstream end of tunnel work where tunneling operation ends. When common, it will have been constructed by First Contractor as Starter Shaft.

F. Back Tunnel. Short length of tunnel constructed at Starter Shaft in opposite direction to main tunnel to facilitate construction operations.

1.05 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO), AASHTO LRFD Bridge Design Specifications HL-93, current edition.

1.06 SYSTEM DESCRIPTION

A. Design Requirements. Common Shaft design to be site specific with minimum clear dimensions, depth and at location shown on Drawings. Differing dimensions may only be used with written consent of Second Contractor, and approval of City Engineer.

1. Design shaft to withstand full piezometric pressure with adequate factor of safety, and without dependence on ground water control system.

2. Design seal slab to have sump for purposes of pumping out seepage and surface water inflow.

3. Design shaft liner for uniformly distributed loading of 200 pounds per square foot at surface, or HL-93 vehicle loading, as applicable.

4. Second Contractor designs shaft structural modifications required to suit his construction needs.

5. Design Common Shaft using materials which minimize ground water intake and prevent migration of fines into shaft.

6. Design shaft with liner or ground support system such that it may be readily removed to depth of 8 feet below existing pavement or ground elevation.

1.07 SUBMITTALS

A. First Contractor.

1. Conform to requirements of Section 02400 - Tunnel Shafts and Section 01330 - Submittal Procedures.

2. Submit to City Engineer, two copies of record photographs showing shaft condition immediately prior to handover.

3. Prepare record drawings for shaft and submit to City Engineer prior to Second Contractor taking over shaft and work site.

B. Second Contractor.

1. Conform shaft modification submittals to requirements of Section 02400 - Tunnel Shafts and Section 01330 - Submittal Procedures.

2. Submit monitoring results in accordance with Section 02400 - Tunnel Shafts and Section 01330 - Submittal Procedures.

1.08 TRANSFER OF SHAFT RESPONSIBILITY

A. First Contractor. First Contractor relinquishes site of Common Shaft and transfers responsibility to Second Contractor on date specified in Section 01110 - Summary of Work. Date is based on specified number of days from Date of Commencement. First Contractor may transfer responsibility of shaft prior to date specified when approved by Second Contractor and City Engineer. Failure to transfer that responsibility by date specified will cause assessment of liquidated damages against First Contractor in accordance with Article 9.12 of Document 00800 - Supplementary Conditions.

B. Second Contractor. Second Contractor takes responsibility for Common Shaft site on date First Contractor relinquishes site. Date shall occur within period specified in Section 01110 - Summary of Work. Second Contractor is not required to take responsibility for shaft prior to first date of period specified, but shall be prepared to take over responsibility on date thereafter. Second Contractor shall have no claim for delay provided First Contractor turns over shaft prior to last day of period specified.

C. Mutual Agreements on Transfer of Responsibility. Changes to date specified for occupation of site requires written approval of both Contractors, with approvals forwarded to City Engineer.

PART 2 PRODUCTS

2.01 EQUIPMENT AND MATERIALS

A. Use equipment and materials for construction in good condition.

B. Construct permanent work as specified and as shown on Drawings.

C. Material or equipment left in shaft or at site by First Contractor, either as defined by this Section, or otherwise, becomes property of Second Contractor.

PART 3 EXECUTION

3.01 SITE EXAMINATION

A. First Contractor: Repair damage to existing structures or facilities which has been caused by construction activity. Leave site in clean condition.

B. Second Contractor: Inspect site and report damage observed to City Engineer immediately prior to transfer. Site includes surrounding area insofar as it may have been impacted by First Contractor’s construction activity.

3.02 CONSTRUCTION

A. First Contractor.

1. Construct Common Shaft, including utility relocations, dewatering, shaft excavation and ground support, seal slab, traffic control, and safety and security barriers in accordance with Section 02400 - Tunnel Shafts.

2. Do not construct back-tunnel in common shaft.

3. Repair damage to shaft liner and grout voids outside shaft ground support to restore integrity of shaft to its original design capabilities, prior to transfer.

4. Install plug immediately upstream of shaft.

5. Clean out shaft, including removal of construction equipment and debris prior to transfer.

6. Monitor for settlement in conformance with Section 02400 - Tunnel Shafts.

7. Remove dewatering system, when used, including backfilling wells and removing header pipes.

8. Repair damage to pavement outside immediate limits of shaft, such as settlement damage to pavement resulting from shaft or tunneling operations.

9. Remove equipment from shaft including thrust blocks when used, except access ladder, prior to handover.

10. Remove traffic control system. Coordinate with Second Contractor to maintain continuous traffic control.

11. Repair damage to site security fencing, shaft fencing or cover, and portable concrete traffic barriers.

12. Transfer security fencing, covers, and portable concrete traffic barriers to Second Contractor.

13. Provide, install, and handover temporary plug at downstream end of sewer pipe installed by First Contractor.

14. Provide and deliver to Second Contractor, two new and undamaged joints of pipe identical to pipe installed by First Contractor immediately upstream of Common Shaft.

B. Second Contractor.

1. Install traffic control system. Coordinate with First Contractor to maintain continuous traffic control.

2. Provide necessary pumps and power source at shaft. Provide ground water control at shaft as required to control inflow.

3. Design, fabricate, and install modification of existing shaft to suit Second Contractor’s needs.

4. Install necessary hoisting equipment, communication system, and other safety provisions, including ventilation and lighting.

5. Monitor for earth settlement in conformance with Section 02400 - Tunnel Shafts.

6. Complete upstream sewer construction within shaft.

7. Complete downstream sewer construction in accordance with Drawings.

8. Complete other permanent construction work within shaft as shown on Drawings and in accordance with Specifications. Place backfill in accordance with Section 02400 - Tunnel Shafts.

9. Restore permanent pavement in accordance with Drawings, including repairs needed to existing pavement outside immediate limits of shaft, such as settlement damage to pavement resulting from shaft or tunnel operations.

10. Clean site and restore site and surrounding area to original condition as shown in Drawings and in accordance with Specifications.

11. Remove and dispose of temporary plug in upstream sewer pipe.

END OF SECTION

SECTION 02425

TUNNEL EXCAVATION AND PRIMARY LINER

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Tunnel construction by placement of Primary Liner for installation of pipe using a primary tunnel liner with a Carrier Pipe. Placement of sewer pipe inside tunnel constructed with Primary Liner shall be in accordance with Section 02426 - Sewer Line in Tunnels.

B. Various construction methods for tunneling, including Tunnel Boring Machine (TBM), hand tunneling, or Shield. Liners include rib and lagging, steel liner plate, bolted steel liner, box tunnels, and segmented concrete. Liners may be expanded or grouted.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01576 – Waste Material Disposal

D. Section 01578 – Control of Ground and Surface Water

E. Section 02426 – Sewer Line in Tunnels

F. Section 02431 – Tunnel Grout

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Work performed under this Section such as excavation, Primary Liner, and grouting will not be paid directly. Include cost of this work in unit prices for installation of sewer line in tunnel, in accordance with Section 02426 - Sanitary Sewer Line in Tunnels.

2. Monitoring will be paid lump sum price for installation, observation, and reporting.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in Total Stipulated Price.

1.04 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO), AASHTO LRFD Bridge Design Specifications, current edition.

B. American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering.

C. ASTM A 307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.

D. Occupational Safety and Health Administration (OSHA).

E. National Electrical Code – NFPA 70.

1.05 DEFINITION

A. Primary liner: First tunnel support installed by Contractor in 2-pass method.

B. Carrier Pipe: Sewer line as specified in Section 02426 - Sewer Line in Tunnels.

C. Zone of Active Excavation. Area located within radial distance about surface point immediately above face of excavation equal to depth to bottom of excavation.

D. Critical Structure: Building, structure, bridge, pier, or similar construction partially or entirely located within Zone of Active Excavation.

E. Tunnel Boring Machine (TBM): Mechanized and fully shielded excavating equipment that is steerable, guided and articulated, with man entry.

F. Tunneling Methodology: Written description, together with supporting documentation that defines Contractor's plans and procedures for tunneling operations.

G. Shield: Fabricated ground support, circular in section, providing 360 degree protection to those working in it. Shield will have cutting edge, and be equipped with independently operated hydraulic propulsion rams, allowing it to be steered. Liner is erected within tail attached to Shield.

H. Open Face: Face of heading or tunnel which is unsupported during excavation (e.g., in hand mining or shield excavation).

I. Closed Face: Face of heading or tunnel which is supported during excavation process from TBM, where cutter head allows both partial exposure of face and full closure, by means of hydraulically operated gates.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. The following submittals are required:

1. Tunneling Methodology. Provide a brief description of proposed tunnel methodology for review. Description should be sufficient to convey following:

   a. Proposed method of tunnel construction and type of face support and lining system.

   b. Manufacturer and type of tunneling equipment proposed; type of lighting and ventilation systems.

   c. Number and duration of shifts planned to be worked each day.

   d. Sequence of operations.

   e. Location of access shafts and work sites.

   f. Method of spoil transportation from face, surface storage, and disposal location.

   g. Method of installing pipe.

   h. Identification of critical utility crossings and special precautions proposed.

   i. Manufacturer and type of chemical grout proposed.

2. Drawings and Calculations. Submit for record purposes, drawings and calculations for tunnel support system designed by Contractor. Drawings shall be adequate for construction, and include installation details. Documents must be signed and sealed by Professional Engineer registered in State of Texas. Include calculations with clear statement of criteria used for design, as described in Paragraph 1.07, Design Criteria.

3. Quality Control. Submit for review brief description of quality control methods including:

   a. Method and frequency of survey control.

   b. Example of tunnel daily log.

   c. Instrumentation plan showing location and frequency of monitoring relative to Critical Structures within Zone of Active Excavation.

   d. Settlement survey plan (may be included in instrumentation plan).

4. Geotechnical Investigation. When geotechnical investigations are conducted by Contractor, submit results to Project Manager for record purposes.

5. Monitoring Plans:

   a. Instrumentation Monitoring Plan. Submit for review, prior to construction, monitoring plan that includes schedule of instrumentation design, layout of instrumentation points, equipment installation details, manufacturer's catalog literature, and monitoring report forms.

   b. Surface Settlement Monitoring Plan. Submit settlement monitoring plan for review prior to construction. Identify location of settlement monitoring points, reference benchmarks, survey frequency and procedures, and reporting formats on plan.

6. Structures Assessment. Submit preconstruction and post-construction assessment reports for Critical Structures, namely those located within Zone of Active Excavation from proposed tunnel centerline. Include photographs or video of existing damage to structures in vicinity of sewer alignment in assessment reports.

7. Submit monitor readings to Project Manager.

8. Daily Reports. Maintain shift log as defined in Paragraph 3.04, Tunneling Data, and make available to Project Manager on request.

1.07 DESIGN CRITERIA

A. Provide primary liner designed by Contractor's Professional Engineer for appropriate loading conditions and deflection criteria, including but not limited to overburden and lateral earth pressures; handling and installation stresses; loads imposed by tunnel shield or Tunnel Boring Machine thrust jacks; subsurface soil and water loads; grouting; and other conditions of service. Assume responsibility for design of primary liner to carry construction loads in combination with overburden, earth and hydrostatic loads.

B. At railroad crossings conform to Cooper E-80 locomotive loading distributions in accordance with AREMA specifications for culverts. In design, account for additive loadings due to multiple tracks. Provide liner type for railroad crossings as specified or as shown on Drawings.

C. For truck loading use HL-93vehicle loading distributions in accordance with AASHTO

D. Use liner system compatible with special requirements shown on Drawings.

PART 2 PRODUCTS

2.01 STEEL LINER PLATES

A. In locations shown on Drawings, manufacture liner plate (2-flange or 4-flange) certified by manufacturer for compliance with Specifications.

B. Provide bolts and nuts conforming to ASTM A 307, Grade A.

C. Punch plates for bolting on both longitudinal and circumferential seams and fabricate to permit complete erection from inside tunnel. Provide plates of uniform fabrication. Plates intended for one size tunnel shall be interchangeable.

D. Material used for construction of liner plates shall be in good condition.

E. Provide sufficient number of bolted steel liner plates with approximately 2-inch diameter grout holes furnished with plugs. Locate holes near plate center.

PART 3 EXECUTION

3.01 PREPARATION

A. Install liner types as shown on Drawings. Use techniques and liner methods appropriate for prevailing ground conditions, unless otherwise indicated.

B. Use methods for tunneling operations that will minimize ground settlement. Select method which will control flow of water, prevent loss of soil into tunnel, and provide stability of face under anticipated conditions.

C. Conduct tunneling operations in accordance with applicable safety rules and regulations, OSHA standards, and Contractor's safety plan. Use methods which include due regard for safety of workmen, adjacent structures, utilities, and public.

D. Maintain clean working conditions inside tunnel and shafts.

E. For tunneling under railroad embankments, highways, or streets, perform installation so as to avoid interference with operation of railroads, highways, or streets, except as approved by owner of facility.

F. Support ground continuously in manner to prevent loss of ground and keep perimeters and faces of tunnel stable.

G. Completed primary tunnel lining shall have full bearing against ground. Grout peripheral space between support elements and excavated surface or close by expanding support elements against ground to achieve full bearing as tunnel advances.

H. Ground Conditions. Perform additional exploration by geotechnical borings in advance of construction to define necessary parameters for design of primary tunnel liner, planning and designing ground water control system, and for selection of tunneling method and equipment to successfully complete each tunnel reach.

I. Be aware that various existing soil borings, piezometers, or instrument wells, where indicated on Drawings, may coincide with proposed tunnel alignment. These may or may not have been backfilled with grout and, therefore, caution should be used in tunneling through these locations. Contractor shall take mitigating measures to counter effect these boreholes, piezometers, or instrument wells may have on tunneling operations.

3.02 GROUND WATER CONTROL

A. Provide necessary ground water control measures to perform work and to provide safe working conditions. Comply with provisions of Section 01578 - Control of Ground and Surface Water.

B. Anticipate that portions of tunnel excavation may be below ground water table and in cohesionless soils, even when not indicated on soil borings, and in conditions which may require ground water control system for tunneling operations. Install filter fabrics, backer rods and other means as necessary to prevent piping of fines into tunnel.

C. When Contractor chooses pumping installations to control ground water level or installs pervious liner through water bearing layers, install and maintain instrumentation system to monitor water level and to detect movement in adjacent structures and property.

D. Operate dewatering system for tunnels until Carrier Pipe has been installed and annular space is fully grouted, or until watertight liner designed for hydrostatic pressures is installed.

E. Do not proceed with tunneling for which ground water control is necessary until monitoring data indicates that ground water control system is operating in accordance with Contractor's plan.

3.03 EQUIPMENT

A. Assume responsibility for selection of tunneling equipment which, based on past experience, has proven to be satisfactory for excavation of soils to be encountered.

B. Employ tunneling equipment that will be capable of handling various anticipated ground conditions and which minimizes loss of soil ahead of face and allows satisfactory support of excavated face.

C. TBM or Shield shall conform to shape of tunnel with uniform perimeter that is free of projections that could produce over excavation or voids. An appropriately sized over cutting bead may be provided to facilitate steering. In addition it shall:

1. Be capable of full directional guidance.

2. Be capable of full face closure, or permit ready installation of breasting boards.

3. Be equipped with appropriate tail in which liner is erected.

4. Be capable of correcting roll.

5. Be designed to handle adverse ground conditions including ground water ingress.

6. Be equipped with visual display to show operator actual position of TBM or Shield relative to design reference.

D. Air Quality. Provide equipment to maintain proper air quality of tunnel operations during construction in accordance with OSHA requirements.

E. Enclose light fixtures in watertight enclosures with suitable guards. Provide separate circuits for lighting and other equipment.

F. Conform to requirements of National Electrical Code - NFPA70 for Electrical Systems.

3.04 TUNNELING DATA

A. Maintain shift logs of construction events and observations. Project Manager shall have access to Contractor's logs with regard to the following information:

1. Location of face by station and progress of tunnel drive during shift.

2. Hours worked per shift on tunneling operations.

3. Completed field forms for checking line and grade of tunneling operation, showing achieved tolerance relative to design alignment. Steering control logs will generally be acceptable for Shield or TBM driven tunnels.

4. Location, elevation and brief soil descriptions of soil strata and strata boundaries.

5. Ground water control operations and piezometric levels, ground water inflow location and rates.

6. Observation of lost ground or other ground movement.

7. Unusual conditions or events.

8. Reasons for operational shutdown in event drive are halted.

B. Clearly mark primary liner with paint every 20 feet along tunnel with distance in feet from centerline of preceding shaft.

3.05 TUNNEL EXCAVATION AND PRIMARY LINER INSTALLATION

A. Tunnel Excavation.

1. Conduct tunneling operations in accordance with applicable safety rules and regulations, and Contractor's safety plan. Use methods which include due regard for safety of workmen, adjacent structures, utilities, and public.

2. Maintain tunnel excavation within easements and rights-of-way indicated on Drawings, to lines and grades shown on Drawings. Excavation shall be of sufficient size to allow installation of sewer pipe to lines and grades indicated on Drawings.

3. Open-face excavations:

   a. Keep face breasted or otherwise supported and prevent falls, excessive raveling, or erosion. Maintain standby face supports for immediate use when needed.

   b. During shut-down periods, support face of excavation by positive means; do not rely solely on hydraulic pressure for support.

4. Closed-face excavation:

   a. Control volume of spoil removed. Determine that advance rate and excavation rate are compatible to avoid over excavation or loss of ground.

   b. When cutting head is withdrawn, keep excavated face supported and stabilized.

   c. When face of machine is open for maintenance, monitor conditions that might threaten stability of heading. Take appropriate action to prevent or limit influx of soils and water which would threaten stability of heading.

5. Whenever condition is identified which could endanger tunnel excavation or adjacent structures, operate continually for 24 hours day, including weekends and holidays, without intermission until condition no longer exists.

B. Determination of primary liner size and section shall be sole responsibility of Contractor, to match construction methods and equipment described in tunneling methodology submittal. Provide tunnels of sufficient size to permit efficient excavation operations, sufficient working space for placing primary tunnel liner, and to allow for installation of sewer pipe.

C. Primary Liner Installation:

1. Provide method to ensure full bearing of soil against Primary Liner without significant settlement or movement of surrounding soil. To fill void behind Primary Liner, either expandable liner (e.g., ring beams and timber lagging) or non-expandable liner (e.g., bolted steel liner plates) may be used provided grout is placed behind non-expandable liner. Box tunnel where ground is excavated to true shape may be ungrouted.

2. When using TBM or tunnel shield, advance equipment only far enough to permit construction of one Primary Liner set, entirely within equipment Shield.

3. Install filter fabric around exterior of Primary Liner when using steel ribs and lagging. Install backer rods at ribs as required to control migration of fines. Close windows in lagging.

4. After grouting, ensure deflection of liner is no more than allowable, nor liner is distorted by excessive pressure.

D. Seal blind headings with temporary bulkhead.

E. Grouting: Requirements pertaining to grout mix design and tunnel grouting are provided in Section 02431 - Tunnel Grout.

3.06 CONTROL OF TUNNEL LINE AND GRADE

A. Construction Control.

1. Project Manager will establish baselines and benchmarks indicated on Drawings. Check baselines and benchmarks at beginning of Work and report errors or discrepancies to Project Manager.

2. Use baselines and benchmarks established by Project Manager to establish and maintain construction control points, reference lines, and grades for locating tunnel.

3. Establish control points sufficiently far from face so as not to be affected by tunneling operations.

B. Benchmark Movement. Ensure that when settlement of ground surface occurs during construction which affects accuracy of temporary benchmarks, detect and report such movement and reestablish temporary benchmarks. Locations of permanent City of Houston monumentation benchmarks are indicated on Drawings. Advise Project Manager of settlement affecting permanent monumentation benchmarks. Upon completion, submit field books pertaining to monitoring of permanent monumentation benchmarks to Project Manager.

C. Line and Grade.

1. Maintain means sufficient to check alignment and grade continuously.

2. Check survey control for tunneling against aboveground undisturbed reference at least once each week and once for each 250 feet of tunnel constructed.

3. When excavation is off line or grade, make alignment corrections to avoid reverse grades in gravity sewers.

4. Construct Primary Liner to such tolerances that permit installation of sewer pipe to be completed to tolerances given in Section 02426 - Sewer Line in Tunnels.

D. Earth Movement. Assume responsibility for damages due to settlement from construction- induced activities or occurrences.

1. Survey crown, invert, and springline on each side of Primary Liner at 50-foot intervals or minimum of once per shift or more frequently when line and grade tolerances have been exceeded, to ensure alignment is within tolerances specified. Conduct survey immediately behind tunnel excavation to allow immediate correction of misalignment.

3.07 MONITORING

A. Instrumentation Monitoring. Instrumentation requirements are shown on Drawings. Ensure instrumentation specified is accessible to Project Manager. Submit readings promptly to Project Manager.

1. Install and maintain instrumentation system to monitor and detect movement of ground surface and adjacent structures. Establish vertical control points at distance from construction areas that avoid disturbance due to ground settlement.

2. Installation of instrumentation shall not preclude Project Manager, through independent Contractor or consultant, from installing instrumentation in, on, near, or adjacent to construction work. Provide access to work for such independent installations.

3. Install instruments in accordance with Drawings and manufacturer's recommendations.

B. Surface Settlement Monitoring

1. Establish monitoring points on all Critical Structures.

2. Record location of settlement monitoring points with respect to construction baselines and elevations. Record elevations to accuracy of 0.01 feet for each monitoring point location. Monitoring points should be established at locations and by methods that protect them from damage by construction operations, tampering, or other external influences.

3. Ground surface elevations must be recorded on centerline ahead of tunneling operations at minimum of 100-foot intervals or at least three locations per tunnel drive. For primary lined tunnels greater than 60 inches cut diameter also record similar data at approximately 20 feet each side of centerline. Clearly mark settlement monitoring points by studs or paint for ease of locating.

4. Railroads. Monitor ground settlement of track subbase at centerline of each track.

5. Utilities and Pipelines. Monitor ground settlement directly above and 10 feet before and after utility or pipeline intersection.

C. Reading Frequency and Reporting. Submit to Project Manager, records of readings from various instruments and survey points.

1. Instrumentation monitoring results to be read at frequency specified, unless otherwise specified. Start monitoring before Zone of Active Excavation is passed and until no further detectable movement occurs.

2. Record surface settlement monitoring readings:

a. Prior to Zone of Active Excavation reaching that point,

b. When tunnel face reaches monitoring point (in plan), and

c. When Zone of Active Excavation has passed and no further movement is detected.

3. Submit monitoring readings promptly to Project Manager.

4. Immediately report to Project Manager movement, cracking, or settlement which is detected.

5. Following substantial completion, but prior to final completion, perform final survey of monitoring points.

3.08 DISPOSAL OF EXCESS MATERIAL

A. Remove spoil from job site and dispose in accordance with Section 01576 - Waste Material Disposal.

END OF SECTION

SECTION 02426

SEWER LINE IN TUNNELS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Handling, transporting, and installing sanitary and storm sewer lines in primary lined tunnels.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02427 – Plastic Liner for Large-Diameter Concrete Sewers and Structures

D. Section 02431 – Tunnel Grout

E. Section 02501 – Ductile Iron Pipe and Fittings

F. Section 02504 – Fiberglass Reinforced Pipe

G. Section 02505 – High Density Polyethylene (HDPE) Solid and Profile Wall Pipe

H. Section 02506 – Polyvinyl Chloride Pipe

I. Section 02508 – Extra Strength Clay Pipe

J. Section 02533 – Acceptance Testing for Sanitary Sewers

K. Section 02611 – Reinforced Concrete Pipe

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Length of sewer installed in primary lined tunnels will be measured by linear foot along center line of completed sewer, center line to center line of manholes, as designated on Drawings, and to end of stubs or termination of pipe; and to inside face of lift stations and treatment plant works. Installation of sewer within limits of structure other than manholes will not be considered for measurement and payment at unit price bid.

2. Payment for installation of sewer in primary lined tunnels is on a linear foot basis.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum): If Contract is Stipulated Price Contract, payment for work in this Section is included in Total Stipulated Price.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Provide brief description of method of transporting carrier pipe into tunnel; method of hoisting and positioning pipe; method of jointing and aligning pipe; and blocking plan.

C. Submit buoyant force calculations, bulkhead design, and blocking details. Include in calculations analysis of stresses and deformation induced on carrier pipe. Submittal must be signed and sealed by Professional Engineer registered in State of Texas.

D. Submit as-built survey as described in Document 02533 - Acceptance Testing for Sanitary Sewers to Project Manager prior to substantial completion.

PART 2 PRODUCTS

2.01 PIPE MATERIAL AND FITTINGS

A. Sewer pipe may consist of fiberglass pipe (FRP), vitrified clay pipe (VCP), polyvinyl chloride (PVC) pipe, high density polyethylene (HDPE) pipe, plastic-lined reinforced concrete pipe (RCP), plastic-lined or epoxy lined ductile iron pipe (DIP) or combinations of these. Storm sewers do not require lining.

B. Assume responsibility for selecting appropriate pipes and pipe joints to safely carry loads imposed during construction.

2.02 FIBERGLASS PIPE

A. Provide fiberglass pipe, joints, and fittings in accordance with Section 02504 - Fiberglass Reinforced Pipe.

2.03 VITRIFIED CLAY PIPE

A. Provide vitrified clay pipe, joints and fittings in accordance with Section 02508 - Extra Strength Clay Pipe.

2.04 POLYVINYL CHLORIDE PIPE

A. Provide Polyvinyl chloride pipe, joints and fittings in accordance with Section 02506 - Polyvinyl Chloride Pip

2.05 HIGH DENSITY POLYETHYLENE PIPE

A. Provide High Density Polyethylene (HDPE) Solid and Profile Wall pipe, joints and fittings in accordance with Section 02505 - High Density Polyethylene (HDPE) Solid and Profile Wall Pipe.

2.06 DUCTILE IRON PIPE

A. As approved for pipe jacking applications, ductile iron pipe lined with polyethylene, polyurethane, or ceramic epoxy, and fittings to be in accordance with Section 02501 - Ductile Iron Pipe and Fittings.

2.07 REINFORCED CONCRETE PIPE

A. Provide reinforced concrete pipe, joints, and fittings in accordance with Section 02611 - Reinforced Concrete Pipe.

B. Provide plastic-liner for sanitary sewers in accordance with Section 02427 - Plastic Liner for Large-Diameter Concrete Sewers and Structures.

2.08 ANNULAR GROUT

A. Provide for grouting of annular space between pipe and tunnel liner as specified in Section 02431 - Tunnel Grout.

PART 3 EXECUTION

3.01 INSTALLATION TOLERANCES

A. Prior to installing sewer pipe, verify that primary liner has been constructed so that sewer pipe may be placed in conformance with specified tolerances.

B. Tolerances from lines and grades shown on Drawings for sewer pipe installed in primary liner are plus or minus 6 inches in horizontal alignment and plus or minus 1-1/2 inches in elevation. Should misalignment of primary liner preclude installation of sewer pipe to tolerances specified, notify Project Manager.

3.02 PIPE HANDLING

A. Handle and transport pipe into tunnel in manner that prevents damage to pipe, joints, gaskets, and plastic liner. Do not install pipe damaged during placement operations. Propose repair procedures for review and approval of Project Manager.

3.03 TUNNEL CLEANUP

A. Prior to pipe placement in tunnel, remove temporary tunnel utilities, such as electrical and ventilation. Remove loose material, dirt, standing water, and debris prior to pipe placement.

B. Temporary steel construction tracks or steel pipe skids may be left in place when they do not interfere with alignment of sewer pipe or interfere with final placement of annular grout.

3.04 INVERT PIPE SUPPORT

A. Provide support adequate to establish final pipe grade. Support may include screeded concrete, steel beam, or other method as designated by Contractor's Engineer. Secure pipe support to pipe or primary liner. When concrete is used for pipe support, cure it minimum of 12 hours prior to setting pipe.

3.05 JOINING PIPE IN TUNNELS

A. Join pipe segments to properly compress gaskets and allow for correct final positioning of pipe for line and grade. Closely align pipes by bringing them loosely together by means of hydraulic jacks, locomotives, pipemobiles, or winches. Once pipes have been loosely joined, pull them home by means of hydraulic tugger or other similar method suitably protecting pipe and joints against damage. Impact jointing such as ramming with locomotives or other mechanical equipment is not permitted.

3.06 BLOCKING PIPE IN TUNNEL AND BULKHEADS

A. Install pipe blocking system. Use pipe blocking to position sewer pipe in tunnel to allow minimum of 4 inches of grout to be placed between sewer pipe and tunnel primary liner or casing.

B. Secure blocking rigidly in place without dependence on wedges to prevent dislodging during pipe placement and grouting operations.

C. Construct bulkheads to withstand imposed grout pressure without leakage. Provide adequate venting for bulkheads.

3.07 ACCEPTANCE TESTING

A. Perform as-built survey on installed sewer pipe. Take invert elevations at each pipe joint. Take two diameter readings, at right angles, randomly at average of 20 feet spacing or less in non-rigid pipe.

B. Test for leakage by low pressure air methods in accordance with Section 02533 - Acceptance Testing for Sanitary Sewers.

END OF SECTION

SECTION 02427

PLASTIC LINER FOR LARGE-DIAMETER CONCRETE SEWERS AND STRUCTURES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Installation of plastic liners for concrete interceptor sewers and structures. Only plastic liners manufactured with integral locking ribs spaced at approximately 2-1/2 inches on center over entire liner is acceptable. Liners relying on mechanically fastened batten strips as primary means of anchorage are unacceptable.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for Work performed under this Section. Cost is incidental to work of large diameter sewers, precast concrete manholes, or cast- in-place, wastewater-containing structures.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCE STANDARDS

A. ASTM D 412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.

B. ASTM D 2440 - Standard Test Methods for Oxidation Stability of Mineral Insulating Oil.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Prior to submittal of shop drawings, manufacturer shall approve proposed panel layout and proposed details. Contractor shall then submit shop drawings showing proposed panel layout to cover area to be lined. Show on shop drawings proposed details for installation of liner at seams, terminations, corners, openings, pipe penetrations, etc., and type of factory and field welds and attachments.

C. Provide sufficient details to permit placement of liner without use of Drawings. Reproduction of Drawings for use as shop drawings will not be allowed. Do not begin fabrication of liner until after shop drawings and submitted materials have been reviewed and accepted by Project Manager.

1.06 INSTALLER QUALIFICATIONS

A. Applicators. Application of plastic liner to forms and other surfaces, liner finishing, repair, and testing is considered highly specialized work and shall be performed only by firms and individuals recommended and approved by lining manufacturer. Personnel performing such work are to be trained in methods of installation and demonstrate their ability to Project Manager.

B. Welders.

1. Each welder is to pass qualification welding test before doing welding. Requalification may be required at time deemed necessary by Project Manager. Provide at least 24 hours notice to Project Manager to schedule qualification welding test.

2. Make test welds in presence of Project Manager. Test welds are to consist of following:

a. Begin with two pieces of liner, at least 15 inches long and 9 inches wide. Hold pieces in vertical position, lapped 1-1/2 inches.

b. Position weld strip over edge of lap and weld to both pieces of liner. Extend each end of weld strip at least 2 inches beyond liner to provide tabs.

3. The weld specimen will be tested as follows:

a. Subject each weld strip tab, tested separately, to 10-pound pull normal to face of liner with liner secured firmly in place. Weld is acceptable when there is no separation between weld strip and liner.

b. Cut three test specimens from welded sample and tested in tension across welds. Tensile strength measured across welded joints is to be at least 2000 psi when tested in accordance with ASTM D 412. When none of these specimens fails when tested as indicated above, weld will be considered satisfactory.

c. If one specimen fails to pass tension test, retest will be permitted. Retest consists of testing three additional specimens cut from original welded sample. When three retest specimens pass test, weld will be considered satisfactory.

4. A disqualified welder may submit new weld sample when welder has had sufficient off- the-job training or experience to warrant re-examination.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Plastic liner shall be as manufactured by Ameron Protective Linings Division; Poly-Tee, Inc.; or approved equal.

2.02 MATERIALS

A. Manufacturing.

1. Manufacture plastic liner sheet, joint, corner and weld strips from high molecular weight thermoplastic polymer compounded to make permanently flexible material suitable for use as protective liner in concrete pipe or other concrete structures. Polyvinyl chloride resin is to constitute not less than 99 percent by weight of resin used in formulation. Copolymer resins will not be permitted.

2. During manufacture or prior to final acceptance of Work, Project Manager may sample specimens taken from sheets, strips, or welded joints for testing.

3. Changes in formulation will be permitted only after prior notice is given to Project Manager and manufacturer demonstrates that new plastic liner will meet or exceed requirements for chemical resistance and physical properties.

B. Properties.

1. Plastic liner sheets including locking extensions, joints, corners, and welding strips are to be free of cracks, cleavages or other defects adversely affecting protective characteristics of material.

2. Except at shop welds, plastic liner sheets, joint, corner, and weld strips are to have the following properties when tested at 77 degrees F plus or minus 5 degrees F.

PROPERTY	ASTM TEST METHOD	CHEMICAL RESISTANCE TEST	
		INITIAL	AFTER CHEMICAL EXPOSURE (Note 1)
Tensile strength, min.	D 412, Die B	2200 psi	2100 psi
Elongation at break, min.	D 412, Die B	200 percent	200 percent
Shore durometer, Type D	D 2240, Within 1 sec.	50-60	+5 (Note 2)
	D 2240, 10 sec.	35-50	+5 (Note 2)
Weight change	(Note 3)	-----	+1.5 % (Note 2)

Notes:
1. For 112 days in chemical solutions
2. With respect to initial test results
3. Specimen to be 1-inch x 3-inch sample sheet thickness, taken from sheet or strip prior to final acceptance of work.

2.03 MATERIAL TESTS

A. Material Properties. Test samples taken from sheets, joints or weld strips to determine material properties. Determine PVC tensile strength and elongation in accordance with ASTM D 412 using Die B. Determine indentation hardness in accordance with ASTM D 2240 using Type D durometer, except that single thickness of material will be used. Determination of change of weight and indentation hardness is to be made of 1-inch by 3-inch specimens. Thickness of specimens shall be thickness of sheet or strip.

B. Measurement of Initial Physical Properties. Determine initial values for tensile strength, weight, elongation and indentation hardness prior to chemical resistance tests.

C. Chemical Resistance Tests.

1. Determine physical properties of specimens after exposure to chemical solutions. Condition test specimens to constant weight at 110 degrees F before and after submersion in the following solutions for period of 112 days at 77 degrees F plus or minus 5 degrees F.

Chemical Solution	Concentration
Sulfuric acid	20%*
Sodium hydroxide	5%
Ammonium hydroxide	5%*
Nitric acid	1%*
Ferric chloride	1%
Soap	0.1%
Detergent (linear alkyl benzyl sulfonate or LAS)	0.1%
Bacteriological	BOD not less than 700 ppm

* Volumetric percentages of concentrated C.P. grade reagents.

2. At 28-day intervals, remove specimens from each chemical solution and test. When specimen fails to meet 112-day property requirements specified in paragraph 2.02B before completion of 112-day exposure, material will be rejected.

D. Pull Test for Locking Extensions. Liner locking extensions embedded in concrete are to withstand test pull of at least 100 pounds per linear inch, applied perpendicularly to concrete surface for period of 1 minute, without rupture of locking extensions or withdrawal from embedment. Perform this test at temperature between 70 degrees F and 80 degrees F, inclusive.

E. Shop-Welded Joints. Shop-welded joints used to fuse individual sections of liner together, are to meet minimum requirements of liner for thickness, corrosion resistance and impermeability. Welds shall show no cracks or separations and be tested for tensile strength. Tensile strength, measured across welded joint in accordance with ASTM D 412 using Die B, shall be at least 2000 psi. Test temperature is to be 77 degrees F plus or minus 5 degrees F and use measured minimum width and thickness of reduced test specimen section.

F. Spark Test. Shop and field test liners for holidays or flaws using an approved spark tester set to provide minimum of 20,000 volts (Tinker and Rasor Model AP-W with power pack, or approved equal). Satisfactorily repair sheets having holes in shop prior to shipment from manufacturer's plant. Repairs shall be made by welders qualified in accordance with these specifications.

2.04 MATERIAL DETAILS AND DIMENSIONS

A. Approval of Details. Liner sheet, strip, and other accessory pieces are to conform to requirements of these Specifications.

B. Thickness of Material. Minimum thickness of PVC sheet and strip shall be as follows:

Material	Thickness in Inches
Sheet, integral locking extensions	0.065
Sheet, plain	0.094
Joint strip	0.094
Weld strip	0.125

C. Material Sizes. Use pipe-size sheets for sheets of PVC liner to provide coverage required by Drawings. Structural sheets are to be standard 48-inches by 96-inches, with special size noted on shop drawings. Lengths specified shall include tolerance at ratio of plus or minus 1/4-inch for each 100 inches, or 0.25 percent. Joint strips shall be 4 inches plus or minus 0.25 inch in width and have each edge beveled prior to application. Weld strips shall be 1 inch plus or minus 0.125 inch in width. Weld strips are to have edges beveled at time of manufacture.

D. Locking Extensions.

1. No polygrip-type holding or locking extension will be permitted.

2. PVC liner to be embedded in concrete is to have integral locking extensions. Liner may not be bonded to concrete surfaces with adhesives except as specifically acceptable to Project Manager.

3. PVC locking extensions are to be same material as liner, be integrally molded or extruded with sheets, and have an approved cross section with minimum height of 0.375 inch and minimum web thickness of 0.085 inch. They are to be approximately 2.5 inches apart and be such that when extensions are embedded in concrete, liner will be held permanently in place.

4. PVC locking extensions are to be parallel and continuous except where interrupted for joint flaps, weep channels, strap channels and for other purposes shown on Drawings or permitted by Project Manager.

5. The liner sheet edge which will be lower terminal edge in structure is not to extend beyond base of final locking extension more than 0.375 inch.

E. Provisions for Strap Channels. Unless alternate methods are acceptable to Project Manager, liner required to be secured to inner form with straps are to have strap channels at not more than 20 inches on center perpendicular to locking extensions. Strap channels are to be maximum of 1-inch wide and formed by removing locking extensions so that maximum of 3/16-inch remains. Channels are not to be provided in final two locking extensions adjacent to terminal edge of liner coverage.

F. Flaps. When transverse flaps are specified or required, fabricate by removing locking extensions so that no more than 1/32 inch of base of locking extensions remains on sheet.

G. Adhesive Products. Adhesive products and application procedures used in installation of liner are to be according to manufacturer's recommendations. Adhesive products intended for use inside cast-in-place structures are to be non-flammable.

H. Cleaners. Cleaners used in installation of liner shall be reviewed by Project Manager prior to use. Cleaners are to be nonflammable and water soluble or water dispersible and not be detrimental to plastic liner.

I. Caulking Products. Caulking products and application procedures used in installation of liner and appurtenances are to be as recommended by manufacturer.

J. Mechanical Anchors. When approved for use with plain sheet liner, provide anchors and washers of Type 316 stainless steel, and as recommended by liner manufacturer.

PART 3 EXECUTION

3.01 NOTIFICATION

A. Notify Project Manager at least 24 hours before reinforcing steel placement so that lining may be inspected and errors corrected without delaying Work.

3.02 PLACING LINER

A. Location. Place liner throughout entire length of interceptor sewer along top 300 degrees of pipe circumference, and inside structures as indicated on Drawings. Liner is to be applied and secured to forms and inspected by Project Manager prior to placement of reinforcing steel.

B. Coverage.

1. In cast-in-place structures, no offset of lower terminal edge is permitted. Unless otherwise shown on Drawings, lower terminal edge is to be one foot below low water level (“all pumps off” level for lift stations), or 6 inches below top of grout or concrete fillet, whichever is higher.

2. At station where there is difference in pipe's circumferential liner coverage, as shown on Drawings, and longitudinal terminal edges of liner downstream from that station are lower than those upstream, uniformly slope terminal edges of liner installed in section of pipe or structure immediately upstream from station for entire length of section of pipe or structure from limits of smaller coverage to those of greater coverage. Wherever longitudinal terminal edges of liner downstream from station are higher than those upstream, accomplish slope uniformly throughout length of section of pipe or structure immediately downstream from station. Provide an approved locking extension along sloping lower terminal edges of liner plate.

C. Positioning Liner.

1. Position PVC liner installed in pipe so that locking extensions are parallel to longitudinal axis of pipe.

2. Position PVC liner installed in cast-in-place structures so that locking extensions are parallel to direction of concrete placement, which is normally vertically for vertical walls.

3. Closely fit liner to inner forms. Cut sheets to fit curved and warped surfaces using minimum number of separate pieces.

4. The Project Manager may require use of patterns or marking of sheet layouts directly on forms where complicated warped surfaces are involved.

5. At transverse joints between sheets of liner used in cast-in-place structures and pipe joints, space between ends of locking extensions, measured longitudinally, shall not exceed 4 inches. Where sheets are cut and joined for purpose of fitting irregular surfaces, this space shall not exceed 2 inches.

D. Securing Liner in Place.

1. Liner shall be held snugly in place against inner forms. For pipes and similar circular sections, use light steel banding straps or other approved means. Prefabricated pipe-size tubular sheets which do not require strap channels may also be used.

2. When used, place banding straps in strap channels, as specified under provision for strap channels, at spacing not to exceed 20 inches.

3. Any method of banding, other than in strap channels, shall be reviewed by Project Manager prior to use.

4. On vertical surfaces where form ties or form stabilizing rods pass through liner, make provisions to maintain liner in close contact with forms during concrete placement. These provisions shall be reviewed by Project Manager.

5. Prevent concrete from flowing around edges of sheets at joints by sealing joint or seam with waterproof tape recommended by manufacturer.

6. Forms in contact with plastic liner need not be oiled.

E. Weep Channels.

1. At each pipe joint and at transverse joints in cast-in-place structures, gap not less than 2 inches nor greater than 4 inches shall be left in locking extensions to provide transverse weep channel. When locking extensions are removed to provide weep channel at joints, base of extension left on sheet shall not exceed 3/16 inch.

2. Provide intermediate weep channels as required to maintain maximum spacing of 8 feet. Intermediate weep channels shall not be less than 2.0 inches nor greater than 4.0 inches in width. When locking extensions are removed to provide intermediate weep channels, base of extension left on sheet shall not exceed 3/16 inch.

3. Any area behind liner, which is not properly served by regular weep channels, shall have additional weep channels 2 inches wide provided by cutting away locking extensions.

4. Provide transverse weep channel approximately 12 inches away from each liner return where surfaces lined with plastic liner join surfaces which are not so lined.

5. As part of work of installing liner, clear outlets of weep channels of obstructions which would interfere with their proper functions.

6. Design weep channels for external hydrostatic pressures of water column equal in height to greater of 50 feet (22 psi) or 1.1 times depth of burial.

F. Liner Returns.

1. Install liner return where shown on approved shop drawings and wherever surfaces lined with plastic liner joins surfaces which are not so lined.

2. Unless otherwise indicated by Drawings or approved shop drawings showing liner installation methods, make returns as follows:

a. Return liner at least 3 inches at surfaces of contact between concrete structure and items not concrete (including access frames, gate guides and pipe penetrations).

b. Follow the same procedure at joints where type of protective lining is changed, or new work is built to join existing unlined concrete.

3. Provide locking extensions on returns to lock returns to concrete of plastic-lined, cast-in- place structures.

4. Seal each liner return to adjacent construction with which it is in contact by means of an adhesive system recommended by manufacturer and acceptable to Project Manager. When joint space is too wide or joint surfaces too rough to permit use of compound, fill joint space with 2 inches of densely caulked cement mortar, lead wool, or other caulking material and finished with minimum of 1 inch depth of an approved corrosion resistant sealant material.

3.03 CONCRETING OPERATIONS

A. Concrete Placement.

1. Carefully vibrate concrete placed against liner shall be so as to avoid damage to liner and to produce dense concrete securely anchoring locking extensions into concrete. Use external vibrators in addition to internal vibrators, particularly along lower terminal edge of liner.

2. Stiffeners, when used along locking extensions of liner installed in forms for pipe, shall be withdrawn completely during placement of concrete in forms. Revibrate concrete to consolidate concrete in void spaces caused by withdrawal of stiffeners.

B. Removing Forms.

1. In removing forms, take care to protect liner from damage. Do not use sharp instruments to pry forms from lined surfaces. When forms are removed, pull nails that remain in liner plate without tearing liner and clearly mark resulting holes. Mark form tie holes before ties are broken off. Mark areas of abrasion of liner.

2. Following completion of form removal, clean liner in pipe and structures for inspection.

3. Remove banding straps used in securing liner to forms for pipe and cast-in-place structures within limits of unlined invert.

3.04 FIELD JOINTING OF LINER

A. Installation Requirements.

1. No field joint shall be made in liner until lined pipe or structure has been backfilled and 7 days have elapsed after flooding or jetting has been completed. Where ground water is encountered, joint shall not be made until pumping of ground water has been discontinued for at least 7 days and no visible leakage is evident at joint. Liner at joints shall be free of mortar and other foreign material and be clean and dry before joints are made.

2. Hot joint compound shall not be brought in contact with liner.

3. No coating shall be applied over joint, corner or welding strip, except where nonskid coating is applied to liner surfaces.

B. Field Joints in Pipe Installation.

1. Field joints in lining at pipe joints shall be one of the following types:

a. Type P-1. Make joint with separate 4-inch joint strip and two welding strips. Center 4-inch joint strip over joint, heat-sealed to lining, then welded along each edge to adjacent liner sheets with 1-inch weld strip. 4-inch joint strip shall lap over each sheet minimum of 1/2 inch.

b. Type P-2

(1) Make joint with joint flap with locking extensions removed as described in paragraph 2.04 above, and extending approximately 4 inches beyond pipe end. Joint flap shall overlap lining in adjacent pipe section minimum of 1/2 inch and be heat-sealed in place prior to welding. Complete field joint by welding flap to lining of adjacent pipe using 1-inch weld strip.

(2) Take care to protect flap from damage. Avoid excessive tension and distortion in bending back flap to expose pipe joint during laying and joint mortaring. At temperatures below 50 degrees F heating of liner may be required to avoid damage.

2. Do not make field joints in liner at pipe joints until mortar in pipe joint, when used, has been allowed to cure for at least 48 hours.

3. Joints between lined pipe and lined structures are to be either Type C-1 joint or Type C-2 joint as described below.

C. Field Joints in Concrete Structures. Field joints in liner on concrete structures are to be one of following types:

1. Type C-1. Make joint with separate 4-inch joint strip and two welding strips. Center 4- inch joint strip over joint, heat-sealed to liner, then welded along each edge to adjacent sheets with 1-inch wide weld strip. Width of space between adjacent sheets is not to exceed 2 inches. 4-inch joint strip is to lap over each sheet minimum of 1/2 inch. It may be used at transverse or longitudinal joint.

2. Type C-2. Make joint by lapping sheets not less than 1/2 inch. One 1-inch weld strip is required. Upstream sheet is to overlap one downstream. Heat-seal lap into place prior to welding on 1-inch weld strip.

3. Type C-3. Make joint by applying 2-inch wide waterproof tape or 1-inch wide welding strip on back of maximum 1/4-inch gap butt joint or by some other method approved by Project Manager to prevent wet concrete from getting under sheet. After forms have been stripped, apply 1-inch weld strip over face to sheet.

D. Installation of Welding Strips.

1. All welding of joints is to be in strict conformance with specifications and instructions of lining manufacturer.

2. Welding is to fuse both sheets and weld strip together to provide continuous joint equal in corrosion resistance and impermeability to liner plate.

3. Hot-air welding tools shall provide effluent air to sheets to be joined at temperature between 500 degrees F and 600 degrees F. Hold welding tools approximately 1/2 inch from and moved back and forth over junction of two materials to be joined. Move welding tool slowly enough as weld progresses to cause small bead of molten material to be visible along both edges and in front of weld strip.

4. Maintain adequate ventilation in confined spaces during welding operations.

5. After repairs have been made, defective welds will be re-inspected and re-tested.

E. Joint Reinforcement. Apply 12-inch long welding strip as reinforcement across each transverse joint and weep channel which extends to lower terminal edge of liner. Center reinforcement strips over joint being reinforced and located as close to lower edge of liner as practicable. Weld in place after transverse welding strips have been installed.

F. Application of Liner to Concrete Surfaces with Adhesives. Application of liner plate to concrete surfaces by means of adhesive is allowed only where shown on Drawings for existing structures, or where specifically acceptable to Project Manager and called out on approved shop drawings, and is to be accomplished by following steps:

1. Etch concrete surface by abrasive blasting to develop slightly granular surface.

2. After abrasive blasting, thoroughly clean concrete surface of dust.

3. Apply primer, adhesive and liner in strict accordance with manufacturer's recommendations, as approved by Project Manager.

4. Place mechanical anchors at 12-inch centers each way after adherence of liner to concrete surface has been achieved. Place anchors after adhesive system has cured for minimum of 24 hours. Seal penetration of liner by anchor in accordance with manufacturer's recommendations.

G. Nonskid Surfaces. Surfaces of liner, shown on Drawings to be nonskid, treated as follows prior to installation:

1. Liner is to be cleaned, dried, and spread with an adhesive coating recommended by manufacturer of liner plate.

2. Liberally sprinkle surface with clean, dry, well graded sand, which will pass No. 30 sieve but be retained on No. 70 sieve.

3. After sanded surface has thoroughly dried, brush away excess sand and spray seal coat of adhesive coating over sand in sufficient quantity to coat and bond sand to liner plate.

4. Allow coated sand surface to dry thoroughly before handling.

H. Protection and Repair of Liner.

1. Take necessary measures and precautions to prevent damage to liner from equipment and materials used in or taken through Work. Repair damage to installed liner plate in accordance with requirements for repair of liner.

2. Patch nail and tie holes and cut, torn and seriously abraded areas in liner plate. Patches made entirely with welding strip are to be fused to liner over entire patch. Use of this method is limited to patches which can be made with single welding strip. Use of parallel, overlapping or adjoining welding strips will not be permitted. Larger patches may consist of smooth liner over damaged area, with edges covered with welding strips fused to patch and to liner adjoining damaged area. Limit size of single patch of latter type only as to its width, which shall not exceed 4 inches.

3. Whenever liner is not properly anchored to concrete, or whenever patches larger than those permitted above are necessary, accomplish repair of liner and restoration of anchorage by injecting epoxy grout behind liner plate by method approved by Project Manager. Use of adhesives will not be allowed to repair improperly anchored liner plate.

I. Field Tests.

1. Upon completion of installation, clean surface of liner to permit visual inspection and spark testing by Project Manager, using spark-type detector complying with requirements for Spark Test. Properly repair and retest areas of liner failing to meet field test.

2. Contractor is to assist in inspection and spark testing by providing adequate ventilation, ladders for access, barricades or other traffic control devices, and is responsible for opening and closing entrances and exits.

3. Spark testing of liner by Contractor is to be done with detector complying with these Specifications.

END OF SECTION

SECTION 02431

TUNNEL GROUT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Mix design requirements, testing, furnishing and production of grout for:

1. Pressure Grouting of bolted liner plates for shafts.

2. Pressure Grouting of primary tunnel liner.

3. Pressure Grouting of jacked-pipe.

4. Annular Grouting of cased or uncased sewer pipe.

5. Grouting of annular space between carrier pipe and primary tunnel liner.

6. Grouting voids in ground resulting from caving, loss of ground, or settlement.

7. Grouting of manholes constructed in shafts.

B. Compaction grouting is not part of this specification.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02517 – Water Line in Tunnels

D. Section 03315 – Concrete for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for work performed under this Section. Include cost of such work in contract unit prices for work of which it is component part.

2. Refer to Section 01270 - Measurement and Payment for Unit Price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

A. Pressure Grouting. Filling void behind liner or pipe with grout under pressure sufficient to ensure void is properly filled but without overstressing temporary or permanent ground support, or causing ground heave to occur.

B. Back Grouting. Secondary Pressure Grouting to ensure that voids have been filled between primary tunnel or shaft liners and surrounding ground.

C. Annular Grouting. Filling annular space between Carrier Pipe and primary tunnel liner, casing, or ground, by pumping.

D. Ground Stabilization Grouting. Filling of voids, fissures, or under-slab settlement due to caving or loss of ground by injecting grout under gravity or pressure to fill void.

E. Carrier Pipe. Sanitary or storm sewer or water line installed inside primary tunnel support.

1.05 REFERENCES

A. ASTM C 138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

B. ASTM C 144 - Standard Specification for Aggregate for Masonry Mortar.

C. ASTM C 150 - Standard Specification for Portland Cement.

D. ASTM C 494 - Standard Specification for Chemical Admixture for Concrete.

E. ASTM C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

F. ASTM C 869 - Standard Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete.

G. ASTM C 937 - Standard Specification for Grout Fluidifier for Preplaced-Aggregate Concrete.

H. ASTM C 942 - Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit description of materials, grout mix, equipment and operational procedures to accomplish each grouting operation. Description may include sketches as appropriate, indicating type and location of mixing equipment, pumps, injection points, venting method, flow lines, pressure measurement, volume measurement, grouting sequence, schedule, and stage volumes. Tests and certifications shall have been performed within last 12 months prior to date of submittal.

C. Submit grout mix design report, including:

1. Grout type and designation

2. Grout mix constituents and proportions, including materials by weight and volume

3. Grout densities and viscosities, including wet density at point of placement

4. Initial set time of grout

5. Bleeding, shrinkage/expansion

6. Compressive strength

7. Detailed description of grout pressure limiting equipment

8. For annular space grouting, buoyant force calculations and bulkhead designs (See Section 02517 - Water Line in Tunnel for further requirements)

D. For cellular grout, also submit the following:

1. Foam concentrate supplier's certification of dilution ratio for foam concentrate.

2. A description of proposed cellular grout production procedures.

E. Maintain and submit logs of grouting operations indicating pressure, density, and volume for each grout placement.

PART 2 PRODUCTS

2.01 MATERIALS

A. Grouting materials: Conform to Section 03315 - Concrete for Utility Construction, except as modified in the following paragraphs.

B. Grout Type Applications.

1. Grout for Pressure Grouting, Backfill Grouting and Annular Grouting: Sand-cement mortar mix or cellular grout with minimum 1,500 psi compressive strength and pH in alkaline region.

2. Grout for Annular Grouting of sanitary sewer: Low density (cellular) grout, unless otherwise approved by Project Manager.

3. Grout for filling space around manholes in shafts: Sand-cement mortar mix.

4. Ground Stabilization: Sand-cement mortar mix.

C. Do not include toxic or poisonous substances in grout mix or otherwise inject such substances underground.

2.02 GROUT

A. Employ and pay for commercial testing laboratory, acceptable to Project Manager, to prepare and test grout mix design. Develop one or more mixes based on following criteria as applicable:

1. Size of annular void between sewer pipe and liner, or size of void between primary liner and surrounding soil

2. Absence or presence of groundwater

3. Adequate retardation

4. Non-shrink characteristics

5. Pumping distances

B. Prepare mixes that satisfy required application. Provide materials conforming to the following standards:

1. Cement: ASTM C 150

2. Fly Ash: ASTM C 618

3. Water: Potable

4. Foam: ASTM C 869

5. Slurry: ASTM C 138

6. Cellular Grout: ASTM C 138

7. Sand for sand-cement mortar mix: ASTM C 144

C. Provide grout meeting the following minimum requirements:

1. Minimum 28-day unconfined compressive strength: 1500 psi for water lines, 1000 psi for other carrier pipes for mortar grout and 300 psi for cellular grout.

2. Determine strength by ASTM C 942.

3. Maximum allowable density: Less than 130 pcf.

D. Fluidifier. Provide fluidifier, meeting ASTM C 937 that holds solid constituents of grout in colloidal suspension and is compatible with cement and water used in grouting operations.

E. Admixtures.

1. Use admixtures meeting ASTM C 494 as required, to improve pump ability, control time of set, hold sand in suspension and reduce segregation and bleeding.

2. For cellular grout, do not use foam or admixtures that promote steel corrosion.

3. Ensure that admixtures used in mix are compatible. Provide written confirmation from admixture manufacturers of their compatibility.

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Project Manager at least 24 hours in advance of grouting operations.

B. Select and operate grouting equipment to avoid damage to new or existing underground utilities and structures.

C. In selection of grouting placement consider pipe flotation, length of pipe, length of tunnel, depth from surface, and type of sewer pipe, type of pipe blocking and bulkheading, grout volume and length of pipe to be grouted between bulkheads.

D. Operate dewatering systems until grouting operations are complete and grout has reached initial set.

3.02 EQUIPMENT

A. Batch and mix grout in equipment of sufficient size and capacity to provide necessary quality and quantity of grout for each placement stage.

B. Use equipment for grouting of type and size generally used for work, capable of mixing grout to homogeneous consistency, and providing means of accurately measuring grout component quantities and accurately measuring pumping pressures. Use pressure grout equipment which delivers grout to injection point at steady pressure.

3.03 PRESSURE GROUTING FOR PRIMARY TUNNEL AND SHAFT LINER

A. Perform grouting operations to fill voids outside of primary tunnel or shaft liner.

B. For nonexpendable primary liners installed behind shield or tunnel boring machine (TBM), fill voids with sand-cement grout promptly after each ring of liner is out of shield. Keep grout pressure below value that may cause damage or distortion to installed liner plate rings. Provide seals on tail of shield or TBM which will prevent grout from spilling.

C. For nonexpendable primary liners installed by hand mining or in shafts, grout once every 4 feet or more frequently when conditions dictate.

D. Control grout pressures so that tunnel or shaft liner is not overstressed, and ground heave is avoided.

E. For liner requiring grout, perform back grouting once each shift, or more often when required to ensure that all voids are filled.

3.04 ANNULAR GROUTING FOR SEWER LINE IN TUNNELS AND IN CASED OR UNCASED AUGERS

A. Fill annular space between sewer pipe and tunnel primary liner, casing or ground, with grout.

B. Placement

1. Placement Limits: Predetermine limits of each grout placement stage by size and capacity of batching equipment and initial set time of proposed grout. Under no circumstances shall placement continue at grout port longer than that period of time for mix to take initial set. Locate grout hole spacing and locations according to number of stages necessary to grout tunnel liners. Stage or lift cannot be installed on another lift until proper set has been attained. Have placement procedures approved by admixture or additive manufacturer.

2. Limit pressure on annular space to prevent damage or distortion to pipe or liner. Define limiting and estimated required pressure range. Provide an open ended, high point tap or equivalent vent and monitor it at bulkhead opposite to point of grouting.

3. Pump grout until material discharging is similar in consistency to that at point of injection.

4. In primary lined tunnel, limit length of pipe installed to 200 feet or less before grouting same length of sewer line. Repeat this cycle until all pipe is installed and grouted.

C. Remove temporary bulkheads installed for grouting.

D. Batch and mix cellular grout mechanically to ensure consistency of mix. Wet solids thoroughly before introduction of foaming agent. Operate batching system to maintain slurry weight within 3 percent of design density. Introduce foam into slurry in accordance with manufacturer's recommendations.

3.05 PRESSURE GROUTING FOR JACKED PIPE

A. For jacked pipe 60 inches in diameter or greater, pressure grout annulus after installation, displacing bentonite lubrication. Jacked pipes less than 60-inch diameter may be left ungrouted unless excavated diameter exceeds external pipe diameter by more than one inch.

B. Inject grout through grout holes in sewer pipe. Drilling holes from surface or through Carrier Pipe walls is not allowed. Perform grouting by injecting it at pipe invert with bentonite displacement occurring through high point tap or vent.

C. Control ground water as necessary to permit completion of grouting without separation of grout materials.

D. Limit pressures to prevent damage or distortion to pipe or to keep flexible pipe within acceptable tolerances.

E. Pump grout until material discharging is similar in consistency to that at point of injection.

3.06 GROUND STABILIZATION GROUTING

A. Completely fill voids outside limits of excavation caused by caving or collapse of ground. Fill with gravity or pressure injected sand-cement grout as necessary to fill void.

B. Take care in grouting operations to prevent damage to adjacent utilities or public or private property. Grout at pressure that will not distort or imperil portion of work or existing installations or structures.

C. Verify that void has been filled by volumetric comparisons and visual inspection. In case of settlement under existing slabs, take cores as directed by Project Manager, at no additional cost to City, to demonstrate that void has been filled.

3.07 FIELD QUALITY CONTROL

A. Pressure Grouting for Primary Tunnel and Shaft Liners.

1. For each shaft, make one set of four compressive test specimens for each 30-foot depth and one set for remaining portion less than 30-foot increment.

2. Make one set of four compressive test specimens for every 200 feet of primary lined, (non-expandable) tunnel requiring grout.

B. Annular Grouting for Sewer Line in Tunnels and in Cased or Uncased Augers.

1. Make one set of four compressive test specimens for every 200 feet of sewer pipe installed in primary lined tunnel.

2. For cased or uncased augers, make one set of four compressive test specimens for each grouting operation, or for each 100 feet of pipe installed, whichever is more frequent.

3. For cellular grout, check slurry density both at point of batching and placement at least twice each hour in accordance with ASTM C 138. Record density, time, and temperature. Density must be within 3 percent of design density at point of batching and 5 percent of design density at point of placement.

C. Pressure Grouting for Jacked Pipe. Make one set of four compressive test specimens for every 400 feet of jacked pipe pressure grouting.

D. Ground Stabilization Grouting. Make one set of four compressive test specimens for every location where Ground Stabilization Grouting is performed.

END OF SECTION

Section 02441

MICROTUNNELING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Tunnel construction of pipes by Microtunneling. Construction method involves jacking pipe following a micro-tunnel boring machine (MTBM), with jacking pipe serving as tunnel liner.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01576 – Waste Material Disposal

D. Section 02400 – Tunnel Shafts

E. Section 02401 – Common Tunnel Shafts

F. Section 02427 – Plastic Liner for Large-Diameter Concrete Sewers and Structures

G. Section 02431 – Tunnel Grout

H. Section 02504 – Fiberglass Reinforced Pipe

I. Section 02508 – Extra Strength Clay Pipe

J. Section 02517 – Water Line in Tunnels

K. Section 02533 – Acceptance Testing for Sanitary Sewers

L. Section 02611 – Reinforced Concrete Pipe

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Length of sewer installed will be measured by linear foot along center line of completed sewer from center line to center line of manholes, as designated on Drawings; and to end of stubs or termination of pipe; and to inside face of lift station and treatment plant works. Installation of sewer within limits of structure other than manholes will not be considered for measurement and payment at unit price bid.

2. Payment will include and be full compensation for labor, equipment, materials, and supervision for construction of sewer and excavation, complete in place including disposal of excess materials, sheeting, shoring or bracing, dewatering, utility adjustments, connections to existing sewers, grouting when required, tests, backfilling, clean-up, and other related work necessary for construction as specified or as shown on Drawings.

3. Payment for installation of sewer will be authorized by Project Manager in two parts. Pay estimates for partial payments will be made as measured above according to following schedule:

   a. 95 percent payment will be made for jacked pipe on linear foot basis for amount of jacked pipe installed but not yet grouted, in cases where grouting is specified.

   b. 100 percent payment will be authorized on a linear foot basis for amount of jacked pipe installed, including grouting when specified.

4. No separate payment will be made for water lines in casing under this Section. Refer to Section 02517 – Water Line in Tunnels for measurement and payment.

5. Refer to Section 01270 - Measurement and Payment for Unit Price procedures.

B. Stipulated Price (Lump Sum): If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering.

B. American Association of State Highway and Transportation Officials (AASHTO).

C. ASTM A 36 – Standard Specification for Carbon Structural Steel.

D. ASTM A 139 – Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over).

E. ASTM A 515 – Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate-and Higher-Temperature Service.

F. ASTM A 572 – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.

G. ASTM A 1097 – Standard Specification for Steel Casing Pipe, Electric-Fusion (Arc)-Welded (Outside Diameter of 10 in. and Larger).

H. AWWA C200 – Steel Water Pipe-6 In. and Larger.

I. National Electrical Code - (NFPA 70).

J. NSF/ANSI 60 – Drinking Water Chemicals – Health Effects.

K. ANSI/AWS D1.1 – Structural Welding Code-Steel.

L. Occupational Safety and Health Administration (OSHA).

1.05 DEFINITIONS

A. Conditioners: Bentonite, foam, polymers and/or other materials added to the excavated materials (cuttings) to modify them. Conditioners are required to form earth paste and an appropriate support medium in the excavation chamber, and to reduce the abrasive nature of the excavated materials.

B. Critical Structure: Building, structure, bridge, pier, or similar construction partially or entirely located within Zone of Active Excavation, unless otherwise defined in Contract Documents.

C. Earth Pressure Balance (EPB) MTBM System: A Microtunneling system that incorporates a screw conveyor to facilitate forming of ground controlling plug and removal of excavated soil into muck car. Face and ground water pressure is balanced by pressure of excavated material held back by the plug. Earth pressure balance systems may utilize ground Conditioners to assist in maintaining pressure balance and enhance controllability and operation of system.

D. Intermediate Jacking Station: Supplementary jacking system installed between two Jacking Pipe sections without use of an additional shaft.

E. Jacking Pipe: Pipe or casing installed by Microtunneling process that is capable of carrying installation jacking loads in addition to normal pipe loads.

F. Microtunneling: Method of installing by jacking pipe or casing behind Microtunnel Boring Machine that is connected to and jacked forward by pipe or casing being installed, generally precluding man entry for routine operation.

G. Microtunnel Boring Machine (MTBM): Mechanized excavating equipment incorporating Pressurized Head that is remotely-controlled, steerable, laser/gyroscope navigational system guided, articulated, with controlled face that fully supports excavation face with fluid and/or earth pressure balance at all times and connected to and shoved forward by pipe or casing being installed, usually precluding man entry for routine operation.

H. Pressurized Head: Bulkhead within MTBM designed to be watertight.

I. Slurry Pressure Balance MTBM System: A Microtunneling system that uses a low-pressure fluid to balance ground and water pressure at face of tunnel and to transport excavated spoils to surface.

J. Work Plan: Written description together with supporting documentation that defines plans and procedures for Microtunneling operations.

K. Zone of Active Excavation: Area located within radial distance centered about surface point immediately above face of excavation and with radius equal to depth from ground surface to bottom of excavation, or as otherwise indicated in Drawings.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. The following submittals are required:

1. Work Plan: Submit brief description of proposed tunnel methodology for record purposes. Description should be sufficient to convey the following:

a. Type of face support.

b. Manufacturer and type of tunneling equipment proposed.

c. Cutter head details.

d. Locations of access shafts and work sites.

e. Proposed method of machine launch, exit and retrieval.

f. Capacity of jacking equipment and type of cushioning.

g. Planned use of Intermediate Jacking Stations, if applicable, and closure of Intermediate Jacking Stations upon completion of drive.

h. System of alignment monitoring and steering control and activation.

i. Lubrication system.

j. Slurry system for slurry Microtunneling.

k. Soil conditioning, if necessary, for EPB Microtunneling.

l. Number and duration of shifts planned to be worked each day.

m. Sequence of operations.

n. Spoil surface storage, separation, and disposal.

o. Contingency plan and emergency procedures, including but not limited to machine maintenance and/or component repair, and Jacking Pipe failure.

p. Supplementary alignment surveying.

q. Lubrication mixing and injection.

r. Source of water used in slurry, lubricant, and grout.

2. Drawings and Calculations: Submit drawings and calculations for tunnel support. Provide adequate drawings and installation details for construction. Show pipe and pipe joint detail. Documents must be signed and sealed by Professional Engineer registered in State of Texas. Calculations shall include clear statement of criteria used for design as described in Article 1.07.A, Design Requirements.

   a. Calculations to demonstrate that the maximum jacking loads will not exceed the maximum allowable jacking forces of the MTBM and the Jacking Pipe selected.

   b. Calculations to demonstrate pipe selected is designed to support maximum anticipated earth loads and superimposed live loads, both static and dynamic, which may be imposed on pipe and additional stresses imposed on the pipe during jacking operations.

   c. Calculations of estimated operating pressure at the tunnel face.

   d. Calculations demonstrating that jacking shaft and backstop arrangement can safely accommodate maximum calculated jacking load without excessive or detrimental movement.

3. Personnel: Submit for record purposes, résumés for project manager, field superintendent and Microtunneling machine operators.

   a. Experience: Minimum of 3 previous successful Microtunneling installations of similar size and scope.

   b. Detailed descriptions of Microtunneling projects.

4. Quality Control: Description of quality control methods including:

   a. Method and frequency of survey control.

   b. Example of tunnel daily log.

5. Geotechnical Investigation: When geotechnical investigations are conducted, submit results to Project Manager for record purposes.

6. Monitoring Plans.

   a. Instrumentation Monitoring Plan: Submit for review, prior to construction, instrumentation monitoring plan that includes schedule of instrumentation design, layout of instrumentation points, equipment installation details, manufacturer's catalog literature, and monitoring report forms.

   b. Surface Settlement Monitoring Plan: Submit surface settlement monitoring plan for review prior to construction. Plan shall identify the location of settlement monitoring points, reference benchmarks, survey frequency and procedures, and reporting formats.

7. Structures Assessment: Provide preconstruction and post construction assessment reports for Critical Structures. Include pre- and post-construction survey and assessment (including photographs or video).

8. Monitoring readings shall be submitted to Project Manager.

9. Daily Reports: Maintain shift log as defined in Article 3.03.B, Tunneling Data and make available to Project Manager on request.

1.07 SYSTEM DESCRIPTION

A. Design Requirements.

1. Assume responsibility for selection of appropriate pipe and pipe joints to carry thrust of any jacking forces or other construction loads in combination with overburden, earth and hydrostatic loads. Design of any pipe or casing indicated on Drawings considers in-place loads only and does not take into account any construction loads. Criteria for longitudinal loading (jacking forces) on pipe and joints shall be determined, based on selected method of construction.

2. Jacking Pipe shall be designed to withstand thrust from MTBM advance without damage or distortion. Configure main jacking frame so thrust is uniformly distributed and will not damage or distort pipe or casing.

3. Take into account loads from handling and storing.

4. Criteria to be used at railroad crossings shall be Cooper E-80 locomotive loading distributions in accordance with AREMA specifications for culverts. In design, account for additive loadings due to multiple tracks.

5. Criteria to be used for truck loading shall be in accordance with the AASHTO LRFD Bridge Design Specification.

6. Provide pipes and casing of diameter shown on Drawings. Substitution of larger diameter to suit MTBM equipment availability for sewer lines will only be permitted if demonstrated to satisfaction of Project Manager that design flows and velocities can be achieved.

PART 2 PRODUCTS

2.01 JACKING PIPE

A. Assume responsibility for selecting appropriate pipes and pipe joints to safely carry loads imposed during construction, including jacking forces. Pipe joints shall be flush with outside pipe face when pipes are assembled. Pipe materials shall be as indicated on Drawings or selected from the following if not indicated on Drawings:

1. Fiberglass Reinforced pipe, joints, and fittings to be in accordance with Section 02504 - Fiberglass Reinforced Pipe.

2. Vitrified clay pipe, joints and fittings to be in accordance with Section 02508 - Extra Strength Clay Pipe.

3. Plastic-lined reinforced concrete pipe with joints and fittings to be in accordance with Section 02611 - Reinforced Concrete Pipe and Section 02427 - Plastic Liner for Large-Diameter Concrete Sewers and Structures. Plastic liner is not required for storm sewers.

4. Steel casing pipe: Provide new, uncoated steel pipe manufactured in accordance with ASTM A 1097 for sewer line applications and ASTM A 1097 and AWWA C200 for water line applications. Joints may be field-welded butt joints or interlocking joints and shall be watertight.

   a. For field-welded butt-joint casing, manufacture in accordance with ASTM A 139 Grade E, or ASTM A 572 Grade 50. Provide full circumferential welds at butt joints.

   b. For steel casing pipe with interlocking joints, provide in accordance with the following:

      (1) Provide ASTM A 36, ASTM A 515, Grade 60, or ASTM A 572, Grade 42 for pipe, and provide minimum ASTM A 36 for connections.

      (2) Maintain pipe roundness to within 1 percent of specified diameter.

      (3) Maintain outside circumference to within 1% of nominal specified circumference, or 3/4 inches, minimum.

      (4) Maintain wall thickness to within 5% of specified thickness.

(5) Provide rolled and welded cylinder method utilizing the double submerged arc welding (DSAW) process in sections not less than 8 feet long, except as needed to achieve the final finished length of pipe.

(6) Provide complete penetration butt-welded connectors square to ends of pipe sections.

(7) Perform welding in accordance with ANSI/AWS D1.1.

(8) Examine connections at time of shipment. Reject sections with defects.

(9) Mark all sections with manufacturer's name, job number, customer name, outside diameter, wall thickness, and weight per foot.

(10) Ship pipe with protective wax coating over machined surfaces.

(11) Provide Permalok or approved equal.

c. Design stress in pipe wall shall be 50 percent of minimum yield point of steel or 18,000 psi, whichever is less when subjected to loading conditions.

d. Design deflection to be used in determining wall thickness shall not exceed 3 percent of nominal casing pipe size.

e. Bedding constant to be used in determining wall thickness shall be 0.10. Lag factors shall be 1.0 for all live loads.

f. Casing pipe design shall also include stresses due to jacking forces.

B. Use pipe that is round with smooth, even outer surface, and has joints that allow for easy connections between pipes. Design pipe ends so jacking loads are evenly distributed around entire pipe joint and point loads will not occur when pipe is installed. Pipe used for pipe jacking shall be capable of withstanding all forces imposed by process of installation, as well as final in-place loading conditions. Protect driving ends of pipe and joints against damage.

C. A list of approved jacking pipes is included in the City of Houston Wastewater Pre-Approved Products List (Reference COHWW02441-). This list is not applicable for casing pipe.

2.02 GROUT

A. Grout shall be in accordance with requirements defined in Section 02431 – Tunnel Grout.

2.03 ANNULAR SPACE LUBRICATION

A. Lubricants shall be NSF 60 approved.

B. Water used for pipe lubrication shall be clean, fresh, and free from oil, organic matter, or other deleterious matter and of neutral pH.

2.04 CONDITIONERS

A. Conditioners shall be inert or biodegradable, accompanied by the manufacturers' certificate of compliance with Safety Data Sheets (SDS).

B. Water is no acceptable as a soil conditioner.

2.05 WATER

A. Water used in slurry, lubricant, and grout shall be obtained from potable water source. Soda ash or accepted equal, with submittal of a Safety Data Sheet (SDS), shall be used to adjust pH of water as required in mix design.

PART 3 EXECUTION

3.01 CONSTRUCTION OPERATIONS CRITERIA

A. Use methods for Microtunneling operations that will minimize ground settlement. Select a method that controls flow of water, prevents loss of soil into the tunnel and provides stability of the face under anticipated conditions.

B. Conduct tunneling operations in accordance with applicable safety rules and regulations, OSHA standards and Contractor's safety plan. Use methods that include due regard for safety of workmen, adjacent structures, utilities, and public and safe means of ingress and egress.

C. Maintain clean working conditions wherever there is man access.

D. Perform installation so as to avoid interference with operation of railroads, highways, or streets, except as approved by owner of facility.

E. Shafts required for microtunnel construction shall be in conformance with Section 02400 – Tunnel Shafts and Section 02401 – Common Tunnel Shafts.

3.02 EQUIPMENT

A. Full directional guidance of MTBM is prerequisite of this method of construction.

B. Assume responsibility for selection of tunneling equipment which, based on past experience, has proven to be satisfactory for excavation of soils to be encountered.

C. Employ tunneling equipment that is capable of handling various anticipated ground conditions, is capable of minimizing loss of soil ahead of and around machine and provides satisfactory support of excavated face.

D. Microtunneling Equipment.

1. Slurry Pressure Balance MTBM System shall be capable of adjustments required to maintain face stability for particular soil condition and shall monitor and continuously balance soil and ground water pressure to prevent loss of slurry or uncontrolled soil and ground water inflow, or, in case of slurry spoil transportation system:

    a. Provides pressure at excavation face by use of slurry pumps, pressure control system, and flow meter.

    b. Includes slurry bypass unit in system to allow direction of flow to be changed and isolated, as necessary.

2. Earth Pressure Balance MTBM System shall be capable of adjustments required to maintain face stability for particular soil condition to be encountered. Monitor and continuously balance soil and ground water pressure to prevent loss of soil or uncontrolled ground water inflow.

    a. The spoil transportation system shall be capable of managing pressure at the excavation face by controlling volume of spoil removal with respect to advance rate. Monitor speed of rotation of screw conveyor, and addition of water.

3. Remote Control System: Provide MTBM that includes remote control system with following features:

    a. Allows for operation of system without need for personnel to enter tunnel for routine operations. Has display available to operator, at remote operation console, showing position of shield in relation to design reference together with other information such as face pressure, roll, pitch, steering attitude, valve positions, thrust force, and cutter head torque; rate of advance and installed length.

    b. Integrates system of excavation and removal of spoil and its simultaneous replacement by pipe. As each pipe section is jacked forward, remote control system shall synchronize all of operational functions of system.

4. Active Direction Control System: Provide MTBM that includes active direction control system with the following features:

    a. Controls line and grade by a guidance system that remotely relates actual position of MTBM to design reference.

b. Provides active steering information that is monitored and transmitted to operating console.

c. Provides positioning and operation information to operator on control console.

E. Pipe Jacking Equipment: Provide pipe jacking system with the following features:

1. Has main jacks mounted in jacking frame located in starting shaft.

2. Has jacking frame which successively pushes string of connected pipes following tunneling excavation equipment towards receiving shaft.

3. Has sufficient jacking capacity to push tunneling excavation equipment and string of pipe through ground. Incorporates Intermediate Jacking Stations, if required.

4. Has capacity at least 20 percent greater than calculated maximum jacking load.

5. Develops uniform distribution of jacking forces on end of pipe by use of spreader rings and packing.

6. Provides and maintains pipe lubrication system at all times to lower friction developed on surface of pipe during jacking.

7. Jack Thrust Reactions. Use reaction/thrust walls for pipe jacking that are adequate to support jacking pressure developed by main jacking system. Special care shall be taken when setting pipe guide rails in jacking shaft to ensure correctness of alignment, grade, and stability.

F. Slurry Separation Equipment: If slurry MTBM is being used, provide a slurry separation system meeting the following requirements:

1. Provide adequate separation of the spoil from the slurry so that slurry content within the limits set by the Contractor’s Work Plan can be returned to the cutting face for reuse.

2. Use a mechanical separation plant, including scalping screens, shaker screens, de-sanding and de-silting cones, and centrifuge as deemed necessary by the Work Plan.

3. Appropriately contain spoil at the site before disposal.

4. The type of separation process is suited to the size of the tunnel being constructed, the ground type being excavated, the volume of expected flow generated by the slurry circuit, and the workspace available at each jacking shaft location for operating the plant.

5. Monitor the composition of the slurry to maintain the slurry weight, gel strength, and viscosity limits defined by the Contractor's Work Plan.

G. Air Quality: Provide equipment to maintain proper air quality assuming manned tunnel operations during construction in accordance with OSHA requirements.

H. Where used, enclose lighting fixtures in watertight enclosures with suitable guards. Provide separate circuits for lighting, and other equipment.

I. Electrical systems shall conform to requirements of National Electrical Code - NFPA70.

3.03 TUNNELING DATA

A. Utilize a real-time data collection system and make available to the Project Manager on request.

B. Maintain shift logs of construction events and observations. Project Manager shall have access to all logs containing the following required information:

1. Location of boring machine face by station and progress of tunnel drive during shift.

2. Hours worked per shift on tunneling operations.

3. Completed field forms, such as steering control logs, for checking line and grade of tunneling operation, showing achieved tolerance relative to design alignment.

4. Maximum pipe jacking pressures per drive.

5. Lubricant pressures and estimated quantities.

6. Observation of any lost ground or other ground movement.

7. Any unusual conditions or events.

8. Reasons for operational shutdown in event drive are halted.

3.04 EXCAVATION AND JACKING OF PIPE

A. Tunnel Excavation.

1. Keep tunnel excavation within easements and rights-of-way indicated on Drawings and to lines and grades designated on Drawings.

2. Perform tunneling operations in a manner that will minimize movement of ground in front of and surrounding tunnel. Prevent damage to structures and utilities above and in vicinity of tunneling operations.

3. Pressurized Head Excavation

   a. Carefully control volume of spoil removed. Advance rate and excavation rate to be compatible to avoid over excavation, loss of ground or ground heave.

   b. When cutting head is withdrawn or is open for any purpose, keep excavated face supported and stabilized.

4. Whenever a condition is encountered which could endanger tunnel excavation or adjacent structures, operate without intermission including 24-hour working, weekends and holidays, until condition no longer exists. Such conditions shall be brought to the attention of Project Manager within 24 hours.

5. Assume responsibility for damage due to settlement from any construction-induced activities.

B. Pipe Jacking.

1. Cushion pipe joints as necessary to transmit jacking forces without damage to pipe or pipe joints, in accordance with pipe manufacturer's recommendations.

2. Maintain envelope of bentonite slurry around exterior of pipe during jacking and excavation operation to reduce exterior friction and possibility of pipe seizing in place.

3. If a recovery access shaft is needed, obtain approval from Project Manager prior to excavation. Coordinate traffic control measures and utility adjustments as necessary prior to commencing work.

4. If a section of pipe is damaged during jacking operation, or joint failure occurs, as evidenced by inspection, visible ground water inflow or other observations, submit for approval Contractor's proposed methods for repair or replacement of pipe. Document repairs by providing repair locations (station numbers), pictures/videos showing condition of the pipe or joint before and after repairs are done, and a certification from manufacturer's representative that repairs have been inspected and are considered acceptable.

C. Grouting: Grouting requirements are defined in Section 02431 - Tunnel Grout.

3.05 CONTROL OF LINE AND GRADE

A. Construction Control.

1. Project Manager will establish baselines and benchmarks indicated on Drawings. Check baselines and benchmarks at beginning of Work and report any errors or discrepancies to Project Manager.

2. Use baselines and benchmarks established by Project Manager to establish and maintain construction control points, reference lines and grades for locating tunnel, sewer pipe, and structures.

3. Establish construction control points sufficiently far from work so as not to be affected by ground movement caused by pipe-jacked tunneling operations.

B. Benchmark Movement: If settlement of ground surface occurs during construction which affects accuracy of temporary benchmarks, detect and report such movement and reestablish temporary benchmarks. Locations of permanent City of Houston monumentation benchmarks are indicated on Drawings. Advise Project Manager of any settlement affecting permanent monumentation benchmarks.

C. Guidance System and Alignment Control.

1. Provide the Project Manager access to the guidance system readings at all times to be able to verify alignment and grade.

2. Initial alignment of equipment and final pipe/casing alignment shall be documented.

D. Line and Grade.

1. Check and record alignment for tunnel against above-ground undisturbed reference after installation of each Jacking Pipe.

2. Record exact position of MTBM after each shove to ensure alignment is within specified tolerances. Make immediate correction to alignment before allowable tolerances are exceeded.

3. When excavation is off line or grade, make alignment corrections to avoid reverse grades in gravity sewers.

4. Acceptance criteria for jacking pipe shall be plus or minus 6 percent of the MTBM diameter in horizontal alignment or 2 inches, whichever is greater, and plus or minus 3 percent of the MTBM diameter in elevation or 1 inch, whichever is greater, from the design line and grade, unless otherwise indicated on the Drawings.

5. If it is determined that the pipe cannot be used, pipe installed outside tolerances shall be fully grouted and abandoned.

3.06 MONITORING

A. Instrumentation Monitoring: Instrumentation requirements are shown on Drawings. Instrumentation specified shall be accessible at all times to Project Manager.

1. Install and maintain instrumentation system to monitor and detect movement of ground surface and adjacent structures. Establish vertical control points at a distance from construction areas that avoids disturbance due to ground settlement.

2. Installation of instrumentation shall not preclude Project Manager, through independent contractor or consultant, from installing instrumentation in, on, near, or adjacent to construction work. Access shall be provided to work for such independent installations.

3. Instruments shall be installed in accordance with Drawings and manufacturer's recommendations.

B. Surface Settlement Monitoring.

1. Establish monitoring points on all Critical Structures.

2. Record location of settlement monitoring points with respect to construction baselines and elevations. Record elevations to accuracy of 0.01 feet for each monitoring point location. Monitoring points should be established at locations and by methods that protect them from damage by construction operations, tampering, or other external influences.

3. Ground surface elevations shall be recorded on centerline ahead of tunneling operations at minimum of 100-foot intervals or at least three locations per tunnel drive. For sewers greater than 60-inch diameter, also record similar data at approximately 20 feet each side of centerline. Settlement monitoring points must be clearly marked by studs or paint for ease of locating.

4. Railroads. Monitor ground settlement of track subbase at centerline of each track. Follow American Railway Engineering and Maintenance-of-Way Association (AREMA) crossing requirements.

5. Utilities and Pipelines. Monitor ground settlement directly above and at least 10 feet or two excavation diameter, whichever is greater, before and after utility or pipeline intersection as shown on the Drawings.

C. Reading Frequency and Reporting: Submit to Project Manager, records of readings from various instruments and survey points.

1. Readings shall be taken:

a. Prior to Zone of Active Excavation reaching that point.

b. When tunnel face reaches monitoring point (in plan).

c. When Zone of Active Excavation has passed and no further movement is detected.

2. All monitoring readings shall be submitted daily to Project Manager.

3. Immediately report to Project Manager any movement, cracking, or settlement detected.

4. Following substantial completion but prior to final completion, make final survey of remaining monitoring points and submit to Project Manager.

3.07 DISPOSAL OF EXCESS MATERIAL

A. Remove spoil in accordance with Section 01576 - Waste Material Disposal.

3.08 ACCEPTANCE TESTING FOR SEWERS

A. Acceptance testing is to be carried out by methods described in Section 02533 - Acceptance Testing for Sanitary Sewer.

END OF SECTION

SECTION 02445

JACK AND BORE/JACK AND MINE/PILOT TUBE GUIDED BORING TUNNELS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnishing and installation of pipes by Jack and Bore, Jack and Mine or Pilot Tube Guided Boring.

1.02 RELATED SECTIONS

A. Section 01330 – Submittal Procedures

B. Section 01576 – Waste Material Disposal

C. Section 01578 - Control of Ground and Surface Water

D. Section 02427 – Plastic Liner for Large-Diameter Concrete Sewers and Structures

E. Section 02431 – Tunnel Grout

F. Section 02504 – Fiberglass Reinforced Pipe

G. Section 02508 – Extra Strength Clay Pipe

H. Section 02511 – Water Lines

I. Section 02517 – Water Line in Tunnels

J. Section 02533 – Acceptance Testing for Sanitary Sewers

K. Section 02611 – Reinforced Concrete Pipe

L. Section 02612 – Precast Reinforced Concrete Box Sewers

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Length of sewer installed will be measured by linear foot along center line of completed sewer from center line to center line of manholes, as designated on Drawings; and to end of stubs or termination of pipe; and to inside face of lift station and treatment plant works. Installation of sewer within limits of structure other than manholes will not be considered for measurement and payment at unit price bid.

2. Payment will include and be full compensation for labor, equipment, materials, and supervision for construction of sewer or casing and excavation, complete in place including disposal of excess materials, sheeting, shoring or bracing, dewatering, utility adjustments, connections to existing sewers, grouting when required, tests, backfilling, clean-up, and other related work necessary for construction as specified or as shown on Drawings.

3. Payment for installation of sewer or casing will be authorized by the Project Manager in two parts. Pay estimates for partial payments will be made as measured above according to following schedule:

   a. 95 percent payment will be made for jacked pipe on linear foot basis for amount of jacked sewer pipe installed but not yet grouted, in cases where grouting is specified.

   b. Remaining 5 percent payment will be made for jacked pipe on linear foot basis for amount of jacked sewer pipe installed and grouted, in cases where grouting is specified. A 100 percent payment will be made for jacked pipe on linear foot basis for amount of jacked sewer pipe installed, in cases where grouting is not specified.

4. No separate payment will be paid for water lines in tunnel under this Section. Refer to Section 02511 – Water Lines or Section 02517 – Water Line in Tunnel for measurement and payment.

B. Stipulated Price (Lump Sum): If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering.

B. American Association of State Highway and Transportation Officials (AASHTO)-LRFD Bridge Design Specification.

C. ASTM A 36 – Standard Specification for Carbon Structural Steel.

D. ASTM A 139 – Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over).

E. ASTM A 515 – Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate and Higher Temperature Service.

F. ASTM A 572 – Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.

G. ASTM A 1097 – Standard Specification for Steel Casing Pipe, Electric-Fusion (Arc)-Welded (Outside Diameter of 10 in. and Larger).

H. AWWA C200 – Steel Water Pipe-6 in. and Larger.

I. National Electrical Code - (NFPA 70).

J. NSF/ANSI 60 – Drinking Water Chemicals – Health Effects.

K. Occupational Safety and Health Administration (OSHA).

1.05 DEFINITIONS

A. Critical Structure: Buildings, structures, bridges, piers, or similar construction partially or entirely located within Zone of Active Excavation, or otherwise identified in Drawings.

B. Jack and Bore: Pipe or casing is installed by jacking process with system that has limited steering capability and does not have continuous face support. Excavation is performed using open face auger.

C. Jack and Mine: Pipe or casing is installed by jacking it into place from jacking shaft to receiving shaft, using hydraulic jacks while excavation takes place at the face by hand mining or mechanical excavation.

D. Jacking Pipe: Pipe or casing installed by jacking process and that is capable of carrying installation jacking loads in addition to normal pipe loads.

E. Pilot Tube Guided Boring: Multi-stage method of installing pipe or casing to line and grade by use of guided pilot tube and followed by enlargement to install pipe or casing.

F. Work Plan: Written description together with supporting documentation that defines plans and procedures for tunneling operations.

G. Zone of Active Excavation: Area located within the radial distance centered about surface point immediately above the face of excavation and with radius equal to depth from ground surface to bottom of excavation, or as otherwise indicated in Drawings.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. The following submittals are required:

1. Work Plan: Written description together with supporting documentation that defines plans and procedures for tunneling operations. Description should be sufficient to convey the following:

a. Proposed method of pipe or casing installation and type of face support.

b. Installation of jacking or boring supports or back stop. Installation of pipe jack or Pilot Tube Guided Boring thrust block.

c. Jack and Bore system manufacturer's literature describing equipment and proposed jacking system including machine:

(1) Dimensions

(2) Weight

(3) Power and torque capabilities

(4) Arrangement and position of jacks and pipe guides

(5) Cutterhead configuration details including cutterhead teeth

(6) Mucking system

(7) Auger size

d. Type of lighting and description of ventilation systems when person entry is required.

e. Pilot Tube Guided Boring tooling and reaming equipment.

f. System of alignment monitoring and steering control and activation.

g. Number and duration of shifts planned to be worked each day.

h. Sequence of operations.

i. Locations of boring and receiving shafts.

j. Method of spoil transportation from face, surface storage and disposal location.

k. Jacking mechanism including maximum jacking capacity.

l. Jacking force monitoring and recording details.

m. Capacity of jacking equipment and type of cushioning. Anticipated jacking forces for each drive. Safe jacking capacity of Jacking Pipe.

n. Identify critical utility crossings and special precautions proposed.

o. Description and details of any temporary underground facility proposed for operation including lights, sump pits, and mud slabs.

p. If a thrust block is used, thrust block design calculations and safe capacity.

q. Calibration table correlating jacking pressure gauge readings and applied load in tons.

r. Provisions for injecting slurry for Pilot Tube Guided Boring. Slurry mix design, volume and measurement procedures, pumps, piping, valve arrangements, and pressure gauges.

s. Provisions for injecting pipe lubricants. Pipe jacking lubricant mix design, including lubricant type, injection volume and measurement procedures, pumps, piping, valve arrangements, and pressure gages.

2. Drawings and Calculations.

a. Submit Drawings and calculations for tunnel support system. Provide adequate drawings and installation details for construction. Shop Drawings shall identify proposed Jack and Bore, Jack and Mine or Pilot Tube Guided Boring method complete in assembled position including locations of equipment, staging, and storage areas, and emergency access around the construction operations. Drawings shall show pipe seals, pipe joint, collars, cushioning materials, and reinforcing details. Calculations shall include clear statement of criteria used for design as described in Article 1.07.A, Design Requirements.

b. Drawings for hydraulic jacking system, including hydraulic jack configuration and frame dimensions.

c. Provide signed and sealed by a Professional Engineer registered in the State of Texas the following calculations:

(1) Confirming maximum allowable loads on pipe will not be exceeded by maximum jacking capacity of the jacking system during Jack and Bore, Jack and Mine, or Pilot Tube Guided Boring operations.

(2) Demonstrate pipe selected has been designed to support maximum anticipated earth loads and superimposed live loads, both static and dynamic, which may be imposed on pipe and additional stresses imposed on pipe during jacking operations.

(3) Showing maximum expected jacking loads and confirm these are not greater than maximum jacking capacity of jacking system. Calculations should indicate if lubrication is being accounted for.

(4) Demonstrating that the jacking shaft and backstop arrangement can safely accommodate the maximum calculated jacking load without excessive or detrimental movement.

3. Personnel – Submit for record purposes, résumés for Project Manager, field superintendent and tunneling machine operators.

   a. Experience: Minimum of 3 previous successful pipe-jacked tunnel installations of similar size and scope.

   b. Detailed descriptions of pipe-jacked tunnel projects.

4. Quality Control: Description of quality control methods including:

   a. Method and frequency of survey control.

   b. Example of daily report.

5. Geotechnical Investigation: When geotechnical investigations are conducted, submit results to the Project Manager for record purposes.

6. Monitoring Plans:

   a. Instrumentation Monitoring Plan: Submit for review, prior to construction, monitoring plan that includes schedule of instrumentation design, layout of instrumentation points, equipment installation details, manufacturer's catalog literature, and monitoring report forms.

   b. Surface Settlement Monitoring Plan. Submit surface settlement monitoring plan for review prior to construction. Plan shall identify the location of settlement monitoring points, reference benchmarks, survey frequency and procedures, and reporting formats.

7. Structures Assessment. Provide preconstruction and post construction assessment reports for Critical Structures (including photographs or video).

8. Monitoring readings shall be submitted to Project Manager at the frequency indicated in Article 3.07.C.2.

9. Daily Reports: Maintain a shift log as defined in Article 3.04 - Tunneling Data and make available to Project Manager on request.

1.07 SYSTEM DESCRIPTION

A. Design Requirements.

1. Assume responsibility for selection of appropriate pipe and pipe joints to carry thrust of any jacking forces or other construction loads in combination with overburden, earth and hydrostatic loads. Design of pipe indicated on Drawings considers in-place loads only and does not take into account any construction loads. Criteria for longitudinal loading (jacking forces) on pipe and joints shall be determined, based on selected method of construction.

2. Jacking Pipe shall be designed to withstand thrust without damage or distortion. Configure main jacking frame so thrust is uniformly distributed and will not damage or distort pipe.

3. Take into account loads from handling and storing.

4. Criteria to be used at railroad crossings shall be Cooper E-80 locomotive loading distributions in accordance with AREMA specifications for culverts. Account for additive loadings due to multiple tracks.

5. Criteria for non-railroad crossings to be in accordance with the AASHTO LRFD Bridge Design Specification.

6. Provide pipes and casing of diameter shown on Drawings. Substitution of pipe with larger diameter to suit equipment availability for sewer lines will only be permitted if demonstrated to satisfaction of the Project Manager that design flows and velocities can be achieved.

PART 2 PRODUCTS

2.01 JACKING PIPE

A. Pipe joints shall be flush with outside pipe face when pipes are assembled. Pipe materials shall be as indicated on Drawings or selected from the following if not indicated on the Drawings:

1. Fiberglass Reinforced pipe, joints, and fittings in accordance with Section 02504 - Fiberglass Reinforced Pipe.

2. Vitrified clay pipe, joints and fittings in accordance with Section 02508 - Extra Strength Clay Pipe.

3. Plastic-lined reinforced concrete pipe with joints and fittings in accordance with Section 02611 - Reinforced Concrete Pipe and Section 02427 - Plastic Liner for Large-Diameter Concrete Sewers and Structures. Plastic liner is not required for storm sewers.

4. Steel casing pipe: Provide new, uncoated steel pipe manufactured in accordance with ASTM1097 for sewer line applications and AWWA C200 for water line applications. Joints may be field-welded butt joints or interlocking joints and shall be watertight.

   a. For field-welded butt-joint casing, manufacture in accordance with ASTM A139 Grade E, or ASTM A572 Grade 50. Provide full circumferential welds at butt joints.

   b. For steel casing pipe with interlocking joints, provide in accordance with the following:

(1) Provide ASTM A36, ASTM A515, Grade 60, or ASTM A572, Grade 42 for pipe, and provide minimum ASTM A36 for connections.

(2) Maintain pipe roundness to within 1 percent of specified diameter.

(3) Maintain outside circumference to within 1% of nominal specified circumference, or 3/4 inches, minimum.

(4) Maintain wall thickness to within 5% of specified thickness.

(5) Provide rolled and welded cylinder method utilizing the double submerged arc welding (DSAW) process in sections not less than 8 feet long, except as needed to achieve the final finished length of pipe.

(6) Provide complete penetration butt-welded connectors square to ends of pipe sections.

(7) Perform welding in accordance with ANSI/AWS D1.1.

(8) Examine connections at time of shipment. Reject sections with defects.

(9) Mark all sections with manufacturer's name, job number, customer name, outside diameter, wall thickness, and weight per foot.

(10) Ship pipe with protective wax coating over machined surfaces.

(11) Provide Permalok joints or approved equal.

c. Design stress in pipe wall shall be 50 percent of minimum yield point of steel or 18,000 psi, whichever is less when subjected to loading conditions.

d. Design deflection to be used in determining wall thickness shall not exceed 3 percent of nominal casing pipe size.

e. Bedding constant to be used in determining wall thickness shall be 0.10. Lag factors shall be 1.0 for all live loads.

f. Casing pipe design shall also include stresses due to jacking forces when pipe is to be installed by jacking method.

B. Use pipe that is round with smooth, even outer surface, and has joints that allow for easy connections between pipes. Design pipe ends so jacking loads are evenly distributed around entire pipe joint and point loads will not occur when pipe is installed. Jacking Pipe shall be capable of withstanding all forces imposed by process of installation, as well as final in-place loading conditions. Protect driving ends of pipe and joints against damage.

C. Precast reinforced box with joints and fittings shall be in accordance with Section 02612– Precast Reinforced Concrete Box Sewers. Precast concrete box is not acceptable for sanitary sewers. Precast concrete box is not used for Jack and Bore or Pilot Tube Guided Boring.

D. For sewer pipe installation, a list of approved jacking pipes is included in the City of Houston Wastewater Pre-Approved Product List (Reference COHWW02441-). This list is not applicable for casing pipe.

2.02 GROUT

A. Grout shall be in accordance with requirements defined in Section 02431 – Tunnel Grout.

2.03 ANNULAR SPACE LUBRICATION

A. Lubricants shall be NSF 60 approved.

B. Water used for pipe lubrication shall be clean, fresh, and free from oil, organic matter, or other deleterious matter and of neutral pH.

2.04 WATER

A. Water used in slurry, lubricant, and grout shall be obtained from potable water source. Soda ash or accepted equal, with submittal of Safety Data Sheet (SDS), shall be used to adjust pH of water as required in mix design.

PART 3 EXECUTION

3.01 CONSTRUCTION OPERATIONS CRITERIA

A. Use methods that minimize ground settlement. Select method that controls flow of water and prevents loss of soil into tunnel and provides stability of face under anticipated conditions.

B. For Jack and Bore, at minimum use a level manometer (Dutch level) for guidance. Free boring is not an acceptable method.

C. For Jack and Mine, use surveying or other means for guidance.

D. Pilot Tube Guided Boring system shall utilize a two or three phase system as described below:

1. Three Pass System.

a. Phase 1 – Rigid steel pilot tube in approximately 3-foot lengths shall be installed through ground from boring shaft to receiving shaft by earth displacement with jacking frame. Alignment of pilot tube shall be established with theodolite mounted at rear of boring shaft and set to desired line and grade. Theodolite shall view lighted target in lead or steering pilot tube. Camera shall be fitted to theodolite and transmit image of crosshair and target onto monitor screen to be viewed in boring shaft by operator. As operator advances pilot tube through ground, center of target will drift from crosshair as a result of biased or slanted leading tip of the pilot tube. Operator shall rotate pilot tube as required to orient slanted steering tip toward crosshair and continue to advance pilot tube until it reaches receiving shaft. Check line and grade of bore at the receiving shaft.

b. Phase 2 – An enlargement casing with an outside diameter up to 1 ½" larger than Jacking Pipe shall be rigidly connected to final pilot tube and advanced into earth behind pilot tube. Auger shall be used inside enlargement casing to remove material being excavated. Auger shall be contained inside limits of enlargement casing as it progresses along proposed alignment. A train of temporary steel casings with an outside diameter very similar to the enlargement casing shall be used to move enlargement casing from the boring shaft to receiving shaft. Enlargement casing will cut bore hole from boring shaft to receiving shaft and temporary casings will case hole as it is cut. Fit each temporary casing with internal auger to transport excavated material to boring shaft to be removed from shaft and disposed at an approved location. Recover pilot tubes in receiving shaft as temporary casings are installed.

c. Phase 3 – Jacking Pipe shall be installed directly behind final temporary casing pipe with jacking frame. Casing pipes and augers shall be recovered in receiving shaft as Jacking Pipe is installed.

2. Two Pass System.

a. Phase 1 – Install pilot tube in same manner described in Phase 1 of Three Pass System.

b. Phase 2 – Install enlargement casing in same manner described in Phase 2 of Three Phase System. Fit each Jacking Pipe with internal protective-casing pipe to house auger and prevent damage to Jacking Pipe. Install Jacking Pipe directly behind enlargement casing with internal casing rigidly connected to auger chamber of enlargement casing. Manufacture internal casing such that excavated material does not leak excessively into Jacking Pipe. Fit internal casing with protective shoe to protect Jacking Pipe from damage and to support casing and auger at centerline of pipe. Advance Jacking Pipe along proposed alignment with jacking frame thus progressing enlargement casing from boring shaft to receiving shaft with pilot tubes being recovered in receiving shaft. Excavated material shall be funneled into and conveyed through internal casing to boring shaft where it shall be removed from shaft and disposed at approved location. Upon reaching receiving shaft remove enlargement casing and internal casings and augers retracted and recovered at boring shaft.

E. Conduct operations in accordance with applicable safety rules and regulations, OSHA standards, and Contractor's safety plan. Use methods which include due regard for safety of workmen, adjacent structures, utilities, and public and safe means of ingress and egress.

F. Maintain clean working conditions wherever there is man access.

G. Perform installation to avoid interference with operation of railroads, highways, or streets, except as approved by owner of facility.

3.02 GROUND WATER CONTROL

A. Provide ground water control measures in conformance with Section 01578 - Control of Ground and Surface Water, when necessary to perform Work.

3.03 EQUIPMENT

A. Assume responsibility for selection of equipment which, based on past experience, has proven to be satisfactory for excavation of soils to be encountered.

B. Employ equipment that will be capable of handling various anticipated ground conditions and is capable of minimizing loss of soil and shall provide satisfactory support of excavated face.

C. Tunnel Shield. If hand shield is used for Jack and Mine (with or without attached mechanized excavating equipment), shield must be capable of handling various anticipated ground conditions. In addition, shield shall:

1. Conform to shape of tunnel with uniform perimeter that is free of projections that could produce over-excavation or voids. Appropriately sized overcutting bead may be provided to facilitate steering.

2. Be designed to allow face of tunnel to be closed by use of gates or breasting boards without loss of ground.

D. The following are minimum requirements for Pilot Tube Guided Boring:

1. Line and Grade Control System: Control system shall include but not be limited to a theodolite, lighted target, camera, and monitor screen. The equipment must be capable of installing the pipe to the desired line and grade.

2. Jacking Frame: The jacking frame shall possess adequate strength to advance the pilot tube, the enlargement casing and the string of Jacking Pipe from the boring shaft to the receiving shaft. The jacking force shall be easily regulated down to the safe working load rating of the Jacking Pipe. The frame shall develop a uniform distribution of jacking forces on the end of the pipe. The auger motor shall possess adequate torque to steer the pilot tube and adequate torque and speed to effectively auger the excavated material from the face of the bore to the boring shaft.

3. Pilot Tube: The pilot tubes shall be constructed of steel in rigid but short sections to accommodate the boring and receiving shafts. The tubes shall rigidly connect to each other, the steering tip and the enlargement casing and have a clear inside diameter large enough to adequately view the lighted target. The tubes shall withstand the torque encountered in the steering process.

4. Enlargement Casing: The enlargement casing shall be constructed of steel to a diameter just larger than the Jacking Pipe and have a leading connection compatible with the pilot tube. The leading face of the enlargement casing shall possess several large openings for the soil to enter as it advances along the proposed alignment. An internal auger chamber shall funnel the excavated material into the temporary full diameter casings of the Three-Phase Process or into the internal auger casings of the Two-Phase Process. Structural members shall connect the leading edge of the casing to the pilot tube connections.

5. Soil Transportation System: The soil transportation system shall consist of an auger train operating inside the full diameter temporary steel casing of the Three-Phase System and an internal casing and auger train operating inside the Jacking Pipe. The internal casings of the Two-Phase Process shall be manufactured to minimize leakage of the excavated material into the Jacking Pipe.

6. Soil Removal: A soil removal system shall be provided to safely remove the excavated material from the boring shaft to the surface.

7. Hydraulic Power Unit: The hydraulic power unit shall rest on the surface and be connected to the jacking frame by hoses

8. Lubrication System: A lubrication system shall be employed to minimize pipe friction to ensure that pipe can be installed from the boring shaft to the receiving shaft within the shaft working load rating of the Jacking Pipe. The system may also be required to minimize the torque required to transport the excavated material to the boring shaft.

E. Jacking Equipment: Provide jacking system with the following features:

1. Has main jacks mounted in jacking frame located in boring shaft. Jacks shall have individual actuation, synchronized actuation, and maximum thrust control. Jacks shall not exert forces when idle but shall resist displacements.

2. Control gauges shall be accessible to allow the Project Manager's representative to check readings during excavation.

3. The maximum thrust on the jacked pipe shall not exceed the safe jacking capacity of the pipe at any point or time.

4. Has jacking frame which successively pushes a string of connected pipes following tunneling excavation equipment towards the receiving shaft.

5. Has sufficient jacking capacity to push the tunneling excavation equipment and string of pipe through ground.

6. Has capacity at least 20 percent greater than calculated maximum jacking load.

7. Develops uniform distribution of jacking forces on end of pipe by use of spreader rings and packing.

8. Provides and maintains pipe lubrication system at all times to lower friction developed on surface of pipe during jacking.

9. Jack Thrust Reactions: Use reaction/thrust walls for pipe jacking that are adequate to support jacking pressure developed by main jacking system. Special care shall be taken when setting pipe guide rails in jacking shaft to ensure correctness of alignment, grade, and stability.

F. Air Quality: Provide equipment to maintain proper air quality of manned tunnel operations during construction in accordance with OSHA requirements.

G. Where used, enclose lighting fixtures in watertight enclosures with suitable guards. Provide separate circuits for lighting, and other equipment

H. Electrical systems shall conform to requirements of National Electrical Code - NFPA70.

3.04 TUNNELING DATA

A. Maintain shift logs of construction events and observations. Project Manager shall have continuous access to all logs containing the following required information:

1. Location of bore face by station and progress during shift.

2. Hours worked per shift on tunneling operations.

3. Completed field forms, such as steering control logs, for checking line and grade of tunneling operation, showing achieved tolerance relative to design alignment.

4. Maximum jacking pressures per drive.

5. Lubricant pressures and estimated quantities.

6. Ground water control operations and piezometric levels.

7. Observation of any lost ground or other ground movement.

8. Any unusual conditions or events.

9. Reasons for operational shutdown in the event a drive is halted or stopped.

3.05 EXCAVATION AND JACKING OF PIPE

A. Excavate material just ahead of Jacking Pipe and remove material through Jacking Pipe as it is forced through ground by jacking, into the space thus provided. In general, excavated material shall be removed as jacking progresses and no accumulation of excavated material within Jacking Pipe will be permitted. Should appreciable loss of ground occur in installations where face of excavation is accessible, voids shall be backpacked promptly to the extent practicable with approved soil cement.

B. The distance that excavation shall extend beyond end of Jacking Pipe depends on character of material encountered but shall not exceed 2 feet.

C. Boring for Jack and Bore and Pilot Tube Guided Boring.

1. Boring shall proceed from shaft provided for boring equipment and workers. Boring shall be done mechanically using either a pilot tube or auger method.

2. For auger method, Jacking Pipe of appropriate diameter equipped with cutter head to mechanically perform excavation shall be used. Augers shall be of sufficient diameter to convey excavated material to shaft.

3. Remove excavated material from shaft and dispose of properly. Use of water or other fluids in connection with boring operation will be permitted only to the extent needed to lubricate cuttings. Water jetting will not be permitted.

D. Excavation for Jack and Mine.

1. Perform excavation operations in a manner to minimize movement of ground in front of and surrounding tunnel. Prevent damage to structures and utilities above and in vicinity of tunneling operations.

2. Keep face breasted or otherwise supported to prevent falls, excessive raveling, or erosion. Maintain standby face supports for immediate use when needed.

3. During shut-down periods, support face of excavation by positive means; no support shall rely solely on hydraulic pressure.

E. Assume responsibility for damage due to settlement from any construction-induced activities.

F. Jacking Operation.

1. Provide a suitable jacking frame or backstop.

2. Set pipe to be jacked on guides properly braced together, to support section of pipe and to direct proper line and grade. Place complete jacking assembly to line up with direction and grade of pipe.

3. Cushion pipe joints as necessary to transmit jacking forces without damage to pipe or pipe joints, in accordance with pipe manufacturer's recommendations. For plywood cushioning material, use ½-inch minimum thickness for pipe diameter 30 inches or less and use ¾-inch minimum thickness for pipe diameter greater than 30 inches.

4. Maintain envelope of bentonite slurry around exterior of pipe during jacking and excavation operation to reduce exterior friction and possibility of pipe seizing in place.

5. If a recovery access shaft is needed, obtain approval from Project Manager prior to excavation. Coordinate traffic control measures and utility adjustments as necessary prior to commencing work.

6. If a section of pipe is damaged during jacking operation, or joint failure occurs, as evidenced by inspection, visible ground water inflow or other observations, submit for approval methods for repair or replacement of pipe. Proposed repair methods shall follow pipe manufacturer's recommendations.

G. Grouting: Grouting requirements are defined in Section 02431 – Tunnel Grout.

3.06 CONTROL OF LINE AND GRADE

A. Construction Control.

1. Project Manager will establish baselines and benchmarks indicated on Drawings. Check baselines and benchmarks at beginning of work and report any errors or discrepancies to Project Manager.

2. Use baselines and benchmarks established by Project Manager to establish and maintain construction control points, reference lines and grades for locating tunnel, sewer pipe, and structures.

3. Establish construction control points sufficiently far from work so as not to be affected by ground movement caused by pipe-jacked tunneling operations.

B. Benchmark Movement: If settlement of ground surface occurs during construction which affects accuracy of temporary benchmarks, detect and report such movement and reestablish temporary benchmarks. Locations of permanent City of Houston monumentation benchmarks are indicated on Drawings. Advise Project Manager of any settlement affecting permanent monumentation benchmarks.

C. Guidance System and Alignment Control for Jack and Mine and Jack and Bore.

1. A laser guidance system shall be used to determine location at front of jacked pipe relative to laser.

2. Guidance system shall include target to indicate deviations in line and grade.

3. Equip system with means by which Project Manager can verify casing alignment and grade, such as access to laser guidance system.

4. Initial alignment of equipment and final alignment shall be documented.

D. Line and Grade.

1. Check and record alignment for tunnel against above-ground undisturbed reference after installation of each Jacking Pipe.

2. Record exact face location after each shove to ensure alignment is within specified tolerances. Make immediate correction to alignment before allowable tolerances are exceeded.

3. When excavation is off-line or grade, make alignment corrections to avoid reverse grades in gravity sewers.

4. Acceptance criteria for sewer pipe shall be plus or minus 6 percent of the tunnel diameter in the horizontal alignment or 2 inches, whichever is greater, and plus or minus 3 percent of the tunnel diameter in elevation or 1 inch, whichever is greater, from the design line and grade, unless otherwise indicated on Drawings.

5. If it is determined that pipe cannot be used, pipe installed outside tolerances shall be fully grouted and abandoned.

3.07 MONITORING

A. Instrumentation Monitoring: Instrumentation requirements are shown on Drawings. Instrumentation specified shall be accessible at all times to Project Manager.

1. Install and maintain instrumentation system to monitor and detect movement of ground surface and adjacent structures. Establish vertical control points at a distance from construction areas that avoids disturbance due to ground settlement.

2. Installation of instrumentation shall not preclude Project Manager, through independent contractor or consultant, from installing instrumentation in, on, near, or adjacent to construction work. Access shall be provided to work for such independent installations.

3. Instruments shall be installed in accordance with Drawings and manufacturer's recommendations.

B. Surface Settlement Monitoring.

1. Establish monitoring points on all Critical Structures.

2. Record location of settlement monitoring points with respect to construction baselines and elevations. Record elevations to accuracy of 0.01 feet for each monitoring point location. Monitoring points should be established at locations and by methods that protect them from damage by construction operations, tampering, or other external influences.

3. Ground surface elevations shall be recorded on centerline ahead of tunneling operations at minimum of 100-foot intervals or at least three locations per tunnel drive. For Jacking Pipe greater than 60-inch diameter, also record similar data at approximately 20 feet each side of centerline. Settlement monitoring points must be clearly marked by studs or paint for ease of locating.

4. Railroads: Monitor ground settlement of track subbase at centerline of each track. Follow American Railway Engineering and Maintenance-of-Way Association (AREMA) crossing requirements.

5. Utilities and Pipelines: Monitor ground settlement directly above and at least 10 feet or two excavation diameters, whichever is greater, before and after utility or pipeline intersection as shown on the Drawings.

C. Reading Frequency and Reporting: Submit to Project Manager records of readings from various instruments and survey points.

1. Readings shall be taken:

a. Prior to Zone of Active Excavation reaching that point.

b. When tunnel face reaches monitoring point (in plan).

c. When Zone of Active Excavation has passed, and no further movement is detected.

2. All monitoring readings shall be submitted daily to Project Manager.

3. Immediately report to Project Manager any movement, cracking, or settlement which is detected.

4. Following substantial completion but prior to final completion, make final survey of remaining monitoring points and submit to Project Manager.

3.08 DISPOSAL OF EXCESS MATERIAL

A. Remove spoil in accordance with Section 01576 - Waste Material Disposal.

3.09 ACCEPTANCE TESTING FOR SEWERS

A. Acceptance testing is to be carried out by methods described in Section 02533 - Acceptance Testing for Sanitary Sewer.

END OF SECTION

SECTION 02447

INSTALLATION OF WATER LINES BY SLURRY BORE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Installing water line pipe up to 20-inches in diameter or casing pipe up to 24-inch diameter by methods of slurry bore.

B. For pilot tube guided boring installation, refer to Section 02445 – Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels.

1.02 RELATED SECTIONS:

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01576 – Waste Material Disposal

D. Section 01578 – Control of Ground and Surface Water

E. Section 02260 – Trench Safety System

F. Section 02317 – Excavation and Backfill for Utilities

G. Section 02400 – Tunnel Shafts

H. Section 02431 – Tunnel Grout

I. Section 02445 - Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels

J. Section 02502 – Steel Pipe and Fittings

K. Section 02511 – Water Lines

L. Section 02517 – Water Line in Tunnels

M. Section 15640 – Joint Bonding and Electrical Isolation

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for pipe installation by slurry bore installation under this Section. Include payment in unit price work for Section 02511 – Water Lines.

2. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

A. Carrier Pipe: Permanent pipe that is used to convey flows.

B. Casing: Pipe installed to support ground and provide a stable underground excavation for installation of Carrier Pipe.

C. Obstruction: Objects located wholly or partially within cross-sectional area excavated that prevent forward movement after all diligent efforts to advance past object have failed.

D. Slurry Bore Method: Installation of casing or pipe by first drilling smaller pilot hole from pit to pit, followed by removing excess soil by reaming the hole larger and installation pipe or conduit by pull-back or jacking method.

E. Work Plan: Written description together with supporting documentation that defines plans and procedures for slurry bore operations.

1.05 REFERENCE STANDARDS

A. ASTM D256 - Standard Test Methods For Determining The Izod Pendulum Impact Resistance Of Plastics.

B. ASTM D638 - Standard Test Method For Tensile Properties Of Plastics.

C. ASTM D648 - Standard Test Method For Deflection Temperature Of Plastics Under Flexural Load In The Edgewise Position.

D. ASTM D695 - Standard Test Method For Compressive Properties Of Rigid Plastics.

E. ASTM D785 - Standard Test Method For Rockwell Hardness Of Plastics And Electrical Insulating Materials.

F. ASTM D790 - Standard Test Methods For Flexural Properties Of Unreinforced And Reinforced Plastics And Electrical Insulating Materials.

G. ISO 9001:2015: Quality Management Systems – Requirements.

H. NSF/ANSI 61: Drinking Water System Components – Health Effects.

I. Occupational Safety and Health Administration (OSHA) Part 1926 – Safety and Health Regulations for Construction.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 – Submittal Procedures.

B. Qualification Statements: Submit resumes and other evidence of qualifications and experience for key design and field personnel, including project manager, field superintendent and equipment operators. Minimum 5 years experience in slurry bore methods is required.

C. Work Plan: Submit the following items, at a minimum, in the Work Plan, including drawings:

1. Bore pit layout including locations, sizes, depths and areas for storage material, and spoil handing.

2. Arrangement drawings and technical specifications of slurry bore machine and boring unit and experience record with this type of machine. Include the following information concerning the slurry bore machine: dimensions, cutters, cutterhead position relative to pipe or casing, pipe or casing and band diameters, torque, speed and thrust, procedure for replacing cutters, overcut, and mucking system.

3. Method of maintaining and controlling line and grade of slurry bore operation.

4. Method and details of spoil removal, including equipment type and numbers, processing, and disposal procedures and locations.

5. Techniques to be used for lubrication including equipment, pumping and injection procedures, pressure grout types, and mixtures, in accordance with manufacturer's recommendations.

6. Details of Slurry Boring Method and operation including Carrier Pipe and Casing, if applicable.

7. Plans for storage and handling of pipe and Casing, if applicable.

8. Slurry mix design, volume and measurement procedures, pumps, piping, valve arrangements, and pressure gauges.

D. Submit shoring system for bore pits in accordance with Section 02400 – Tunnel Shafts.

E. For water lines in casing, submit manufacturer's data on casing spacers.

F. Quality Control Methods: Submit description of quality control methods proposed for slurry bore operation. Include the following:

1. Supervisory control to ensure that Work is performed in accordance with Drawings and Specifications.

2. Line and grade: Procedures for surveying, controlling, and checking line and grade, including field forms.

3. Observation and Monitoring: Procedures for preparing and submitting daily logs of operations, including field forms.

4. Disposal of surface discharge.

5. Groundwater control and drainage.

G. Contingency Plans: The following list includes problem scenarios that may be encountered during slurry bore operations. Submit contingency plans for dealing with each problem scenario while satisfying Specifications. Include observations and measurements required to identify cause of problems.

1. Machine Unable to Advance:

   a. Insufficient reamer torque or jacking capacity.

   b. Machine malfunction.

   c. Excess cutter wear or damage requiring access to replace or repair cutters.

   d. Obstruction in path of cutter head.

2. Spoil Feed Problems:

   a. Strong hydrocarbon smell is detected in spoils or in shaft.

   b. Obstruction jamming mucking system.

3. Jacking Forces:

   a. Jacking forces increase dramatically or suddenly.

   b. Jacking forces reach design capacity of casing, jacking frame, or thrust wall (treat these scenarios as separate incidents).

4. Settlement and Subsidence:

   a. Plan to manage unraveling soils.

5. Line and grade tolerances being exceeded:

   a. Level system subject to physical disturbance.

6. Pipe has been damaged or has been found to be out of compliance with Specifications during, or after installation.

7. Thrust block (if applicable) deforms excessively under jacking loads or provides insufficient capacity to advance casing.

1.07 SYSTEM DESCRIPTION

A. Design Requirements.

1. Select slurry bore equipment suitable for and capable of efficiently advancing through the geologic conditions anticipated by the Contractor.

2. For all bores, provide a means to measure grade during installation.

3. Methods and equipment shall control surface settlement and heave above the pipeline to prevent damage to existing utilities, facilities, and improvements. Limit ground movements (settlement/heave) to values that do not cause damage or distress to surface features, utilities, or improvements. Monitor survey control points before, during and after installation.

4. Use thrust block to transfer jacking loads to soil behind jacking shaft. Construct thrust block face perpendicular to proposed casing alignment. Design thrust block to withstand the maximum jacking forces developed by main jacks, without excessive deflection or displacement. Do not exceed allowable passive earth pressure, with a minimum factor of safety of 2.0 of forces applied to soil.

1.08 QUALITY ASSURANCE

A. Perform slurry bore work by an experienced subcontractor who has at least 5 years of experience in performing slurry bore work in similar soil conditions and has completed at least three similar projects involving at least a 250-foot slurry bore on each project. Provide subcontractor superintendent with at least 5 years of experience supervising slurry bore operations. Provide slurry bore machine operator(s) technically trained in operation of proposed slurry bore equipment and having completed, as primary operator, at least three similar slurry bore projects involving at least 250-foot slurry bore in similar subsurface conditions on each project. Provide a site safety representative and personnel responsible for air quality monitoring experienced in tunnel construction and having current certification by OSHA.

PART 2 PRODUCTS

2.01 MATERIALS

A. Carrier Pipe: Pipes used as a carrier pipe shall conform Section 02511 – Water Lines.

B. Steel Casing Pipe: Steel Casing to serve as continuous Casing for Carrier Pipe shall conform to Section 02502 – Steel Pipe and Fittings.

C. Grout: Refer to Section 02431 – Tunnel Grout.

D. Casing Spacers and End Seals: Provide carbon steel, polypropylene or polyethylene casing spacers in accordance with the following requirements. Install in accordance with manufacturer's recommendations. Casing Spacer manufacturer to be certified conformance with ISO 9001:2015.

1. Carbon Steel Spacers:

   a. Carbon steel spacers with thermoplastic coating may be provided for water lines up to 20-inches in diameter.

   b. Band width and spacing: For water lines up to 12-inches in diameter, provide 8-inch wide band. For water lines larger than 12-inches in diameter, provide 12-inch wide band. Install every 6 to 8 feet along carrier pipe as recommended by manufacturer.

   c. Band: 14 gauge, hot rolled, pickled & oiled steel.

   d. Riser: 10 gauge, hot rolled, pickled and oiled steel.

   e. Liner: PVC with dielectric strength 60,000 V min. Thickness 0.090-inches, and Hardness 80 Durometer.

   f. Bolts, Nuts and Washers: Electro-plated.

   g. Runners: Glass-filled polymer plastic with Rockwell Hardness (M) (ASTM D785) – 101, Tensile Strength (ASTM D638) – 27,000 psi, Flexural Strength (ASTM D790) – 38,000 psi, Deflection Temperature at 264 psi – 480 F (ASTM D648).

   h. Finish: Thermoplastic powder coating 10-16 mil thickness.

2. Polypropylene Spacers:

   a. Polypropylene spacers may be provided for water lines up to 20-inches in diameter. Install every 8 feet or less according to manufacturer's recommendations.

   b. Provide non-metallic, UV-resistant, virgin polypropylene, molded in segments for field assembly without any special tools. Secure segments around carrier pipe by insertion of a slide-lock.

   c. Compressive strength 4,000 psi; Dielectric Strength 365 Volts/mil; Impact Strength 1.8 ft.-lbs/inch.

   d. Skids to be integrally molded with spacer band and shall extend beyond bell or mechanical joint of the carrier pipe to maintain clearance.

3. Polyethylene Spacers:

a. Polyethylene spacers may be provided for ductile iron pipe up to 12-inches in diameter and PVC pipe up to 20-inches in diameter. Install every five feet along carrier pipe as recommended by manufacturer.

b. Injection molded polyethylene material to provide Flexural Strength (ASTM D790) 4,600 psi; Compressive Strength (ASTM D695) 4,600 psi; Tensile Strength (ASTM D638) 4,600 psi; and Impact Strength (ASTM D256) 1.3 ft. lb/in.

c. Skids to be integrally molded with spacer band and shall extend beyond bell or mechanical joint of the carrier pipe to maintain clearance.

d. Bolts, Nuts and Washers: Electro-plated.

4. Refer to City of Houston's Pre-Approved Products List.

5. End Seals: Refer to Section 15640 – Joint Bonding and Electrical Isolation and City of Houston's Pre-Approved Products List.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Do not discharge surface water inflows into storm sewers, sanitary sewers, drainage ditches, water bodies, or streets without an approved discharge permit.

B. Conduct operations such that trucks and other vehicles do not interfere with traffic or create mud, dust, or noise nuisance in streets and to adjacent properties.

C. Promptly clean up, remove, and dispose of spoils spillage, and any material discharges. Do not discharge slurry or spoils into storm sewers, sanitary sewers, drainage ditches, water bodies or streets. Conform to Section 01576 – Waste Material Disposal.

D. Conduct Work so as not to disturb roadways, railways, adjacent structures, private properties, landscaped areas, or existing utilities. Repair damage immediately to original or better condition and to the satisfaction of Project Manager.

E. Overnight staging of equipment and security: Utilize temporary fencing to secure equipment and work zone.

3.02 BORE PITS

A. Locate bore pits within rights-of-way where there is minimum interference with traffic or access to property.

B. Size pits to provide adequate room to meet operational requirements for slurry bore construction.

C. Install sheeting, lining, shoring and bracing required for protection of workmen and public in accordance with Section 02260 – Trench Safety System.

D. Provide groundwater control and drainage from pits while work is in progress and until pit is properly backfilled. Conform to requirements of Section 01578 – Control of Ground and Surface Water.

E. Provide and properly maintain safety protection against traffic, and accidental or unauthorized entry. Make provisions to include concrete traffic barrier or other suitable barrier around periphery of pit as appropriate. Fully cover and secure pits where no construction activity is in progress.

F. Backfill pits in accordance with Section 02317 – Excavation and Backfill for Utilities.

3.03 JACKING OPERATIONS

A. Provide suitable jacking frame and thrust block (if required) to carry out Work.

B. Pipe or Casing used in jacking operations must be designed to withstand jacking forces.

C. Transport pipe or Casing from storage to bore pit without damage. Utilize transport methods acceptable to Casing manufacturer. Do not use damaged pipe or Casing in Work. Set the Casing on properly braced and supported guide rails or jacking frame.

D. Distribute axial forces from thrust jacks to pipe or casing uniformly through thrust ring and cushion material, if applicable, to prevent damage to ends of pipe. Do not exceed the specified allowable compressive stresses for jacking forces applied to the pipe or Casing.

E. Jack Casing into position following design line and grade without damaging pipe or Casing.

3.04 SLURRY BORE METHOD

A. Complete slurry bore in accordance with approved Submittals, and applicable permit conditions.

B. Conduct slurry bore operations to control surface settlement and heave above pipe or casing to prevent damage to existing utilities, facilities, and improvements. Repair damage resulting from construction activities. Pressure grout voids caused by or encountered during the shaft construction and slurry bore. Modify equipment and procedures as required to avoid recurrence of excessive settlements or damage.

C. Control the advance of bore and casing so as to restrict excavation of the materials to volume equal to pipe jacked plus allowance for allowable radial overcut, to prevent loss of ground and settlement or possible damage to overlying structures. Control advance rate and monitor volume of material excavated and adjust advance rate, as required, to avoid loss of ground, over excavation, or surface heave.

D. Diameter of bore hole to not exceed outer diameter of pipe plus 2 inches.

E. Completely contain, transport, and dispose of excavated materials and fluid additives away from construction site. Contain spoils in trucks or other containers. Dumping of spoil on ground, discharge into sewers or ditches, or discharge into bore pits is not permitted. Only use disposal sites identified in approved Submittals for muck and spoil disposal.

F. Lubricants shall be NSF 61 approved. Water used for pipe lubrication shall be clean, fresh, and free from oil, organic matter, or other deleterious matter and of neutral pH.

3.05 CONTROL OF LINE AND GRADE

A. Establish and protect benchmarks as necessary prior to start of construction.

B. After establishing required benchmarks, use these benchmarks to furnish and maintain reference lines and grades for slurry bore.

C. Control bore and pipe or Casing advancement to maintain line and grade within tolerances specified. If the installation is off line or grade, attempt to make necessary corrections. Mount guidance system independently from thrust block and jacking frame to maintain alignment if there is movement of equipment during jacking. Stop boring operations and reset guidance system, if its alignment shifts or is moved off design alignment and grade for any reason. Check guidance system setup at least once per shift. Guidance system should only be reset by experienced, competent surveying personnel in accordance with approved procedures outlined in the Submittals.

D. Monitor line and grade during slurry bore operations. Record deviation with respect to design line and grade at least once per shift and submit records to Project Manager as requested. Control line and grade of pipe or Casing to within 6-inch tolerance of line and grade shown on Drawings.

E. Correct installation, including any necessary redesign and acquisition of necessary easements, if pipe or Casing installation does not meet specified tolerance. Performance of corrective work is subject to the written approval of Project Manager.

3.06 GROUTING

A. Refer to Section 02431 – Tunnel Grout.

B. After pipe is installed, block void space around approximately the first 12 inches of pipe with packed clay to prevent bedding or backfill from entering void around pipe when pit is backfilled.

3.07 INSTALLATION OF CARRIER PIPE

A. For Carrier Pipe inside Casing, follow installation guide for casing spacer installation provided by the manufacturer. Refer to Section 02517 -Water Line in Tunnels.

3.08 CLEANUP

A. Refer to Section 01576 – Waste Material Disposal.

END OF SECTION

SECTION 02448

PIPE AND CASING AUGERING FOR SEWERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Installation of casing for sewer pipe by Dry Augering or slurry boring methods, together with installation of sewer pipe in casing.

B. Installation of sewer pipe by slurry boring methods. Construction casing may be used at Contractor's option.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01576 – Waste Material Disposal

D. Section 02260 – Trench Safety System

E. Section 02431 – Tunnel Grout

F. Section 02502 – Steel Pipe and Fittings

G. Section 02531 – Gravity Sanitary Sewers

H. Section 02533 – Acceptance Testing for Sanitary Sewers

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Casing, including sewer pipe, installed by augering methods in mid-run of open cut segments where shown on Drawings, will be measured and paid by linear foot from end to end of casing. Casing may be installed, at Contractor's option, at locations other than shown on Drawings, at no additional cost to City.

2. Sewer pipe installed by augering method in mid-run of open-cut segments where shown on Drawings, will be measured and paid by linear foot from end to end of augered section.

3. Pipe or casing segments installed by augering methods in locations other than mid-run of open cut segments and shown on Drawings, will be measured and paid by linear foot along centerline of completed sewer from centerline to centerline of manholes to ends of stubs or termination of pipe, and to inside face of lift stations and other structures.

4. Payment will include and be full compensation for labor, equipment, materials and supervision for excavation and construction of sewer, complete in place including disposal of excess materials, shoring, dewatering, utility adjustments, grouting, backfill, clean-up, and other related work necessary for construction as indicated on Drawings and specified in this Section.

5. Cost for pits and other excavations are included in unit price for pipe with or without casing.

6. Trench safety systems for pits are paid as specified in Section 02260 - Trench Safety Systems.

7. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

A. Augering means either “Dry Augering” or “slurry augering”.

B. Dry Augering is jacking casing while excavating soil at heading and transporting spoil back through casing by otherwise uncased auger.

C. Slurry Auger Method: Installation of casing or pipe by first drilling small diameter pilot hole from shaft to shaft, followed by removing excess soil and installing pipe or conduit by pull back or jacking method.

1.05 REFERENCES

A. American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineering.

B. American Association of State Highway and Transportation Officials (AASHTO).

C. Texas State Department of Highways and Public Transportation.

1.06 REGULATORY REQUIREMENTS

A. Conform to Texas State Department of Highways and Public Transportation for installations under state highways. City will obtain required permits for State Highway crossings.

B. Installations under Railroads:

1. Secure and comply with requirements of right-of-entry for crossing railroad company's easement or right-of-way from railroad companies affected. Comply with railroad permit requirements.

2. Use Dry Auger method only.

3. Damages due to delays caused by railroad requesting work to be done at hours which will not inconvenience the railroad will be at no additional cost to City.

4. Maintain minimum 35-foot clearance from centerline of tracks.

1.07 SUBMITTAL

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. For installation by Augering, submit for review:

1. Description of mechanized excavating equipment.

2. Method of controlling line and grade.

3. Grouting techniques to be used for filling annular void between sewer pipe and casing, and void between sewer pipe or casing and ground, including equipment, pumping and injection procedures, pressure grout types, and mixes.

4. Locations and dimensions of pits.

5. Pit design and construction drawings.

6. Identification of casings required and paid under Contract and casings installed at Contractor's option.

7. Design of casings.

8. Copy of railroad company permits and right-of-entry.

C. Prepare auger pit and casing design submittals that are site specific. Have auger pit and casing design submittals signed and sealed by qualified Professional Engineer registered in State of Texas.

D. Include in construction phase submittals:

1. Daily logs of Augering and boring operations.

2. Settlement monitoring data to meet requirements of paragraph 3.05, Settlement Monitoring.

3. Submit daily logs and settlement monitoring data within 5 days after day of observation.

1.08 CRITERIA FOR DETERMINING CASING INSTALLATION LOADS

A. Select and design casing pipe and pipe joints to carry thrust of jacks or loads due to pulling mechanism in combination with overburden, earth and hydrostatic loads. Select casings for dry Augering to withstand action of auger without damage.

B. Use Professional Engineer to determine design stresses, design deflections and factors of safety for design of casing. Present such determination as part of design submittal. Apply the following maximum casing pipe stresses and deflections to casings shown on Drawings:

1. Design stress in pipe wall: 50 percent of minimum yield point of steel or 18,000 psi, whichever is less, when subjected to applicable loading conditions.

2. Wall thickness: Maximum allowable deflection which does not exceed 3 percent of nominal casing diameter.

C. Use Cooper E-80 locomotive loading distributions as criteria for railroad crossings in accordance with AREMA specifications for culverts. In design, account for additive loadings due to multiple tracks.

D. Use HL-93 vehicle loading distributions as criteria for truck loading in accordance with AASHTO.

E. When not specifically indicated on Drawings, select casing diameter to permit practical installation (including skids when applicable) and grouting.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide casing pipe which is straight, circular in section, uncoated, welded steel pipe, in accordance with Section 02502 - Steel Pipe and Fittings.

B. Provide sewer pipe in accordance with Section 02531 - Gravity Sanitary Sewers. Do not use high density polyethylene pipe for augering.

C. Provide restrained-joint sewer pipe when installing sewer pipe in slurry bored holes by pull- back method.

D. Supply grout as specified in Section 02431 - Tunnel Grout.

PART 3 EXECUTION

3.01 LOCATION AND SIZE OF AUGER PITS

A. Show location of auger pits on auger pit construction drawings. Locate auger pits for slurry boring so that distance between pits is no greater than 80 feet; and for dry augering not more than 120 feet apart.

B. Locate auger pits and associated work areas to avoid blocking driveways and cross streets and to minimize disruption to business and commercial interests. Avoid auger pit locations near areas identified as potentially contaminated.

C. Make size adequate for construction of structures indicated on Drawings. Provide adequate room to meet Contractor's operational requirements for Augering.

D. Provide portable concrete traffic barrier around periphery of pit, meeting applicable safety standards. Properly maintain barrier throughout period pit remains open. Angle traffic barriers in direction of lane flow; do not place barriers perpendicular to on-coming traffic.

E. Provide full cover or other security fencing for each access pit in which there is no construction activity or which is unattended by Contractor's personnel.

3.02 DRY AUGERING OF CASING

A. Provide jacks, mounted on frame or against backstop, of capacity suitable for forcing excavating auger and casing through soil conditions to be encountered. Operate jacks so that even pressure is applied to casing.

B. Provide steerable front section of casing to allow vertical grade adjustments. Provide water level or other means to allow monitoring of grade elevation of auger casing.

C. Bentonite slurry may be used to lubricate casing during installation. Use of water to facilitate removal of spoil is permitted; however, water jetting for excavation of soil is not allowed when jacking casing.

D. Tolerances from lines and grades shown on Drawings for gravity sewer pipe installed in casing are plus or minus 6 inches in horizontal alignment, and plus or minus 1-1/2 inches in elevation.

3.03 SLURRY BORING OF CASING OR PIPE

A. Drill small diameter pilot hole and check for line and grade at receiving end. Redrill pilot hole when bored pipe does not meet specified tolerances.

B. Using pilot hole as guide bore larger diameter hole of sufficient size for pipe or casing installation. Water jetting is not permitted.

C. Bentonite slurry may be used to maintain stable hole and furnish lubrication for pipe or casing installation.

D. Tolerances from lines and grades shown on Drawings for installed sewer pipe are plus or minus 6 inches in horizontal alignment and plus or minus 1-1/2 inches in elevation.

E. Completely fill annular space between sewer pipe and surrounding soil or casing with grout, without displacing pipe during grouting operation.

3.04 SEWER PIPE IN CASING

A. Grout annular void between sewer pipe and casing from end to end of casing. Block and brace sewer pipe to prevent movement during grout placement and to maintain specified line and grade. Grout as specified in Section 02431 - Tunnel Grout.

3.05 SETTLEMENT MONITORING

A. Monitor ground surface elevation along length of augering operation. Locate and record settlement monitoring points with respect to construction baseline and elevations. Record elevations to accuracy of 0.01 feet for each monitoring point location. Establish monitoring points at locations and by methods that protect them from damage by construction operations, tampering, or other external influences. As minimum, locate survey points as follows:

1. For road crossings: Centerline and each shoulder

2. Railroads: Track subbase at centerline of each track

3. Utilities and Pipelines: Directly above and 10 feet before and after utility or pipeline intersection

4. Long bores under improved areas such as pavements: Ground surface elevations must be recorded on centerline ahead of Augering operations at locations not to exceed 50 feet apart (including points located for roads, railroads, utilities, and pipelines), or at least three locations per augering drive

B. Reading Frequency and Reporting. Take settlement survey readings:

1. Prior to auger excavation reaching point

2. After auger reaches monitoring point in plan

3. After grouting of ground supporting pipe or casing is complete

C. Immediately report to Project Manager movement, cracking, or settlement which is detected.

D. Following substantial completion but prior to final completion, make final survey of monitoring points.

3.06 DISPOSAL OF EXCESS MATERIAL

A. Remove and dispose of spoil from job site in accordance with Section 01576 - Waste Material Disposal.

3.07 LEAKAGE TESTING

A. Test sanitary sewers for leakage by low pressure air methods in accordance with Section 02533 - Acceptance Testing for Sanitary Sewer.

END OF SECTION

SECTION 02465

DRILLED SHAFT FOUNDATIONS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Construction of foundations consisting of reinforced concrete drilled shafts.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 01504 – Temporary Facilities and Controls

E. Section 01576 – Waste Material Disposal

F. Section 01785 – Project Record Documents

G. Section 03211 – Reinforcing Steel

H. Section 03310 – Structural Concrete

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for drilled shaft foundations under this Section. Include cost in lump sum payment for structure requiring drilled shaft foundations.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit work plan for each structure with complete written description which identifies details of proposed method of construction and sequence of operations for construction relative to drilled shaft activities. Descriptions, with supporting illustrations, shall be sufficiently detailed to demonstrate to Project Manager that procedures meet requirements of Specifications and Drawings.

C. Submit project record documents under provisions of Section 01785 - Project Record Documents. Record locations of drilled shafts, as installed referenced to survey benchmarks. Include location of utilities encountered or rerouted. Give horizontal dimensions, elevations, inverts and gradients.

1.05 REFERENCE STANDARDS

A. ACI 336.1 - Standard Specification for Construction of Drilled Piers.

B. TxDOT Standard Specification Item 416 - Drilled Shaft Foundations.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Perform excavation with equipment suitable for achieving requirements of this Specification.

2.02 MATERIAL

A. For cast-in-place concrete, use Class A concrete. Refer to Section 03310 - Structural Concrete.

B. For reinforcing steel, refer to Section 03211 - Reinforcing Steel.

PART 3 EXECUTION

3.01 PREPARATION

A. Conduct an inspection to determine condition and locations of existing structures and other permanent installations, prior to commencing work.

3.02 EXCAVATION

A. Perform excavation required for drilled cylindrical shafts, at locations shown on Drawings through whatever materials encountered, to dimensions and elevations shown or required by site conditions. When satisfactory material is not encountered at plan depth, bottom of shaft will be adjusted or foundation altered, as determined by Project Manager, to satisfactorily comply with design requirements.

B. Do not make shaft excavations within 3 shaft diameters (edge to edge) of shafts which have been concreted within previous 24 hours.

C. Inspect drilled shaft excavations for verticality and side sloughing. Verticality is specified at one inch in 10 feet of shaft length. Check to full depth of dry auguring prior to introducing drilling mud. Straighten or add suitable reinforcing steel to shafts not meeting specified tolerance.

D. Slurry is to contain 4 to 8 percent by weight of bentonite additive and satisfy slurry specifications set forth in ACI 336.1, Section 2.3.5.2e. These requirements are more stringent than TxDOT Standard Specification Item 416.3.1. Stricter slurry specifications are required to assure suspension of detritus from drilling operations, and to ensure adequate cleaning of slurry prior to concreting. Cleaning of slurry is important to prevent deposition of detritus on reinforcement cages and ensure that inclusions of detritus will not be formed within concrete mass.

E. At final bearing elevation, clean bottom of each shaft and remove seepage water for examination by Project Manager before reinforcing steel and concrete is placed. Suitable access and lighting for proper inspection of completed excavation is to be provided. Reinforcing steel and concrete is to be placed in drilled shaft without delay after approval of excavation by Project Manager.

3.03 DRILLED SHAFT CONSTRUCTION

A. Drilled shaft construction and installation is to follow TxDOT Standard Specification Item 416 (with exceptions noted below) and ACI 336.1.

B. Before placing concrete, clean out shaft bottom with drilling bucket in order to remove sediments which may not be displaced by concrete. Clean shaft bottom with "clean-out" bucket until rotation on bottom without crowd (i.e., penetration under force) produces little spoil. Probing after cleaning out is essential to verify condition of base of shaft.

C. Concrete is to conform to requirements of ACI 336.1 Section 2.3.5.5.

D. Concrete is to be placed continuously in shaft to construction joint indicated on Drawings or as directed in TxDOT Standard Specification Item 416.3.3. Concrete is to be placed through suitable tube or tremie to prevent segregation of materials. Tremie pipe diameter is to be at least 8 times as large as largest concrete aggregate size.

E. Computation of final concrete volume for each shaft is to be made. Core and check the integrity of shafts taking an unreasonably high or low volume of concrete.

F. If caving soil conditions or excessive groundwater is encountered, use of temporary casing is permitted to prevent caving of material around shaft and to control seepage of groundwater into excavation.

G. Casing material is to be metal of ample strength to withstand handling stresses, pressure of concrete and of surrounding earth or backfill materials and is to be water-tight. Casing shall be smooth, clean and free of accumulations of hardened concrete. Outside diameter of casing is not to be less than specified diameter of drilled shaft.

H. Elapsed time is not to exceed one hour from beginning of concrete placement in cased portion of shaft, until extraction of casing is begun.

I. Withdraw temporary casings as shaft is filled with concrete, or immediately following concreting operation. Bottom of casing is to always remain at least one foot below level of concrete during placement to overcome hydrostatic pressure. Smoothly extract casing with vibratory hammer. Casing extraction is to be at slow, uniform rate with pull in line with vertical axis of shaft. Leave no casing in place.

J. If upward movement of concrete or reinforcing steel occurs inside casing at beginning of pulling operation or at anytime during pulling, stop pulling immediately and leave casing in place.

K. If casing must be left in place, Project Manager is to be informed to determine shaft capacity calculations.

3.04 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

3.05 DISPOSAL OF EXCESS MATERIAL

A. Dispose of excess materials in accordance with requirements of Section 01504 - Temporary Facilities and Control or Section 01576 - Waste Material Disposal.

END OF SECTION

SECTION 02476

CAISSON FOR LIFT STATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Constructing external walls of lift station wet well structures by caisson method, including base slab and excavation cell partitions. Valve/pump chamber to be constructed by open cut.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01450 – Contractor's Quality Control

D. Section 01576 – Waste Material Disposal

E. Section 01578 – Control of Ground and Surface Water

F. Section 02316 – Excavation and Backfill for Structures

G. Section 02321 – Cement Stabilized Sand

H. Section 02431 – Tunnel Grout

I. Section 03211 – Reinforcing Steel

J. Section 03310 – Structural Concrete

K. Section 15140 – Pipe Hangers, Supports, and Restraints

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for lift station construction using caisson method. Include cost for caisson construction in lump sum for lift station.

2. No separate measurement will be made for payment of concrete in wet well caisson except listed in an approved schedule of values.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 DEFINITION

A. Caisson is defined as external walls of concrete structure, together with excavation cell partition walls, erected at-grade or in starter pit and sunk by gravity to final position through excavation inside structure under dry or wet conditions. Complete caisson includes structural base slab. Caisson walls provide ground support during construction and for permanent installation.

B. Dry construction means that Contractor operates sufficient external ground water control system to maintain ground water level and piezometric head safely below excavation bottom within caisson.

C. Wet construction means that external hydrostatic ground water pressure is counteracted by water or slurry within caisson.

1.05 REFERENCE STANDARDS

A. ASTM D 698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3 (600 kN-m/m3)).

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit safety plan to meet OSHA requirements. These procedures will not be subject to approval by Project Manager and are for record purposes only. Address in plan, as minimum but not limited to the following:

1. Protection against caisson instability, soil instability, and ground water inflow.

2. Safety for caisson access and exit, including ladders, stairs, walkways, and hoists.

3. Protection against equipment operations, and for lifting and hoisting equipment and material.

4. Support of surcharge weights.

5. Ventilation systems.

6. Monitoring for hazardous gases.

7. Protection against flooding of caisson and inflow into sewers when connected to caisson structure.

8. Protection of workers and public, including traffic barriers, accidental or unauthorized entry, and falling objects.

9. Safety supervising responsibilities.

C. Building and Structures Assessment. Submit for review prior to construction, Building and Structures Assessment Plan. Provide preconstruction and post-construction assessment reports for buildings and structures located within distance equal to depth of caisson but at least 50 feet in plan from proposed caisson perimeter. Include photographs or video of existing damage to structures in vicinity of caisson in assessment reports.

PART 2 PRODUCTS

2.01 CONCRETE

A. Concrete is to be in accordance with Section 03310 - Structural Concrete.

2.02 REINFORCEMENT

A. Reinforcement is to be in accordance with Section 03211 - Reinforcing Steel.

2.03 EMBEDDED ITEMS

A. Embedded items are to be in accordance with Section 15140 - Pipe Hangers, Supports, and Restraints.

2.04 BACKFILL

A. Select material is to be in accordance with Section 02316 - Excavation and Backfill for Structures.

B. Cement stabilized sand is to be in accordance with Section 02321 - Cement Stabilized Sand.

2.05 GROUT

A. Use grout conforming to Section 02431 - Tunnel Grout.

PART 3 EXECUTION

3.01 SITE PREPARATION

A. Perform site preparation for site clearing and for grading of site to required elevation. Provide for site drainage.

B. Relocate and protect utilities to remain that may be affected by caisson construction area, including starter pit.

C. Install security fencing around caisson construction areas to prevent accidental or unauthorized entry.

D. Provide for control of ground water and surface water according to Section 01578 - Control of Ground and Surface Water.

E. Compact disturbed soils to 95 percent of maximum density as determined by ASTM D 698. Compact soil at moisture content sufficient to develop the required density.

3.02 CAISSON WALL CONSTRUCTION

A. Place concrete as specified in Section 03310 - Structural Concrete.

B. Inspect concrete surfaces after form removal and repair defects before wall section is sunk into ground.

3.03 CAISSON CLEAN UP AND INSPECTION

A. Clean interior of caisson after seal slab has been poured. Remove soil, mud, slurries, spilled grout or concrete, or other materials not part of structure from caisson and clean surfaces.

B. Inspect caisson for possible structural damage or damage to embedded items occurring during excavation and caisson sinking. Notify and allow Project Manager to witness caisson inspection. Repair and replace damage before proceeding with construction.

3.04 CAISSON CONSTRUCTION TOLERANCES

A. Maximum acceptable deviation of caisson from vertical is 1 inch in 5 feet.

B. Maximum acceptable horizontal deviation from design location of center of caisson at ground surface level is 12 inches.

C. Install elevation of base of caisson structure equal to or lower than elevation shown in Drawings. Show top of caisson structure elevation on Drawings.

D. Provide block-outs with allowance for pipe entry deviations of plus or minus 1.5 inches vertically and plus or minus 6 inches horizontally, plus caisson construction tolerances.

E. Tolerances defined above are only acceptable provided that Contractor can adjust sewer connections, structural, mechanical and electrical components to resolve deviation from plumpness and horizontal or vertical location as approved by Project Manager. Adjustments must be made without adversely affecting operation or maintenance of lift station.

F. Monitor caisson installation to verify that no settlement or heave is observed for 10 consecutive days starting not later than 50 days after structural completion.

3.05 BACKFILL

A. Remove starter pit shoring to depth of at least 8 feet below ground surface and for at least 5 feet from pipes and tunnels penetrating shoring. Remove shoring concurrent with backfilling operations. Perform shoring removal and backfilling so that stability of pit is maintained.

B. Compact backfill material in accordance with Sections 02316 - Excavation and Backfill for Structures.

3.06 MONITORING

A. Settlement. Install series of settlement monitoring points on ground and structures within area of potential influence due to soil movements at caisson, before start of caisson or starter pit construction.

1. As minimum, equally space 4 monitoring points around caisson at distance of 15 feet and 4 more at distance 30 feet from caisson for total of 8 monitoring points.

2. Survey monitoring point elevations before start of caisson excavation and weekly thereafter until structure has been completed and dewatering terminated.

B. Caisson

1. Determine plumpness of caisson at least once each shift at two locations, 90 degrees apart, during caisson sinking operations until caisson is secured by grout and base slab hardened.

2. As soon as caisson has been secured, install 3 benchmarks, 120 degrees apart, on top concrete placement for settlement monitoring of installed caisson. Transfer benchmarks to higher elevation on structure as required due to continued lift station construction. Continue weekly monitoring of settlement points until 60 days after completed construction of structure.

3. Install and monitor borehole heave points in caisson for dry construction as defined on Drawings. Survey heave points before excavation starts and upon retrieval when final excavation bottom has been reached.

C. Submit monitoring results to Project Manager weekly.

3.07 CAISSON SURVEY

A. When caisson has been secured, seal slab poured, and, in case of wet construction, when fluid has been pumped out, survey installed caisson for compliance with tolerances defined in Paragraph 3.04, Caisson Construction Tolerances. Include in Survey:

1. Location of center of caisson at ground level.

2. Elevation of top and bottom of caisson and structural slab connection.

3. Elevation and locations of penetrations and embedded items and other support points for lift station installation completion.

4. Deviation from plumb from caisson top to structural slab at two locations 90 degrees apart.

3.08 FIELD QUALITY CONTROL

A. Perform field inspection and testing in accordance with Section 03310 - Structural Concrete and Section 01450 - Contractor's Quality Control.

3.09 DISPOSAL OF EXCESS MATERIAL

A. Remove excavated material from job site in accordance with Section 01576 - Waste Material Disposal.

END OF SECTION

SECTION 02501

DUCTILE IRON PIPE AND FITTINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Ductile iron pipe and fittings for water lines, wastewater force mains, and gravity sanitary sewers.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02105 – Chemical Sampling and Analysis

D. Section 02511 – Water Lines

E. Section 02515 – Hydrostatic Testing of Pipelines

F. Section 02531 – Gravity Sanitary Sewers

G. Section 02532 – Sanitary Sewer Force Mains

H. Section 02553 – Point Repairs and Obstruction Removals

I. Section 16640 – Cathodic Protection for Pipelines

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for ductile iron pipe and fittings under this Section, with the exception of extra fittings in place. Include cost in unit prices for work as specified in the following Sections, as applicable:

a. Section 02511 - Water lines

b. Section 02531 - Gravity Sanitary Sewers

c. Section 02532 - Sanitary Sewer Force Mains

2. Payment for extra Ductile Iron Compact Fittings in place is per ton. This shall be for additional fittings required to complete job. This is not to exclude extension of pipe across driveway or intersection for purpose of terminating line in more advantageous position. This determination shall be at discretion of Project Manager. This bid item includes additional fittings as may be necessary to complete job in conformance with intent of Drawings.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ANSI/AWS D11.2 –Guide for Welding Iron Castings.

B. ASME B 16.1 - -Gray Iron Pipe Flanges and Flanged Fittings.

C. ASTM D 1248 - Standard Specification Polyethylene Plastics Molding and Extrusion Materials for Wire and Cable.

D. ASTM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

E. ASTM G 62 - Standard Test Methods for Holiday Detection in Pipeline Coatings.

F. AWWA C 104/ANSI A 21.4 - Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.

G. AWWA C 110/ANSI A 21.10 - Standard for Ductile-Iron and Gray-Iron Fittings, 3In. through 48In.

H. AWWA C 111/ANSI A 21.11 - Standard for Rubber - Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

I. AWWA C 115/ANSI A 21.15 - Standard for Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges.

J. AWWA C 116/ANSI A21.16 - Protective Fusion-Bonded Epoxy Coating for the Interior and Exterior Surfaces of Ductile-Iron and Grey-Iron Fittings.

K. AWWA C 150/ANSI A 21.50 - Standard for Thickness Design of Ductile-Iron Pipe.

L. AWWA C 151/ANSI A 21.51 - Standard for Ductile-Iron Pipe, Centrifugally Cast.

M. AWWA C 153/ANSI A 21.53 - Standard for Ductile Iron Compact Fittings.

N. AWWA C 105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.

O. AWWA C 600 - Standard for Installation of Ductile-Iron Water Mains and Their Appurtenances.

P. AWWA M 41 – Ductile-Iron Pipe and Fittings.

Q. SSPC-SP 6 - Steel Structures Painting Council, Commercial Blast Cleaning.

R. American Railway Engineering and Maintenance-of-Way Association (AREMA)-E-80- Manual for Railway Engineering.

S. American Association of State Highway Transportation Officials (AASHTO)-HL-93.

T. DIPRA – Thrust Restraint Design for Ductile Iron Pipe.

U. NSF/ANSI 61 – Drinking Water System Components – Health Effects.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. For pipes 16 inches and greater submit shop drawings signed and sealed by Professional Engineer registered in State of Texas showing the following:

1. Manufacturer's pipe design calculations.

2. Provide lay schedule of pictorial nature indicating alignment and grade, laying dimensions, fitting, flange, and special details, with plan view of each pipe segment sketched, detailing pipe invert elevations, horizontal bends, restrained joints, and other critical features. Indicate station numbers for pipe and fittings corresponding to Drawings. Do not start production of pipe and fittings prior to review and approval by Project Manager. Provide final approved lay schedule on CD-ROM in Adobe portable document format (*.PDF).

3. Calculations and limits of thrust restraint shall be based on AWWA M41 or DIPRA Thrust Restraint for Ductile Iron Pipe, latest edition.

4. Class and length of joint.

C. Submit manufacturer's certifications that ductile iron pipe and fittings meet provisions of this Section and have been hydrostatically tested at factory and meet requirements of ANSI A 21.51.

D. Submit certifications that pipe joints have been tested and meet requirements of ANSI A 21.11.

E. Submit affidavit of compliance in accordance with ANSI A 21.16 for fittings with fusion bonded epoxy coatings or linings.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Use pre-approved manufacturers listed in City of Houston approved products.

2.02 DUCTILE IRON PIPE

A. Ductile Iron Pipe Barrels: Shall conform to AWWA C115, C150 and C151 and bear mark of Underwriters' Laboratories approval. Provide minimum thickness Class 52 for sanitary sewers. Unless otherwise shown on Drawings, use a minimum Pressure Class 250 for water lines less than or equal to 20-inch diameter. For 24-inch and larger, design for project specific hydraulics as per AWWA C150. Use minimum Pressure Class 350 for water lines in casing or trenchless construction and for flanged pipe.

B. Provide pipe sections in standard lengths, not less than 18 feet long, except for special fittings and closure sections as indicated on shop drawings.

C. For 24-inch and larger water lines, furnish and install cathodic protection in accordance with Section 16640 - Cathodic Protection for Pipelines

D. For sanitary sewer lines, modify pipe for cathodic protection in accordance with Section 16640 - Cathodic Protection for Pipelines. In lieu of furnishing ductile iron pipe with cathodic protection system, furnish ductile iron pipe with polyethylene encasement, provided the following criteria is met:

1. Provide minimum thickness class.

2. Provide polyethylene encasement material and installation in accordance with AWWA C105, and backfill as specified. Minimum of two complete wraps of 8-mil-thick polyethylene.

3. Use polyethylene encasement for open cut installations only. For augured sections or sections installed inside a casing, provide coating in accordance with paragraph 2.06 D.2.

4. Adhere to other requirements specified herein (e.g., insulation kits, etc.).

E. For use of pressure class pipe for water lines, design pipe and fittings to withstand most critical simultaneous application of external loads and internal pressures. Base design on minimum of AASHTO HL-93 loading, AREMA E-80 loads and depths of bury as indicated on Drawings. Design pipes with Marston's earth loads for a transition width trench for zero to 16 feet of cover. Use Marston's earth loads for a trench width of O.D. (of pipe) + 4 feet for pipe greater than 16 feet of cover. Use Marston's equations for a trench condition in both open-cut and tunnel applications. Design for most critical groundwater level condition. Pipe design conditions:

1. Working pressure = 150 psi.

2. Hydrostatic field test pressure = 150 psi.

3. Maximum pressure due to surge = 225 psi.

4. Minimum Pressure due to surge = -10 psi.

5. Design tensile stress due to surge or hydrostatic test pressure: No greater than 50% minimum yield.

6. Design bending stress due to combined earth loads and surge or hydrostatic test pressure: No greater than 48,000 psi.

7. Unit weight of fill 2' 120 pcf.

8. Deflection lag factor (Dl) = 1.2.

9. Bedding constant (K) = 0.1.

10. Moment coefficient = 0.16.

11. Fully saturated soil conditions hw=h=depth of cover above top of pipe.

F. Hydrostatic Test of Pipe: AWWA C 151, Section 5.2.1, at point of manufacture. Hold test for a minimum 2 minutes for thorough inspection of pipe. Repair or reject pipe revealing leaks or cracks.

G. Pipe Manufacturer for large diameter water lines: Minimum of 5 years of successful pipe installations in continuous service. Manufacturer must maintain on site or in plant enough fittings to satisfy the following requirements:

Line Diameter	Required Bends*
20 and 24 inches	Four 45° bends per 5,000 LF of water line
> 24 inches	Four 22.5° bends per 10,000 LF of water line
*Based on total length of contract (minimum of four). Any combination of bends may be substituted at manufacturer's option (i.e. two 22.5° bends are equivalent to one 45° bend) and will be counted as one fitting.	

Manufacturer or supplier must be capable of delivering bends to job site within 12 hours of notification. Use fittings at direction of Project Manager where unforeseen obstacles are encountered during construction. These fittings are in addition to any fittings called out in construction documents and must be available at all times.

H. Provide flange adapter with insulating kit as required when connecting new piping to existing piping and piping of different materials, unless otherwise approved by Project Manager.

I. Clearly mark pipe section to show location and thickness/pressure class color coded.

J. No welding will be permitted on Ductile Iron Pipe except at restrained joint spigots or fittings as per ANSW/AWS D11.2. No field welding is allowed.

2.03 JOINTS

A. Joint Types: ANSI A 21.11 push-on; ANSI A 21.11 mechanical joint; or ANSI A 21.16 flanged end. Provide push-on joints unless otherwise indicated on the Drawings or required by these specifications.

1. For sanitary sewer lines with bolted joints, conform to requirements of AWWA C111; provide minimum 304 stainless steel for restraint joints.

2. For water lines with bolted joints, conform to requirements of AWWA C111; provide Denso or approved equal petrolatum-based tape coating system for exposed portion of nuts and bolts.

B. Where required by Drawings, provide approved restrained joints for buried service. Refer to City's List of Approval Products for approved joint restraint mechanisms.

C. Threaded or grooved-type joints which reduce pipe wall thickness below minimum required are not acceptable.

D. Provide for restrained joints designed to meet test pressures required under Section 02515 - Hydrostatic Testing of Pipelines or Section 02532 - Sanitary Sewer Force Mains, as applicable. Provide restrained joints for test pressure or maximum surge pressure as specified, whichever is greater for water lines. Do not use passive resistance of soil in determining minimum restraint lengths.

E. Electrical Bond Wires: Bond Wires; use stranded, copper cable furnished with high molecular weight polyethylene insulation (HMWPE). Use wire gauge (AWG) as shown on Drawings.

F. Make curves and bends by deflecting joints. Do not exceed maximum deflection recommended by pipe manufacturer for pipe joints or restraint joints. Submit details of other methods of providing curves and bends for consideration by Project Manager. When other methods are deemed satisfactory, install at no additional cost to City.

2.04 GASKETS

A. Furnish, when no contaminant is identified, plain rubber (SBR) gasket material in accordance with ANSI A21.11 or ASTM F 477; for flanged joints 1/8-inch-thick gasket in accordance with ANSI A 21.15.

B. For pipes to be installed in potentially contaminated areas, see Specification Section 02105 – Chemical Sampling and Analysis.

C. For Pipes to be installed in any other contaminated areas, use gaskets as recommended by the Pipe Manufacturer, Engineer of the Record and approved by City Engineer prior to installation.

2.05 FITTINGS

A. Use fittings of same size as pipe. Reducers are not permitted to facilitate an off-size fitting. Reducing bushings are also prohibited. Make reductions in piping size by reducing fittings. Line and coat fittings as specified for pipe they connect to.

B. Push-on Fittings: ANSI A 21.10; ductile iron ANSI A 21.11 joints, gaskets, and lubricants; pressure rated at 250 psig.

C. Flanged Fittings: ANSI 21.10; ductile iron ANSI A 21.11 joints, gaskets, and lubricants; pressure rated at 250 psig.

D. Mechanical Joint Fittings: ANSI A 21.11; pressure rated at 250 psi.

E. Ductile Iron Compact Fittings: Shall conform to AWWA C153 and shall be:

1. Fusion bonded epoxy lined or

2. Cement mortar lined.

F. For tangential flanged outlets shown on Drawings, substitute with a tee with an equivalent sized outlet unless otherwise approved by Project Manager.

2.06 COATINGS AND LININGS

A. Water line Interiors: ANSI A21.4, cement lined with seal coat; ANSI A 21.16 fusion bonded epoxy coating for interior; comply with NSF 61.

B. Sanitary Sewer and Force Main Interiors:

1. Preparation: Commercial blast cleaning conforming to SSPC-SP6.

2. Liner thickness: Nominal 40 mils, for pipe barrel interior; minimum 6 to 10 mils at gasket groove and outside spigot end to 6-inches back from end.

3. Testing: ASTM G 62, Method B for voids and holidays; provide written certification.

4. Acceptable Lining Materials:

a. Provide approved virgin polyethylene conforming to ASTM D 1248, with inert fillers and carbon black to resist ultraviolet degradation during storage; heat bonded to interior surface of pipe and fittings.

b. Ceramic Epoxy – Protecto 401 or approved equal.

C. Sanitary Sewer Point Repair Pipe: For pipes which will be lined with high density polyethylene liner pipe or cured-in-place liner, provide cement-lined with seal coat in accordance with ANSI A 21.4. For pipes which will not be provided with named liner, provide pipe as specified in Paragraph 2.05B, Sanitary Sewer and Force Main Interiors.

D. Exterior:

1. Encasement requirement for water lines.

a. Open cut construction method: Provide double wrap polyethylene encasement in accordance with AWWA C105.

b. Auger or casing construction method:

(1) Double wrap with polyethylene encasement in accordance with AWWA C105. Place circumferential wraps of tape or plastic tie straps at two-foot intervals along the barrel of the pipe, and thoroughly seal each end of the polyethylene tube.

2. Sanitary Sewers: Prime coat and outside asphaltic coating conforming to ANSI A21.10, ANSI A21.15, or ANSI A21.51 for pipe and fittings in open cut excavation and in casings.

E. For buried sanitary sewer pipes not cathodically protected, provide polyethylene wrap unless otherwise specified or shown. Conform to requirements of AWWA C105.

F. For flanged joints in buried service, provide petrolatum wrapping system, Denso, or equal, for the complete joint and alloy steel fasteners. Alternatively, sanitary sewer lines may use bolts made of Type 304 stainless steel.

G. Pipe to be installed in potentially contaminated areas shall have coatings and linings recommended by the manufacturer for maximum resistance to the contaminants identified in the Phase II Environmental Site Assessment Report. If no alternative coating is specified for water lines, provide polyethylene wrap in potentially contaminated areas.

PART 3 EXECUTION

3.01 INSTALLATION

A. Conform to installation requirements of Sections 02511 - Water Lines, 02531 - Gravity Sanitary Sewers, 02532 - Sanitary Sewer Force Mains and 02553 - Point Repairs and Obstruction Removal, except as modified in this Section.

B. Install in accordance with AWWA C 600 and manufacturer's recommendations.

C. Install double wrap polyethylene encasement in conformance with requirement of AWWA C105.

D. Holiday Testing.

1. Fusion Bonded Epoxy: Conform to requirements for new fittings in ANSI A 21.16.

E. Provide electrical continuity bonding across buried mechanical and push-on joint assemblies, except where insulating flanges are required by Drawings.

1. Provide minimum number of bond wires shown on Drawings. Remove one inch of HMWPE insulation from each of bond wire prior to attaching.

2. Secure wire onto pipe using approved Thermite Welding procedures.

3. Coat bare metal and weld metal after weld is secure. Use coal-tar compound or other compatible coating. For polyurethane coated pipe, use compatible polyurethane coating.

4. Visually inspect Thermite Weld connections for electrical continuity, strength and suitable coating prior to backfilling or placing pipe in augered hole or casing.

3.02 FIELD REPAIR OF COATINGS

A. Fusion Bonded Epoxy: Conform to requirements for new fittings in ANSI A 21.16.

END OF SECTION

SECTION 02502

STEEL PIPE AND FITTINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Steel pipe and fittings for water lines for aerial crossings, aboveground piping, and encasement sleeves. Do not bury steel pipe, unless it is large diameter water line.

B. Specifications identify requirements for small-diameter less than or equal to 20 inches.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02511 – Water Lines

E. Section 15640 – Joint Bonding and Electrical Isolation

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for steel pipe and fittings under this Section. Refer to Section 02511 - Water Lines for measurement and payment.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AASHTO - Standard Specifications for Highway Bridges.

B. ASME B 16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250

C. ASTM A 36 - Standard Specification for Carbon Structural Steel.

D. ASTM A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

E. ASTM A 105 - Standard Specification for Carbon Steel Pipe Forgings for Piping Applications.

F. ASTM A 106 - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.

G. ASTM A 135 - Standard Specification for Electric-Resistance-Welded Steel Pipe.

H. ASTM A 139 - Standard Specification for Electric-Fusion (ARC) - Welded Steel Pipe (NPS 4 and Over).

I. ASTM A 1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.

J. ASTM D 4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

K. AWWA C 200 - Standard for Steel Water Pipe 6 in. and Larger.

L. AWWA C 206 - Standard for Field Welding of Steel Water Pipe.

M. AWWA C 207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 in. through 144 in.

N. AWWA C 210 - Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.

O. AWWA C 604 – Installation of Buried Steel Water Pipe – 4 In. (10 mm) and Larger.

P. AWWA M 11 – Steel Pipe – A Guide for Design and Installation.

Q. SSPC Good Painting Practice, Volume 1.

R. SSPC SP 1 - Surface Preparation Specification No. 1 Solvent Cleaning.

S. SSPC SP 5 - Joint Surface Preparation Standard White Blast Cleaning.

T. SSPC SP 6 - Surface Preparation Specification No. 6 Commercial Blast Cleaning.

U. SSPC SP 10 - Surface Preparation Specification No. 10 Near-White Blast Cleaning.

V. SSPC VIS 1 - Visual Standard for Abrasive Blast Cleaned Steel.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures. For aerial crossings and above ground piping, include lay schedule of new pipe and fittings indicating alignment and grade, laying dimensions, lining and coating systems, proposed welding procedures, fabrication, fitting, flange, and special details. Show station numbers for pipe and fittings corresponding to Drawings.

B. Submit manufacturer's certifications that pipe and fittings are new and unused.

C. Submit manufacturer's certifications that pipe and fittings have been hydrostatically tested at factory in accordance with AWWA C 200.

D. Submit manufacturer's affidavits that coatings and linings comply with applicable requirements of this Section and:

1. Polyurethane coatings were applied in strict accordance with manufacturer's recommendation and allowed to cure at temperature 5 degrees above dewpoint.

2. Linings were applied and allowed to cure at temperature above 32 F.

E. Submit certification from NACE Certified Coatings Inspector, having Level III certification for coatings and linings, that steel pipe furnished on project was properly inspected and defective coatings detected were properly repaired.

1.06 QUALITY CONTROL

A. Prior to start of work, provide proof of certification of qualification for welders employed for type of work, procedures and positions involved. Provide welder qualifications in accordance with AWWA C 206.

B. Shop-applied coatings and linings; provide services of an independent coating and lining inspection service or testing laboratory with qualified coating inspectors. Perform inspection by NACE trained inspectors under supervision of NACE Level III Certified Coatings Inspector verifying compliance with same requirements specified in Paragraph 3.02.

C. Coatings: Measure temperature and dew point of ambient air before applying coatings. Inspect physical dimensions and overall condition of coatings. Inspect for visible surface defects, thickness, and adhesion of coating to surface and between layers.

D. Final Inspection:

1. Before shipment, inspect each finished pipe, fitting, special and accessory for markings, metal thickness, coating thickness, lining thickness (if shop applied), joint dimensions, and roundness.

2. Inspect for coating placement and defects. Test exterior coating for holidays.

a. Inspect linings for thickness, pitting, scarring, and adhesion.

E. Ensure workmen engaged in manufacturing are qualified and experienced in performance of their specific duties.

PART 2 PRODUCTS

2.01 STEEL PIPE

A. Provide steel pipe and encasement sleeves designed and manufactured in conformance with AWWA C 200 and AWWA M 11 except as modified herein. Steel to be minimum of ASTM A106, ASTM A 36, ASTM A 1011 Grade 36, ASTM A 53 Grade B, ASTM A 135 Grade B, or ASTM A 139 Grade B.

B. Minimum Allowable Steel-Wall Thickness:

CARRIER PIPE			
Nom. Pipe Size	Min. Wall		Approx. Wt. Per L.F. Uncoated (Lb.)
	O.D (In.)	Thick. (In.)	
4	4.50	0.250	11.35
6	6.625	0.280	18.97
8	8.625	0.322	28.55
10	10.75	0.365	40.48
12	12.75	0.375	49.56
16	16.00	0.375	62.58
20	20.00	0.375	78.60

1. Notes for Carrier Pipe:

a. Review pipe and fitting design for conditions exceeding those specified herein.

b. Provide pipe with wall thickness of no less than listed in table above.

MINIMUM DIAMETER CASING PIPE (ENCASEMENT SLEEVES)			
Corresp. Casing Pipe Size (In.)	Min. Wall		Approx. Wt. Per L.F. Uncoated (Lb.)
	O.D. (In.)	Thick. (In.)	
8	8.625	0.219	19.64
10	10.75	0.219	24.60
12	12.75	0.219	29.28
16	16.00	0.219	36.86
18	18.00	0.25	47.39
20	20.00	0.250	52.73
24	24.00	0.250	63.41

2. Notes for Casing Pipe:

   a. Provide casing pipe with wall thickness of no less than listed in table above.

   b. Casing pipe: AWWA C 200 new uncoated welded steel.

   c. Verify casing diameter required with dimensions of casing spacer.

C. Provide pipe sections in lengths of no less than 16 feet except as required for special sections, and no greater than 40 feet.

D. Provide short sections of steel pipe no less than 4 feet in length unless indicated on Drawings or specifically permitted by Project Manager.

E. Fittings: Factory forged for sizes 4 inches through 20 inches; long radius bends; beveled ends for field butt welding; wall thickness equal to or greater than pipe to which fitting is to be welded unless otherwise shown on Drawings.

F. Joints:

1. Standard field joint for steel pipe and encasement sleeve: AWWA C 206. Single- welded, butt joint.

2. Electrically isolate flanged joints between steel and cast iron by using flange isolation fittings as specified in paragraph 2.03 of Specification Section 15640 – Joint Bonding and Electrical Isolation. Use epoxy coated nuts and bolts to assemble the fittings.

3. Elbows to be standard weight seamless elbows per ASTM A106, Grade A or B.

G. Flanges: Refer to Specification Section 02511 – Water Lines.

2.02 INTERNAL LINING SYSTEMS FOR STEEL PIPE, ALL INSTALLATIONS

A. Supply steel pipe with epoxy lining, capable of conveying water at temperatures not greater than 140 degrees F. Provide linings conforming to American National Standards Institute/National Sanitation Foundation (ANSI/NFS) Standard 61 and certification to be from organization accredited by ANSI. Unless otherwise noted, coat exposed (wetted) steel parts of flanges, blind flanges, bolts, access manhole covers, etc., with epoxy lining, as specified.

B. Epoxy Lining AWWA C 210, White, or approved equal for shop and field applied, except as modified in this Section. Provide material from same manufacturer.

Surface Preparation as recommended by manufacturer	SSPC-10 Near White Blast Clean
Finish Coat	AWWA C210. Provide Devoe Bar Rust 233H or approved equal.

1. Provide dry film thickness in accordance with product manufacturer recommendations. Do not exceed maximum DFT as recommended by manufacturer.

2. Factory Testing: In accordance with AWWA C210.

2.03 EXTERNAL COATING SYSTEM FOR STEEL PIPE INSTALLED ABOVEGROUND AND IN VAULTS (EXPOSED)

A. Provide approved epoxy/polyurethane coating system as designated below. Provide material from same manufacturer.

Surface Preparation as recommended by manufacturer	SSPC SP 10 Near White Blast Clean
Intermediate Coat	Chemical Resistant Epoxy, or approved equal, AWWA C210
Finish Coat	Polyurethane, or approved equal Blue Fed Std. No. 15102 color as approved by Project Manager

B. Total Allowable Dry Film Thickness (DFT) for System: as recommended by manufacturer.

C. Factory and field testing: in accordance with AWWA C210.

D. Clean bare pipe free from mud, mill lacquer, oil, grease, or other contaminant. Inspect and clean surfaces according to SSPC-SP-1 to remove oil, grease, and loosely adhering deposits prior to blast cleaning. Remove visible oil and grease spots by solvent wiping. Use only approved safety solvents which do not leave residue. Use preheating to remove oil, grease, mill scale, water, and ice provided pipe is preheated in uniform manner to avoid distortion.

E. Remove surface imperfections such as slivers, scabs, burrs, weld spatter, and gouges. Grind weld bead for proper coating application as recommended by coating manufacturer. Presence of metallic defects may be cause for rejection of pipe.

PART 3 EXECUTION

3.01 PIPING INSTALLATION

A. Conform to applicable provisions of Section 02511 - Water lines, except as modified in this Section.

B. Comply with the following:

1. Bedding and Backfilling: Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

2. For pipes with coating: Do not roll or drag pipe on ground, move pipe in such a manner as not to damage pipe or coating. Carefully inspect pipe for abrasions and repair damaged coating before pipe is installed.

C. Static Electricity:

1. Properly ground steel pipeline during construction as necessary to prevent build-up of static electricity.

2. Electrically test where required after installation is complete.

3.02 EXTERNAL COATING SYSTEM FOR STEEL PIPE INSTALLED ABOVE GROUND AND IN VAULTS (EXPOSED) AND EPOXY INTERNAL LINING SYSTEM.

A. Safety: Paints, coatings, and linings specified in this Section are hazardous materials. Vapors may be toxic or explosive. Protective equipment, approved by appropriate regulatory agency, is mandatory for personnel involved in painting, coating, and lining operations.

B. Workmanship:

1. Application: By qualified and experienced workers who are knowledgeable in surface preparation and application of high-performance industrial coatings.

2. Paint Application Procedures: SSPC Good Painting Practices, Volume 1.

C. Surface Preparation:

1. Prepare surfaces for painting by using abrasive blasting.

2. Schedule cleaning and painting so that detrimental amounts of dust or other contaminants do not fall on wet, newly-painted surfaces. Protect surfaces not intended to be painted from effects of cleaning and painting operations.

3. Prior to blasting, clean surfaces to be coated or lined of grease, oil and dirt by steaming or detergent cleaning in accordance with SSPC SP 1.

4. Metal and Weld Preparation: Remove surface defects such as gouges, pits, welding and torch-cut slag, welding flux and spatter by grinding to 1/4-inch minimum radius.

5. Abrasive Material:

a. Blast only as much steel as can be coated same day of blasting.

b. Use sharp, angular, properly graded abrasive capable of producing depth of profile specified herein. Transport abrasive to job site in moisture-proof bags or airtight bulk containers. Copper slag abrasives are not acceptable.

c. After abrasive blast cleaning, verify surface profile with replica tape such as Tes-Tex Coarse or Extra Coarse Press-O-Film Tape, or approved equal. Furnish tapes to Project Manager.

d. Do not blast if metal surface may become wet before priming commences, or when metal surface is less than 5 degrees F above dew point.

6. Evaluate degree of cleanliness for surface preparation with use of SSPC Pictorial Surface Preparation Standards for Painting Steel Surfaces, SSPC-Vis 1.

7. Remove dust and abrasive residue from freshly blasted surfaces by brushing or blowing with clean, dry air. Test cleanliness by placing 3/4-inch by 4-inch piece of clear Scotch type tape on blasted surface, then removing and placing tape on 3x5 white index card. Reclean areas exhibiting dust or residue.

D. Coating and Lining Application:

1. Environmental Conditions: Do not apply coatings or linings when metal temperature is less than 50 degrees F; when ambient temperature is less than 5 degrees F above dew point; when expected weather conditions are such that ambient temperature will drop below 40 degrees F within 6 hours after application; or when relative humidity is above 85 percent. Measure relative humidity and dew point by use of sling psychrometer in conjunction with U.S. Department of Commerce Weather Bureau Psychometric Tables. Provide dehumidifiers for field-applied coatings and linings to maintain proper humidity levels.

2. Application Procedures:

    a. Apply in accordance with manufacturer's recommendations and requirements of this Section. Provide finish free of runs, sags, curtains, pinholes, orange peel, fish eyes, excessive over spray, or delaminations.

    b. Thin materials only with manufacturers recommended thinners. Thin only amount required to adjust viscosity for temperature variations, proper atomization and flow-out. Mix material components using mechanical mixers.

    c. Discard catalyzed materials remaining at end of day.

3. Thoroughly dry pipe before primer is applied. Apply primer immediately after cleaning surface. Apply succeeding coats before contamination of undersurface occurs.

4. Cure a minimum of 24 hours at 77 degrees F before successive coats are applied. During curing process, provide force air ventilation in volume sufficient to maintain solvent vapor levels below published threshold limit value. Apply successive coats within recoat threshold time as recommended by coating or lining manufacturer on printed technical data sheets or through written communications. Brush blast joints of pipe which have been shop primed and are to receive intermediate and finish coats in field prior to application of additional coats. After interior coatings are applied, provide forced air ventilation in sufficient volume and for sufficient length of time to ensure proper curing before filling pipe with water.

E. Testing of Coatings and Linings:

1. Inspect pipe for holidays and damage to coating:

    a. If test indicates no holidays and coating is damaged, remove damaged layers of coating and repair in accordance with coating manufacturer’s recommendations.

2. Perform holiday test in accordance with NACE Standard Recommended Practice, RPO 188-90, Discontinuity (Holiday) Testing of Protective Coatings.

3. Begin testing of completed coating after coating has sufficiently cured, usually one to 5 days. Consult coating manufacturer for specific curing schedule.

4. Perform adhesion test on pipe in accordance with ASTM D 4541.

5. For coating thickness of 20 mils or less, test with wet sponge low-voltage holiday detector. For coating thickness in excess of 20 mils, test with high-voltage holiday detector. Perform electrical holiday test with 60-cycle current audio detector. Select test voltage as suggested in table below.

MINIMUM VOLTAGES FOR
HIGH VOLTAGE SPARK TESTING

Total Dry Film Thickness (mils)	Suggested Inspection (V)
20 to 40	3,000
41 to 55	4,000
56 to 80	6,000

3.03 JOINTS AND JOINTING

A. Welded Joints:

1. Conform to requirements of Section 02511 - Water Lines.

2. Field weld to be full penetration butt welded joints for steel pipe and encasement sleeves for entire circumference.

3. City will employ an independent certified testing laboratory to perform weld acceptance tests on welded joints. Testing Laboratory will test by X-ray methods for butt welds, for 100 percent of joint welds. Project Manager has final decision as to suitability of welds tested.

B. Flanged Joints: Conform to requirements of Section 02511 - Water Lines.

3.04 COATINGS AND LININGS INSPECTION RESPONSIBILITIES

A. Contractor is responsible for quality control of coatings and linings applications and testing and inspection stipulated in this Section. Project Manager is responsible for quality assurance and reserves the right to inspect or acquire services of an independent third-party inspector who is fully knowledgeable and qualified to inspect surface preparation and application of high- performance coatings at all phases of coatings and linings work, field- or shop-applied. Contractor is responsible for proper application and performance of coatings and linings whether or not Project Manager provides such inspection.

END OF SECTION

SECTION 02503

COPPER TUBING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Copper tubing for water service lines.

1.02 REALTED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02512 – Water Tap and Service Line Installation

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for copper tubing under this Section. Include cost in unit price for water taps and service lines.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM B 88 - Standard Specification for Seamless Copper Water Tube.

B. AWWA C 800 - Standard for Underground Service Line Valves and Fittings.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certified test results of ASTM B 88.

C. Submit manufacturer's testing certification that copper tubing conforms to requirements of ASTM B 88. Number of samples for testing of each size of tubing is modified as follows:

1. For each 7500 feet of tubing: 1 sample

2. For each set of tubing less than 7500 feet: 1 sample

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide Type K annealed, seamless, copper tubing, 3/8 inch to 2 inch in diameter conforming to requirements of ASTM B 88.

B. Provide 3/8-inch and 1-inch tubing in coils of minimum 60 feet in length, and 1-1/2-inch and 2-inch tubing in coils 40 feet in length.

C. Provide tubing manufactured in United States of America. Tubing shall be inspected and tested by laboratory designated by Project Manager at point of manufacture or locally. Furnish tubing, at no additional cost to designated testing laboratory along with mill compliance certificates.

D. Provide flared or compression-type brass fittings for use with Type K annealed copper tubing in accordance with AWWA C 800.

PART 3 EXECUTION

3.01 INSTALLATION

A. Conform to installation requirements of Section 02512 - Water Tap and Service Line Installation, except as modified in this Section.

3.02 JOINTS

A. Minimum joint spacing for 3/4-inch and 1-inch tubing shall be 60 feet and for 1-1/2-inch and 2-inch tubing shall be 40 feet.

B. Cut copper tubing squarely by using cutting tools designed specifically for purpose and avoid procedures that cause pipe to bend or pipe walls to flatten.

C. After tubing has been cut, but before flaring, use reamer to remove inside rolled lip from tubing. Expand flared ends by use of flaring tool using care to avoid splitting, crimping, or over stressing metal. Provide at least 10 inches of straight pipe adjacent to fittings.

D. When compression fittings are used, cut copper tubing squarely prior to insertion into fitting. Assemble in accordance with manufacturer's recommended procedure.

3.03 BENDS

A. Bend tubing by using appropriate sized bending tool. No kinks, dents, flats, or crimps shall be permitted. Cut out and replace damaged section. Install no bends with radius smaller than radius of coil of tubing as packaged by manufacturer. Copper tubing shipped in straight lengths conforms to the following:

1. For 2-inch diameter: Maximum of one 45-degree bend per 4-foot section.

2. For 1-1/2-inch diameter: Maximum of one 45-degree bend per 3-foot section.

END OF SECTION

SECTION 02504

FIBERGLASS REINFORCED PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Fiberglass reinforced (FRP) pipe for sanitary sewers.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02081 – Cast-In-Place Concrete Manholes

D. Section 02082 – Precast Concrete Manholes

E. Section 02105 – Chemical Sampling and Analysis

F. Section 02317 – Excavation and Backfill for Utilities

G. Section 02441 – Microtunneling

H. Section 02445 – Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels

I. Section 02531 – Gravity Sanitary Sewers

J. Section 02532 – Sanitary Sewer Force Mains

K. Section 02533 – Acceptance Testing for Sanitary Sewers

L. Section 02550 – Sliplining Sanitary Sewers

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for fiberglass pipe under this Section. Include cost in unit price for Work, as specified in Section 02531 - Gravity Sanitary Sewers, Section 02532 - Sanitary Sewer Force Mains, or Section 02550 - Sliplining Sanitary Sewers.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 REFERENCES

A. ASTM D 3262 - Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting- Resin) Sewer Pipe.

B. ASTM D 3681 – Standard Test Method for Chemical Resistance of "Fiberglass" (Glass-Fiber- Reinforced Thermosetting-Resin) Pipe in a Deflected Condition.

C. ASTM D 3754 - Standard Specification for "Fiberglass" (Glass-Fiber Reinforced Thermosetting- Resin) Sewer and Industrial Pressure Pipe.

D. ASTM D 4161 - Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting- Resin) Pipe Joints Using Flexible Elastomeric Seals.

E. ASTM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

F. AWWA Manual of Practices M45 Fiberglass Pipe Design.

G. AASHTO LRFD Bridge Design Specifications

H. TAC Texas Administrative Code. 30 TAC Chapter 317.20.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Provide sufficient data for the Project Manager to properly evaluate the pipe.

C. Product data submittals shall include the following, as a minimum:

1. Details of the proposed pipe.

2. Properties and strengths of the pipe.

3. Details of pipe joint.

4. Pipe design calculations per AASHTO LRFD Bridge Design Specifications or AWWA Manual of Practice M45 are required for each pipe location and are to be signed and sealed by a licensed engineer.

5. Instruction on storage, handling, transporting, and installation.

6. Standard catalog sheets.

D. Test Reports: Provide test reports upon request, certifying that the pipe has been tested in accordance with and exceeds minimum requirements of ASTM D 3262 and ASTM D 3681.

E. Submit manufacturer technical catalog.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide fiberglass reinforced pipe per the City of Houston Pre-Approved Product List.

2.02 MATERIALS

A. Resin Systems: The manufacturer shall use only polyester resin systems with a proven history of performance in this particular application. The historical data shall have been collected from applications of a composite material of similar construction and composition as the proposed product.

B. Glass Reinforcements: The reinforcing glass fibers used to manufacture the components shall be of highest quality commercial grade glass filaments with binder and sizing compatible with impregnating resins.

C. Fillers: Silica sand or other suitable materials may be used.

D. Additives: Resin additives, such as pigments, dyes, and other coloring agents, if used, shall in no way be detrimental to the performance of the product nor shall they impair visual inspection of the finished products.

E. Rubber Gaskets: Supply from an approved gasket manufacturer in accordance with ASTM F 477, when no contaminant is identified and suitable for the service intended. Gaskets shall either be affixed to the pipe by means of a suitable adhesive or shall be installed in such a manner so as to prevent the gasket from rolling out of the pre-cut groove in the pipe or sleeve coupling. When pipe is to be installed in potentially contaminated areas, especially where free product is found near the elevation of the proposed sewer, provide the following gasket materials for the noted contaminants.

CONTAMINANT	GASKET MATERIAL REQUIRED
Petroleum (diesel, gasoline)	Nitrile Rubber
Other Contaminants	As recommended by the pipe manufacturer, Engineer of the Record and approved by City Engineer prior to installation

1. If required gasket material is not available for use, pipe other than fiberglass pipe must be used in potentially contaminated areas in accordance with specification section 02105 - Chemical Sampling and Analysis in PPCA.

F. The internal liner resin shall be suitable for service as sewer pipeand shall be highly resistant to exposure to sulfuric acid as produced by biological activity from hydrogen sulfide gases. Pipe shall meet or exceed requirements of ASTM D 3681.

2.03 MANUFACTURE AND CONSTRUCTION

A. Pipes

1. Furnish pipes in the diameters specified and within the tolerances specified below.

2. Manufacture pipe by the centrifugal casting process or filament winding to result in a dense, nonporous, corrosion-resistant, consistent composite structure to meet the operating conditions as shown on the Drawings.

3. Do not use stiffening ribs or rings.

B. Couplings: Unless otherwise specified, the pipe shall be field connected with fiberglass sleeve couplings that utilize elastomeric sealing gaskets as the sole means to maintain joint watertightness. The joints must meet the performance requirements of ASTM D 4161.

C. Fittings: Flanges, elbows, reducers, tees, and other fittings shall be capable of withstanding operating conditions when installed. They may be contact molded or manufactured from mitered sections of pipe joined by glass fiber reinforced overlays.

D. Manhole Connections: Provide a water stop flange (wall pipe) for connection to manhole base or other structure in accordance with Section 02081 - Cast-In-Place Concrete Manholes, or Section 02082 - Precast Concrete Manholes.

E. Grout Ports: Provide grout ports in the wall of pipe when required. Provide plugs of 316 stainless steel or other corrosion-resistant material compatible with the pipe. Grout port plugs shall be designed and installed to meet the test pressure of the pipe.

2.04 DIMENSIONS

A. Diameters: The actual outside diameter of the pipes shall be in accordance with Table 3 of ASTM D 3262 for gravity sewers, or ASTM D 3754 for force mains.

B. Lengths: The pipe standard length will be approximately 20 feet. A maximum of 10 percent of the lengths, excluding special order pipes, may be supplied in random lengths.

C. Wall Thickness: The minimum average wall thickness shall be the stated design thickness. The minimum single point thickness shall not be less than 90 percent of the stated design thickness.

D. End Squareness: Pipe ends shall be square to the pipe axis.

E. Tolerance of Fittings: The tolerance of the angle of an elbow and the angle between the main and leg of a wye or tee shall be plus or minus 2 degrees. The tolerance on the laying length of a fitting shall be plus or minus 2 inches.

2.05 STIFFNESS CLASSES

A. Stiffness class of FRP pipe shall satisfy design requirements, but shall not be less than 46 psi, when used in direct bury operation; 36 psi, when installed within a primary tunnel liner.

B. Stiffness class of FRP in a pipe jacking operation shall be governed either by the ring deflection limitations or by a pipe design providing longitudinal strength required by the jacking method and shall satisfy design requirements stated below. Submit design calculations as required in Paragraph 1.05, Submittals.

1. Pipe stress calculations based on jacking loads shall be performed to conform to Section 02441 – Microtunneling and or Section 02445 - Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels.

2. Ring deflection calculations shall conform to design requirements of 30 TAC Chapter 317.20 pertaining to flexible pipe used in gravity sewers. The pipe deflection calculations shall ensure that predicted deflection will be less than 5 percent under long-term loading conditions (soil prism load) for the highest density of soil overburden and surcharge loads. Deflection on calculations shall be prepared using long-term (drained) values for soil parameters contained in the geotechnical investigation report for the Project, or other site-specific data obtained by the Contractor as approved by the Engineer.

2.06 TESTING

A. Pipes shall be tested in accordance with ASTM D 3262 or ASTM D 3754, as applicable, except that the factory hydrostatic pressure testing is not required.

B. Joints: Coupling joints shall be qualified per the tests of Section 7 of ASTM D 4161.

2.07 INSPECTION

A. The Project Manager shall be entitled to inspect pipes or witness the pipe manufacturing. Such inspection shall not relieve the manufacturer of the responsibilities to provide products that comply with the applicable standards and these Specifications.

B. Manufacturer's Notification: Should the Project Manager wish to see specific pipes during any phase of the manufacturing process, the manufacturer must provide the Project Manager with adequate advance notice of when and where the production of those pipes will take place.

C. Failure to Inspect: Should the Project Manager elect not to inspect the manufacturing, testing, or finished pipes, it in no way implies approval of products or tests.

2.08 PACKAGING, HANDLING, AND SHIPPING

A. Packing, handling, and shipping should be done in accordance with the manufacturer's recommendations.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install pipe and fittings in accordance with requirements of Section 02531 - Gravity Sanitary Sewers, 02532 - Sanitary Sewer Force Mains, or Section 02550 - Sliplining Sanitary Sewers.

B. The manufacturer must supply a suitable qualified field service representative to be present periodically during the installation of pipe.

C. Pipe Bedding and backfill: Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

D. Pipe Handling: Use textile slings.

E. Jointing

1. Clean ends of pipe and coupling components.

2. Check pipe ends and couplings for damage. Correct any damage found.

3. Coupling grooves must be completely free of dirt.

4. Apply joint lubricant to pipe ends and rubber seals of coupling. Use only lubricants approved by the pipe manufacturer.

5. Use suitable auxiliary equipment, such as a wire rope puller, to pull joints together.

6. Do not exceed forces recommended by the manufacturer for coupling pipe. If excessive force is required, remove coupling, determine source of problem, and correct it.

7. In the process of jointing the pipe, do not allow the deflection angle to exceed the deflection permitted by the manufacturer.

F. If pressure grouting of the pipe is conducted as part of a pipe-jacked tunnel installation, seal the grout holes with liner resin to a thickness equal to the pipe liner thickness or with a threaded plug for that purpose.

G. Tests: Conform to requirements of Section 02533 - Acceptance Testing for Sanitary Sewers.

END OF SECTION

SECTION 02505

HIGH DENSITY POLYETHYLENE (HDPE) SOLID AND PROFILE WALL PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. High density polyethylene (HDPE) pipe for gravity sanitary sewers and drains, including fittings.

B. High density polyethylene (HDPE) pipe for sanitary sewer force mains, including fittings.

C. High density polyethylene (HDPE) pipe for gravity storm sewers and drains, including fittings.

D. High density polyethylene (HDPE) pipe for storm sewers culverts.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02531 – Gravity Sanitary Sewers

E. Section 02532 – Sanitary Sewer Force Mains

F. Section 02533 – Acceptance Testing for Sanitary Sewers

G. Section 02550 – Sliplining Sanitary Sewers

H. Section 02571 – Pipe Bursting/Crushing Sanitary Sewers

I. Section 02631 – Storm Sewers

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for HDPE pipe under this Section. Include cost in unit prices for work, as specified in following sections:

a. Section 02531 - Gravity Sanitary Sewers.

b. Section 02532 - Sanitary Sewer Force Mains.

c. Section 02550 - Sliplining Sanitary Sewers.

d. Section 02571 - Pipe Bursting/Crushing Sanitary Sewers.

e. Section 02631 - Storm Sewers.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

A. AASHTO - American Association of State Highway and Transportation Officials.

B. AASHTO's Product Evaluation and Audit Solutions – AASHTO's program to evaluate materials, products, and devices of common interest for use in highway and bridge construction.

C. Soil-tight Joints: Joints meeting the definition in AASHTO Standard Specifications for Highway Bridges, Section 26.4.2.4.

D. Watertight Joints: Joints meeting the requirements of ASTM D 3212.

1.05 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO), AASHTO LRFD Bridge Design Specifications, current edition.

B. AASHTO M 294 - Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter

C. AASHTO, Standard Specifications for Highway Bridges, current edition.

D. ASTM D 618 - Standard Practice for Conditioning Plastics for Testing.

E. ASTM D 1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

F. ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

G. ASTM D 2657 - Standard Practice for Heat Fusion Joining Polyolefin Pipe and Fittings.

H. ASTM D 2774 - Standard Practice for Underground Installation of Thermoplastic Pressure Piping.

I. ASTM D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.

J. ASTM D 3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

K. ASTM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

L. ASTM F 2306 - Standard Specification for 12 to 60 in. [300 to 1500 mm] Annular Corrugated Profile-Wall Polyethylene (PE) Pipe and Fittings for Gravity-Flow Storm Sewer and Subsurface Drainage Applications.

M. AWWA C 906 - Polyethylene (PE) Pressure Pipe and Fittings, 4 In. Through 65 In. (100 mm Through 1,650 mm), for Waterworks.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit shop drawings showing design of pipe and fittings indicating alignment and grade, pipe length, laying dimensions, fabrication, fittings, flanges, gasket material, and special details.

C. Submit detailed calculations for pipe design per AASHTO LRFD Bridge Design Specifications. Refer to Section 02631 – Storm Sewers submittal requirements for more details.

D. Submit details of Pipe Joints and jointing procedure for HDPE pipe.

E. Submit manufacturer technical catalog.

F. Submit manufacturer’s installation specifications before beginning work. Include maximum fill depth and backfill requirements in manufacturer’s installation specifications.

G. Submit a certificate of compliance with each shipment stating that the materials and assemblies fully comply with the requirements of the Contract.

1. Ensure that manufacturer’s Certification of Compliance contains the following information:

a. Project Name.

b. Name of the Contractor.

c. Material description.

(1) Manufacturing plant

(2) Date of manufacture

(3) Pipe dimensions

(4) Pipe stiffness

(5) Pipe flattening

(6) Brittleness

(7) ASTM Resin Cell classification

(8) Workmanship

d. Typed or printed name of the person who signed the certification.

2. Provide the date and method of shipment from the product origin within the transmittal.

1.07 QUALITY ASSURANCE

A. Provide manufacturer's certificate of conformance to Specifications.

B. Furnish pipe and fittings that are homogeneous throughout and free from visible cracks, holes, foreign inclusions, or other injurious defects. Provide pipe as uniform as commercially practical in color, opacity, density, and other physical properties.

C. Project Manager reserves right to inspect pipes or witness pipe manufacturing. Inspection shall in no way relieve manufacturer of responsibilities to provide products that comply with applicable standards and these Specifications.

1. Manufacturer's Notification: Should Project Manager wish to witness manufacture of specific pipes, manufacturer shall provide Project Manager with minimum three weeks notice of when and where production of those specific pipes will take place.

2. Failure to Inspect. Approval of products or tests is not implied by Project Manager’s decision not to inspect manufacturing, testing, or finished pipes.

D. Manufacturer Qualifications: Manufacturer shall specialize in manufacturing the products specified in this section with documented experience of minimum 5 years of pipe installations that have been in successful, continuous service for same type of service as proposed Work.

E. Manufacturers shall be AASHTO- Product Evaluation and Audit Solutions certified. Qualified manufacturers must also maintain and submit a current AASHTO- Product Evaluation and Audit Solutions certificate of compliance.

1. For a list of AASHTO-Product Evaluation and Audit Solutions certified manufacturers, see the following webpage: https://transportation.org/product-evaluation-and-audit-solutions/.

1.08 STORAGE

A. Store HDPE pipes out of direct sunlight unless manufacturer's specifications allow.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide approved products listed on the City of Houston Approved Products List or approved equal.

B. Furnish solid wall pipe with plain end construction for heat joining (butt fusion) conforming to ASTM D 2657. Utilize controlled temperatures and pressures for joining to produce fused leak-free joint.

C. Furnish profile-wall gravity sanitary sewer pipe with bell-and-spigot end construction conforming to ASTM D 3212. Joining will be accomplished with elastomeric gasket in accordance with manufacturer's recommendations. Use integral bell-and-spigot gasketed joint designed so that when assembled, elastomeric gasket, contained in machined groove on pipe spigot, is compressed radially in pipe bell to form positive seal. Design joint to avoid displacement of gasket when installed in accordance with manufacturer's recommendations.

D. Furnish solid wall pipe for sanitary sewer force mains with minimum working pressure rating of 150 psi, and with inside diameter equal to or greater than nominal pipe size indicated on Drawings.

E. Furnish corrugated profile-wall polyethylene (CPE) pipe for gravity storm sewer and storm sewer culvert pipe. Joints shall be installed such that connection of pipe sections will form continuous line free from irregularities in flow line.

F. Jointing:

1. Provide joints and fittings meeting the following requirements:

    a. Integral Bell and Spigot with dual elastomeric gaskets. Bell shall overlap minimum of two corrugations of spigot end when fully engaged. Provide the spigot end with an O-ring gasket in accordance with 2.01.F.2.

    b. Exterior Bell and Spigot. Bell shall be fully welded to exterior of pipe and overlap spigot end so that flow lines and ends match when fully engaged. Provide the spigot end with an O-ring gasket in accordance with 2.01.F.2.

    c. Split Couplers. Used for gravity storm sewer Soil-Tight Joint connections only. Join pipe with coupling bands covering at least two full corrugations on the ends of each pipe being joined.

2. Gaskets:

a. Meet requirements of ASTM F 477. Use gasket molded into circular form or extruded to proper section and then spliced into circular form. When no contaminant is identified, use gaskets of properly cured, high-grade elastomeric compound. Basic polymer shall be natural rubber, synthetic elastomer, or blend of both.

b. HDPE Pipes are Not allowed to be installed in potentially contaminated areas, unless approved by City Engineer.

CONTAMINANT	GASKET MATERIAL REQUIRED
Petroleum (diesel, gasoline)	Nitrile Rubber
Other Contaminants	As recommended by pipe manufacturer

3. Lubricant. Use lubricant for assembly of gasketed joints which has no detrimental effect on gasket or on pipe, in accordance with manufacturer's recommendations.

4. Diameters 12-inch through 48-inch storm sewer shall have a reinforced bell with a polymer composite band installed by the manufacturer.

2.02 MATERIALS FOR SANITARY SEWER

A. Pipe and Fittings: High density, high molecular weight polyethylene pipe material meeting requirements of Type III, Class C, Category 5, Grade P34, as defined in ASTM D 1248. Material meeting requirements of cell classification 345434D or E, in accordance with ASTM D 3350, are also suitable for making pipe products under these specifications. Inner wall of pipe shall be of light color for television inspection purposes.

B. Other Pipe Materials: Materials other than those specified in Paragraph 2.02A, Pipe and Fittings, may be used as part of profile construction, e.g., as core tube to support shape of profile during processing, provided that these materials are compatible with base polyethylene material and are completely encapsulated in finished product and in no way compromise performance of pipe products in intended use. Examples of suitable material include polyethylene and polypropylene.

2.03 MATERIALS FOR GRAVITY STORM SEWERS AND STORM SEWER CULVERTS

A. Pipe and Fittings:

1. High density, high molecular weight polyethylene HDPE virgin compound material meeting requirements of cell class outlined in ASTM D 3350.

2. Provide Type S pipes (outer corrugated wall with smooth inner liner).

3. Section Properties shall meet the following requirements:

a. Provide the minimum wall thickness of the inner walls for Type S pipe as specified in AASHTO M 294, Section 7.2.2. Meet the pipe stiffness at 5% deflection requirement as specified in AASHTO M 294, Section 7.4. The minimum section properties must meet the 75- yr. design life requirements in the AASHTO LRFD Bridge Design Specifications, Section 12.

4. Pipe size shall not exceed 48-inches in diameter.

B. Manufacturing shall meet requirements of ASTM F 2306.

2.04 TEST METHODS FOR SANITARY SEWER

A. Conditioning. Conditioning of samples prior to and during tests is subject to approval by Project Manager. When referee tests are required, condition specimens in accordance with Procedure A in ASTM D 618 at 73.4 degrees F plus or minus 3.6 degrees F and 50 percent relative humidity plus or minus 5 percent relative humidity for not less than 40 hours prior to test. Conduct tests under same conditions of temperature and humidity unless otherwise specified.

B. Flattening. Flatten three specimens of pipe, prepared in accordance with Paragraph 2.05A, in suitable press until internal diameter has been reduced to 40 percent of original inside diameter of pipe. Rate of loading shall be uniform and at 2 inches per minute. Test specimens, when examined under normal light and with unaided eye, shall show no evidence of splitting, cracking, breaking, or separation of pipe walls or bracing profiles.

C. Joint Tightness. Test for joint tightness in accordance with ASTM D 3212, except replace shear load transfer bars and supports with 6-inch-wide support blocks that can be either flat or contoured to conform to pipe's outer contour.

D. Purpose of Tests. Flattening and joint tightness tests are not intended to be routine quality control tests, but rather to qualify pipe to a specified level of performance.

2.05 TEST METHODS FOR GRAVITY STORM SEWERS AND STORM SEWER CULVERTS

A. All testing and material requirements shall be in accordance with ASTM F 2306.

B. MANDREL TESTING: use a mandrel to test flexible pipe for deflection. Refer to Section 02533 – Acceptance Testing for Sanitary Sewers for a mandrel and test requirements.

2.06 MARKING

A. Mark each standard and random length of pipe in compliance with these Specifications with following information:

1. Pipe size.

2. Pipe class.

3. Production code.

4. Material designation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Conform to requirements of following Sections:

1. Section 02550 - Sliplining Sanitary Sewers.

2. Section 02531 - Gravity Sanitary Sewers.

3. Section 02532 - Sanitary Sewer Force Mains.

4. Section 02533 - Acceptance Testing for Sanitary Sewers.

5. Section 02571 - Pipe Bursting/Crushing Sanitary Sewers.

6. Section 02631 - Storm Sewers.

B. Install pipe in accordance with the manufacturers recommended installation procedures and ASTM D 2774 for pressure pipe and ASTM D 2321 for gravity flow pipe.

C. Install the joints so that the connection of the pipe sections forms a continuous line free from irregularities in the flow line. For storm sewer applications only, if no joint type is specified in the Contract documents, provide a soil-tight joint meeting the requirements of this specification.

D. Unless otherwise authorized, start laying pipe on the bedding at the outlet end with the separate sections firmly joined together. Hoist and lower sections of pipe into the trench without damaging the pipe or disturbing the bedding or the sides of the trench. Remove and re-lay any pipe that is not in alignment or that shows excessive settlement after laying, at no expense to the City.

E. HDPE pipe is not approved in applications requiring augering of pipe.

F. Bedding and backfill:

1. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

2. Inspect inside periphery of pipe for local or unequal deformation caused by improper construction methods during backfilling. Stop work and address backfilling technique if measured deflection of pipe exceeds 5% or there are other issues found effecting quality of pipe installation.

3. To validate pipe installation methods, perform an initial quality control inspection after first installation of each size of pipe is completed on the project. Notify the Engineer of Record and Project Manager when this inspection takes place.

G. Use only workmen trained in the installation of HDPE Pipe.

H. Allow pipe temperature to approach ground temperature before each individual pipe section is terminally connected.

I. Joints: Join sections of HDPE pipe into continuous lengths above ground by thermal butt fusion method in accordance with AWWA C 906 and pipe manufacturer's recommendations for specified service. Fusion joints: meeting minimum requirements of manufacturer for cool down time and other fusing requirements. Socket fusion and extrusion welding or hot gas welding will not be accepted.

J. Cutting pipe: Comply with pipe manufacturer's recommendations. After cutting, leave end pipe in accordance with manufacturer's recommendations.

K. Store pipe above ground on adequate blocking. Always keep pipe clean and fully drained during storage. Provide proper equipment for hoisting and lowering the pipe into the trench without damaging the pipe or disturbing the bedding or the walls of the trench. Any protective covering of gaskets should remain until the pipe is ready for installation.

L. Multi-barrel installations are not allowed.

3.02 MANUFACTURER SERVICES

A. Pipe manufacturer to provide services of experienced, competent, and authorized representative to visit site to advise and consult Contractor during jointing and installation of pipe.

END OF SECTION

SECTION 02506

POLYVINYL CHLORIDE PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Polyvinyl chloride (PVC) pressure pipe for water distribution, in nominal diameters 4 inches through 20 inches.

B. Polyvinyl chloride sewer pipe for gravity sewers in nominal diameters 4 inches through 60 inches.

C. Polyvinyl chloride pressure pipe for gravity sewers and force mains in nominal diameters 4 inches through 20 inches.

D. Fusible PVC®, or FPVC®, pipe for pressure pipe in horizontal directional drilling applications up to 20 inches in diameter.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02501 – Ductile Iron Pipe and Fittings

E. Section 02511 – Water Lines

F. Section 02528 – Polyethylene Encasement/Wrap

G. Section 02531 – Gravity Sanitary Sewers

H. Section 02532 – Sanitary Sewer Force Mains

I. Section 02534 – Sanitary Sewer Service Stubs or Reconnections

J. Section 02631 – Storm Sewers

K. Section 16124 – Conductive Trace Wire for Non-Metallic Water Line Pipes

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for PVC pipe under this Section. Include cost in unit price for work included as specified in the following sections:

   a. Section 02511 - Water Lines

   b. Section 02531 - Gravity Sanitary Sewers

   c. Section 02532 - Sanitary Sewer Force Mains

   d. Section 02631 - Storm Sewers

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

B. ASTM C 923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.

C. ASTM D 618 - Standard Practice for Conditioning Plastics for Testing.

D. ASTM D 1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

E. ASTM D 1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

F. ASTM D 2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).

G. ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

H. ASTM D 2412 – Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel Plate Loading.

I. ASTM D 2444 - Standard Practice for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight).

J. ASTM D 3034 - Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

K. ASTM D 3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.

L. ASTM D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.

M. ASTM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

N. ASTM F 794 - Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.

O. ASTM F 949 - Standard Specification for Poly (Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings.

P. AWWA C 110 (ANSI A 21.10) - American National Standard for Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In., for Water and Other Liquids.

Q. AWWA C 111 (ANSI A 21.11) - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

R. AWWA C 153 (ANSI A 21.53) - Ductile-Iron Compact Fittings.

S. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In. (100 mmThrough 1,500mm).

T. AWWA C909 - Standard for Molecularly-Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 In. (100mm) and Larger.

U. AWWA M23 – PVC Pipe – Design and Installation.

V. PPI TR-3 - Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Hydrostatic Design Stresses (HDS), Pressure Design Basis (PDB), Strength Design Basis (SDB), Minimum Required Strength (MRS) Ratings, and Categorized Required Strength (CRS) for Thermoplastic Piping Materials or Pipe.

W. ASTM F1674 - Standard Test Method for Joint Restraint Products for Use with PVC Pipe.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit shop drawings showing design of new pipe and fittings indicating alignment and grade, laying dimensions, fabrication, fittings, flanges, and special details.

C. Contractor to review and submit PVC pipe manufacturers recommended installation procedures.

D. Calculations and limits of thrust restraint shall be based on AWWA M23, latest edition.

E. For Fusible PVC® Pipe, submit qualifications of Fusion Technician to be used on the project.

F. Provide manufacturer's product data for bell insertion protection system.

G. Submit manufacturer technical catalog.

1.06 QUALITY ASSURANCE

A. Submit manufacturer's certifications that PVC pipe and fittings meet requirements of this Section and AWWA C900, and AWWA C909 for pressure pipe applications, or appropriate ASTM standard specified for gravity sewer pipe.

B. Submit manufacturer's certification that PVC pressure pipe for water lines and force mains has been hydrostatically tested at factory in accordance with AWWA C900 and AWWA C909, and this Section.

C. When foreign manufactured material is proposed for use, have material tested for conformance to applicable ASTM requirements by certified independent testing laboratory located in United States. Certification from other source is not acceptable. Furnish copies of test reports to Project Manager for review. Cost of testing paid by Contractor.

D. Fusible PVC®

1. Fusion Technician shall be fully qualified by the pipe supplier to install type(s) and sizes(s) being used. Qualification shall be current as of the actual date of fusion performance on the project.

2. Refer to approved product list for approved manufacturer.

1.07 STORAGE

A. Store pipe under cover out of direct sunlight and protect from excessive heat or harmful chemicals in accordance with manufacturer's recommendations.

PART 2 PRODUCTS

2.01 MATERIAL

A. Use PVC compounds in manufacture of pipe that contain no ingredient in amount that has been demonstrated to migrate into water in quantities considered to be toxic.

B. Furnish PVC pressure pipe manufactured from Class 12454 virgin PVC compounds as defined in ASTM D 1784. Use compounds qualifying for rating of 4000 psi for water at 73.4 F per requirements of PPI TR-3. Provide pipe which is homogeneous throughout, free of voids, cracks, inclusions, and other defects, uniform as commercially practical in color, density, and other physical properties. Deliver pipe with surfaces free from nicks and scratches with joining surfaces of spigots and joints free from gouges and imperfections which could cause leakage.

C. For FPVC®, pipe shall be extruded with plain ends. The ends shall be square to the pipe and free of any bevel or chamfer. There shall be no bell or gasket of any kind incorporated into the pipe.

D. PVC Restrained Pipe: Must be listed on City's current Product Approval List.

1. Pipe Material:

a. Pressure Class 235 psi (DR 18): For restrained joints where shown on Drawings.

b. Pressure Class 305 psi (DR 14): For alternate to offset pipe sections shown on Drawings. Do not use PVC for offset sections with depth of cover greater than 20 feet or less than 4 feet. Do not use PVC in potentially petroleum contaminated areas.

E. Water Service.

1. Provide self-extinguishing PVC pipe that bears Underwriters' Laboratories mark of approval and is acceptable without penalty to Texas State Fire Insurance Committee for use in fire protection lines.

2. Bear National Sanitation Foundation Seal of Approval (NSF-PW).

F. Gaskets:

1. Gasket materials shall meet requirements of ASTM F 477. Use elastomeric factory- installed gaskets to make joints flexible and watertight.

2. Flat Face Mating Flange: Full faces 1/8inch-thick ethylene propylene (EPR) rubber.

3. Raised Face Mating Flange: Flat ring 1/8inch ethylene propylene (EPR) rubber, with filler gasket between OD of raised face and flange OD to protect flange from bolting moment.

G. Lubricant for rubber-gasketed joints: Water soluble, non-toxic, non-objectionable in taste and odor imparted to fluid, non-supporting of bacteria growth, having no deteriorating effect on PVC or rubber gaskets.

H. Bell Insertion Protection System: Refer to City of Houston’s Approved Product List.

I. Do not use PVC in potentially or known contaminated areas.

J. Do not use PVC in areas exposed to direct sunlight.

2.02 WATER SERVICE PIPE

A. Pipe 4 inchs through 20-inch: AWWA C900, Pressure Class 235 psi (DR 18); AWWA C900, Pressure Class 305 psi (DR 14) as alternate to offset pipe sections; nominal 20-foot lengths; cast-iron equivalent outside diameters.

B. Provide Polyvinyl Chloride Pipe from manufacturers listed on City of Houston's Approved Products List.

C. Install trace wire with PVC pipe. Refer to Section 16124 – Conductive Trace Wire for Non-Metallic Water Line Pipes.

D. Make curves and bends by offsetting (i.e., deflecting joints). Do not exceed maximum offset recommended by pipe manufacturer or the City, whichever is less.

E. Hydrostatic Test: AWWA C900, ANSI A 21.10 (AWWA C 110); at point of manufacture; submit manufacturer's written certification.

2.03 GRAVITY SEWER PIPE

A. PVC gravity sanitary sewer pipe shall be in accordance with provisions in following table:

WALL CONSTRUCTION	ASTM DESIGNATION	SDR (MAX.)/ STIFFNESS (MIN.)	DIAMETER SIZE RANGE
Solid	D3034	SDR 26 / PS 115	6" to 10"
	D3034	SDR 35 / PS 46	12" & 15"
	D3034	SDR 35 / PS 46	18" to 60"
	AWWA C900	DR 18 / N/A	4" to 20"
	AWWA C909	DR 18 / N/A	4" to 12"

Note: Refer to City of Houston Approved Products List for list of manufacturers.

B. PVC storm sewer pipe shall be in accordance with provisions in following table:

WALL CONSTRUCTION	MANUFACTURER	ASTM DESIGNATION	SDR (MAX.)/ STIFFNESS (MIN.)	DIAMETER SIZE RANGE
Solid	J-M Pipe CertainTeed Diamond Uponor ETI North American	D3034	SDR 26 / PS 115	6" to 10"
		D3034	SDR 35 / PS 46	12" & 15"
		D3034	SDR 35 / PS 46	18" to 27"
		AWWA C900	DR 18 / N/A	4" to 16"
		AWWA C909	DR 18 / N/A	4" to 12"
Truss (Gasketed)	Contech	D2680	N/A /200 psi	8" to 15"
Profile	Contech A-2000 Contech A-2026 ETI, Ultra-Rib ETI, Ultra-Corr	F949 F949 F794 F794	N/A / 46 psi N/A / 115 psi N/A / 46 psi N/A / 46 psi	12" to 36" 8" to 10" 8" to 30" 24" to 36"

C. When solid wall PVC pipe 18 inches to 27 inches in diameter is required in SDR 26, provide pipe conforming to ASTM D 3034, except provide wall thickness as required for SDR 26 and pipe stiffness of 115 psi.

D. For sewers up to 12inchs diameter crossing over water lines or crossing under water lines with less than 2-feet separation, provide minimum 150 psi pressure-rated pipe conforming to ASTM D 2241 with suitable PVC adapter couplings.

E. Joints: Spigot and integral wall section bell with solid cross section elastomeric or rubber ring gasket conforming to requirements of ASTM D 3212 and ASTM F 477, or ASTM D 3139 and ASTM F 477. Gaskets shall be factory-assembled and securely bonded or otherwise held in place to prevent displacement. Manufacturer shall test sample from each batch conforming to requirements ASTM D 2444.

F. Fittings: Provide PVC gravity sewer sanitary bends, tee, or wye fittings for new sanitary sewer construction. PVC pipe fittings shall be full-bodied, either injection molded or factory fabricated. Saddle-type tee or wye fittings are not acceptable.

1. Fittings for straight through and transition connections conform to requirements of Section 02534- Sanitary Sewer Service Stubs or Reconnections.

G. Conditioning. Conditioning of samples prior to and during tests is subject to approval by Project Manager. When referee tests are required, condition specimens in accordance with Procedure A in ASTM D 618 at 73.4 degrees F plus or minus 3.6 degrees F and 50 percent relative humidity plus or minus 5 percent relative humidity for not less than 40 hours prior to test. Conduct tests under same conditions of temperature and humidity unless otherwise specified. This is a brief summary of the test method, and the full current edition of the standard must be followed.

H. Pipe Stiffness. Determine pipe stiffness at 5 percent deflection in accordance with Test Method D 2412. Minimum pipe stiffness shall be 46 psi. For diameters 4 inches through 18 inches, test three specimens, each a minimum of 6 inches (152 mm) in length. For diameters 21 inchs through 36inchs, test three specimens, each a minimum of 12 inchs (305 mm) in length. This is a brief summary of the test method, and the full current edition of the standard must be followed.

I. Flattening. Flatten three specimens of pipe, prepared in accordance with Paragraph 2.03F, in suitable press until internal diameter has been reduced to 60 percent of original inside diameter of pipe. Rate of loading shall be uniform. Test specimens, when examined under normal light and with unaided eye, shall show no evidence of splitting, cracking, breaking, or separation of pipe walls or bracing profiles. Perform the flattening test in conjunction with pipe stiffness test. This is a brief summary of the test method, and the full current edition of the standard must be followed.

J. Joint Tightness. Test for joint tightness in accordance with ASTM D 3212, except that joint shall remain watertight at minimum deflection of 5 percent. Manufacturer will be required to provide independent third party certification for joint testing each diameter of storm sewer pipe. This is a brief summary of the test method, and the full current edition of the standard must be followed

K. Purpose of Tests. Flattening and pipe stiffness tests are intended to be routine quality control tests. Joint tightness test is intended to qualify pipe to specified level of performance.

L. Saddle for pipe with 0.5inch width and greater: Connect side sewer by drilling proper size round hole in wall of the main sewer pipe, inserting an approved pipe compression saddle. The Saddle shall meet requirements of ASTM C 923. Saddles will accept 4”, 6”, and 8” pipe. The lateral pipe shall be held in place by one stainless steel compression band with stainless steel nut and bolt (any AISI Series 300) type tightening device and meeting requirements of ASTM A 240. A stainless steel shear band shall wrap around the pipe a minimum of 380 degrees. Saddle may not protrude into mainline pipe.

2.04 SANITARY SEWER FORCE MAIN PIPE

A. Provide approved PVC pressure pipe conforming to requirements for water service pipe and conforming to minimum working pressure rating specified in Section 02532 - Sanitary Sewer Force Mains.

B. Acceptable pipe joints are integral bell-and-spigot, containing a bonded-in elastomeric sealing ring meeting requirements of ASTM F 477. In designated areas requiring restrained joint pipe and fittings, use approved joint restraint device conforming to ASTM F 1674, for PVC pipe 12inchs diameter and less.

C. Fittings: Provide approved ductile iron fittings as per Section 02501 - Ductile Iron Pipe and Fittings, Paragraph 2.04, except furnish fittings with one of following approved internal linings:

1. Nominal 40 mils (35 mils minimum) virgin polyethylene complying with ASTM D 1248, heat fused to interior surface of fitting

2. Nominal 40 mils (35 mils minimum) polyurethane

3. Nominal 40 mils (35 mils minimum) ceramic epoxy

4. Nominal 40 mils (35 mils minimum) fusion bonded epoxy

D. Exterior Protection: Provide polyethylene wrapping of ductile-iron fittings as required by Section 02528 - Polyethylene Encasement/Wrap.

E. Hydrostatic Tests: Hydrostatically test pressure rated pipe in accordance with Paragraph 2.02E.

2.05 BENDS AND FITTINGS FOR PVC PRESSURE PIPE

A. Bends and Fittings: ANSI A 21.10 or ANSI A 21.53, ductile iron; ANSI A 21.11 single rubber gasket push-on type joint; minimum 150 psi pressure rating. Approved restrained joints, 250 200 psi, may be provided for up to 12 inches in diameter (water or sanitary).

B. Provide approved restrained joint fittings: Integral restrained joint fittings and pipe do not require secondary restraint.

PART 3 EXECUTION

3.01

3.02 INSTALLATION

A. Conform to requirements of Section 02511 - Water Lines, Section 02531 - Gravity Sanitary Sewers, and Section 02532 - Sanitary Sewer Force Mains, as applicable.

B. Install PVC pipe in accordance with Section 02317 - Excavation and Backfill for Utilities, ASTM D 2321 for Sewer Pipe, and manufacturer's recommendations.

C. Install PVC water service pipe to clear utility lines with minimum 6-inch separation, unless otherwise shown on Drawings:

D. Avoid imposing strains that will overstress or buckle pipe when lowering pipe into trench.

E. Hand shovel pipe bedding under pipe haunches and along sides of pipe barrel and compact to eliminate voids and ensure side support. Ensure barrel is fully supported along entire length of pipe, prior to backfilling.

F. For PVC pipe installed by trenchless methods, provide integral restrained joints and pull pipe through hole or casing. For PVC pipe pushed through hole or casing, provide approved bell insertion protection system.

G. Store PVC pipe under cover out of direct sunlight. Protect pipe from excessive heat or harmful chemicals. Prevent damage by crushing or piercing.

H. Allow PVC pipe to cool to ground temperature before backfilling when assembled out of trench to prevent pullout due to thermal contraction.

I. Pipe Assembly Procedures

1. Do not remove gasket from pipe.

2. Lay pipe by inserting spigot end into bell flush with the insertion line or as recommended by pipe manufacturer.

3. Do not assemble joint by swinging or stabbing.

4. Do not assemble joint using machinery or equipment such as backhoe bucket.

5. At no time shall spigot go past insertion line or homing mark. Continuously observe and check each homing mark for proper length and install pipe with home mark visible.

3.03 INSTALLATION FOR FUSIBLE PVC® PIPE

A. General

1. Fusible PVC® pipe will be handled in a safe and non-destructive manner before, during, and after the fusion process and in accordance with this specification and pipe supplier’s guidelines.

2. Fusible PVC® pipe will be fused by qualified fusion technicians, as documented by the pipe supplier.

3. Each fusion joint shall be recorded and logged by an electronic monitoring device (data logger) connected to the fusion machine.

4. Only appropriately sized and outfitted fusion machines that have been approved by the pipe supplier shall be used for the fusion process. Fusion machines must incorporate the following elements:

a. HEAT PLATE – Heat plates shall be in good condition with no deep gouges or scratches. Plates shall be clean and free of any debris or contamination. Heater controls shall function properly; cord and plug shall be in good condition. The appropriately sized heat plate shall be capable of maintaining a uniform and consistent heat profile and temperature for the size of pipe being fused, per the pipe supplier's guidelines.

b. CARRIAGE – Carriage shall travel smoothly with no binding at less than 50 psi. Jaws shall be in good condition with proper inserts for the pipe size being fused. Inset pins shall be installed with no interference to carriage travel.

c. GENERAL MACHINE – Overview of machine body shall yield no obvious defects, missing parts, or potential safety issues during fusion.

d. DATA LOGGING DEVICE – An approved datalogging device with the current version of the pipe supplier's recommended and compatible software shall be used. Datalogging device operations and maintenance manual shall be with the unit at all times. If fusing for extended periods of time, an independent 110V power source shall be available to extend battery life.

B. Pipe rollers shall be used for support of pipe to either side of the machine:

1. A weather protection canopy that allows for full machine motion of the heat plate, fusion assembly and carriage shall be provided for fusion in 1506-14 RSM – 50 Rev 3.5 2/12/13 inclement, extreme temperatures, and / or windy weather, per the pipe supplier's recommendations.

2. An infrared (IR) pyrometer for checking pipe and heat plate temperatures.

3. Fusion machine operations and maintenance manual shall be kept with the fusion machine at all times.

4. Facing blades specifically designed for cutting Fusible PVC® pipe shall be used.

C. Joint Recording

1. Each fusion joint shall be recorded and logged by an electronic monitoring device (data logger) connected to the fusion machine. The fusion data logging and join report shall be generated by software developed specifically for the butt-fusion of Fusible PVC® pipe. The software shall register and/or record the parameters required by the pipe supplier and these specifications. Data not logged by the data logger shall be logged manually and be included in the Fusion Technician's joint report.

D. Installation

1. Installation guidelines from the pipe supplier shall be followed for all installations.

2. The fusible PVC® pipe will be installed in a manner so as not to exceed the recommended bending radius.

3. Where fusible PVC® pipe is installed by pulling in tension, the recommended Safe Pulling Force established by the pipe supplier shall not be exceeded.

3.04 PVC RESTRAINED MECHANISM

A. For low-profile coupling with spline-type joints:

1. Do not apply lubricant to spline or pipe or coupling spline grooves.

2. Do not use excessive force while inserting the spline through coupling.

3. Insert spline until it is fully seated around circumference of pipe.

B. Field Cutting of Pipe Ends:

1. Perform by workers certified by manufacturer.

2. Use a PVC pipe cutter and provide square ends.

3. Follow manufacturer’s recommendation to disassemble restrained joint after it has been locked in place.

4. For low-profile coupling with spline-type joints, use manufacturer approved power routing and grooving tool to field fabricate required pipe groove.

END OF SECTION

SECTION 02507

PRESTRESSED CONCRETE CYLINDER PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Prestressed concrete cylinder pipe (PCCP) and fittings for buried water lines sizes 20 inches in diameter and larger.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02511 – Water Lines

E. Section 02518 – Steel Pipe and Fittings for Large Diameter Water Lines

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. No separate payment will be made for PCCP under this Section. Include cost in unit price for work in Section 02511 – Water Lines.

2. Maintain on site minimum of two 3-degree and two 5-degree grade angle adapters. Adapters are considered “extra unit price.” When used during construction, adapter will be paid at unit price.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum): If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AASHTO - Standard Specifications for Highway Bridges.

B. AREMA - Manual of Railway Engineering, Volume II, Chapter 15.

C. ASTM A 648 - Standard Specification for Steel Wire, Hard-Drawn for Prestressed Concrete Pipe.

D. ASTM A1032 – Standard Test Method for Hydrogen Embrittlement Resistance for Steel Wire Hard-Drawn Used for Prestressed Concrete Pipe.

E. ASTM C 33 - Standard Specification for Concrete Aggregates.

F. ASTM C 35 - Standard Specification for Inorganic Aggregates for Use in Gypsum Plaster.

G. ASTM C 150 - Standard Specification for Portland Cement.

H. ASTM C 497 - Standard Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile.

I. ASTM C 1107 (CRD C-621) - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).

J. ASTM D 512 - Standard Test Methods for Chloride Ion In Water.

K. ASTM D 1293 - Standard Test Methods for pH of Water.

L. ASTM E 165 - Standard Practice for Liquid Penetrant Testing for General Industry.

M. ASTM E 340 - Standard Test Methods for Macroetching Metals and Alloys.

N. ASTM E 709 - Standard Guide for Magnetic Particle Testing.

O. ASTM E 1032 - Standard Practice for Radiographic Examination of Weldments Using Industrial X-Ray Film.

P. ANSI/AWS A3.0 - Standard Welding Terms and Definitions.

Q. AWWA C 200 - Standard for Steel Water Pipe 6 In. (150 mm) and Larger.

R. AWWA C 206 - Standard for Field Welding of Steel Water Pipe.

S. AWWA C 207 - Standard for Steel Pipe Flanges for Waterworks Service, Sizes 4 In. through 144 In. (100 mm Through 3,600 mm).

T. AWWA C 301 - Standard for Prestressed Concrete Pressure Pipe, Steel-Cylinder Type.

U. AWWA C 304 - Standard for Design of Prestressed Concrete Cylinder Pipe.

V. AWWA M 9 –Concrete Pressure Pipe.

W. NSF/ANSI 61 - Drinking Water System Components - Health Effects.

X. NACE No. 4/SSPC-SP 7 – Joint Surface Preparation Specification - Brush Off Blast Cleaning.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit shop drawings and certification signed and sealed by Professional Engineer registered in State of Texas showing following:

1. Manufacturer's pipe design and thrust restraint calculations in accordance with AWWA M9, latest edition.

2. Provide lay schedule of pictorial nature indicating alignment and grade, laying dimensions, welding procedures, fabrication, fitting, flange, and special details, with plan view of each pipe segment sketched, detailing pipe invert elevations, horizontal bends, welded joints, and other critical features. Indicate station numbers for pipe and fittings corresponding to Drawings. Do not start production of pipe and fittings prior to review and approval by Project Manager. Provide final approved lay schedule on CD-ROM in Adobe portable document format (*.PDF).

3. Include hot tapping procedure.

4. Submit certification from manufacturer that design was performed for project in accordance with requirements of this section.

C. Within 30 calendar days following Notice to Proceed and before initiation of manufacture of prestressing wire, submit following:

1. Name and location of prestressing wire manufacturer.

2. General description of quality control procedures used by wire manufacturer. Include physical and chemical property tests utilized, testing frequency and test records; and description of methods employed to assure compliance with AWWA C301 regarding wire surface temperature, type of thermometer, location of temperature measurement, frequency of temperature tests and test records.

3. Approximate dates when wire will be manufactured for use in pipe.

4. Hydrogen embrittlement sensitivity test report for wire.

D. Submit inspection procedures to be used by manufacturer and for quality control and assurance for materials and welding. Submit standard repair procedures that describe in detail shop and field work to be performed.

E. Submit following within 45 days after manufacturing of pipe and fittings:

1. Prestressing wire records.

a. ASTM A 648 for wire.

b. Steel reports as required in AWWA C301, Section 5.2.5.

c. Records of testing accomplished to measure wire surface temperature as required in ASTM A648.

d. Results of other tests of steel reinforcement required in AWWA C301, Section 4.4.7, 4.4.8, and 4.4.9.

e. Wire tension records required in AWWA C301, Section 4.6.7.1. Indicate heat and coil of prestressing wire used.

2. Test results.

a. Hydrostatic testing, acid etching, dye penetration, magnetic particle and x-ray weld test reports as required.

b. Compressive strength (28 day) test results for each type of coating, lining and core mix design.

3. Pipe manufacturer's certification that PCCP:

a. Cylinder assembly has been hydrostatically tested at factory for two (2) minutes minimum in accordance with Section 2.01 J and AWWA C301.

b. Mortar coatings and linings were applied or allowed to cure at temperature above 32 degrees F.

F. Submit following for non-shrink grout for special applications:

1. Manufacturer's technical literature including specifications for mixing, placing, and curing grout.

2. Results of tests performed by certified independent testing laboratory showing conformance to ASTM C 1107, Non-shrink Grout and requirements of this specification.

3. Certification product is suitable for use in contact with potable water.

G. Submit proof of certification for welders. Indicate certified procedures and position each welder is qualified to perform. Provide documentation of the most recent weld qualification test date and continuity of use in each process for which the welder or welding operator is required.

H. Submit certification showing calibration within last 12 months for equipment such as scales, measuring devices, and calibration tools used in manufacture of pipe. Each device used in manufacture of pipe is required to have tag recording date of last calibration. Devices are subject to inspection by Project Manager.

I. Submit manufacturer technical catalog.

1.06 QUALITY CONTROL

A. Manufacturer to have permanent quality control department and laboratory facility capable of performing inspection and testing required. Inspection procedures and manufacturing process are subject to inspection by Project Manager. Perform manufacturer tests and inspections required by AWWA C 301 as modified by these Specifications. Repair defects when as substandard welds, excessive radial offsets (misalignment), pitting, gouges, cracks, other nonconforming conditions.

1. Cylinder and Joint Ring Assembly:

a. Review mill certifications for conformance to requirements of Specifications.

b. Perform physical testing of each heat of steel for conformance to applicable ASTM standards.

c. Inspect physical dimensions and overall condition of joint rings and cylinder/joint ring assembly to verify compliance with requirements of AWWA C 301.

d. Test cylinder/joint ring weld for tensile strength. Test one specimen for each 500 cylinder/joint ring assemblies in addition to those tests required by AWWA C 301.

e. Reject dented steel cylinders.

2. Prestressing Wire:

a. Inspect wire spacing during wire placement on core.

b. Test wire splices for each production run or a minimum of once a week, whichever is less, for conformance with minimum strength criteria.

3. Pipe Cores and Coating:

a. Review mill certificates for each load of cement for conformance to ASTM C 150.

b. Perform sieve analysis weekly for each source of coarse and fine aggregate for conformance to ASTM C 33.

c. Inspect kiln recorder charts daily to confirm proper curing environment.

d. Prior to prestressing, inspect each core for voids, chips, cracks, deleterious surfaces and foreign matter.

e. Check mortar batch proportions, moisture content and slurry application rate. Check coating thickness over wire on each pipe.

f. Check physical integrity of cured mortar coating.

g. Reject pipe with cracks in mortar coating exceeding 0.01 inches wide.

4. Protective Coatings: Check daily application rate and resulting dry film thickness.

B. Gaskets: Randomly test rubber cord for diameter, tensile strength, elongation, compression set, hardness, and specific gravity after oven aging on one out of 100 gaskets.

C. Weld Testing:

1. Perform macroetching tests for complete -penetration production welds on normal production weld tests. Complete joint penetration welds are defined in ANSI/AWS A3.0. Verify complete joint penetration by means of macroetch of joint weld cross section. Macroetch technique in accordance with ASTM E 340.

2. Perform x-ray, ultrasonic, magnetic particle, or dye penetrant testing per AWWA C200 of manual welds on special pipe and fittings.

3. Perform minimum of one set of weld test specimens in accordance with ANSI/AWS A3.0 on each size, grade and wall thickness at minimum of every 3,000 feet of pipe manufactured. Perform no less than one test per project by each welding machine and each operator.

D. Cast four standard test cylinders each day for each 50 cubic yards of core concrete or mortar coating or portion thereof for each mix placed in day. Perform compressive strength test at 28 days. No cylinder test result shall be less than 80 percent of specified strength.

E. Make available copy of Physical and Chemical testing reports for steel cylinders and provide reports at request of Project Manager.

F. Check physical dimensions of pipe and fittings: Physical dimensions to include pipe lengths, pipe LD., pipe O.D. and bend angles.

PART 2 PRODUCTS

2.01 PRESTRESSED CONCRETE CYLINDER PIPE

A. Furnish all concrete pressure pipe by same manufacturer.

B. Provide prestressed concrete cylinder pipe in conformance with AWWA C 301, AWWA C 304 and AWWA M 9 except as modified in this Section. Use of pipe from inventory is permitted only if specifications and certifications are met. Provide testing records for pipe.

C. Do not use prestressed concrete cylinder pipe in aerial crossings, exposed or other unburied areas.

D. Pipe Manufacturer:

1. Must have minimum of 5 years of manufacturer's pipe installations that have been in successful and continuous service.

2. Must maintain on site or in plant minimum of four 22.5-degree bends per 10,000 linear feet of water line. Additionally, for 102" pipe and larger, four bevel adaptors must be maintained on site or in the plant. Any combination of bends may be substituted at manufacturer's option (i.e. two 11.25-degree bends are equivalent to one 22.5-degree bend and will be counted as one fitting). Must be capable of delivering bends or bevel adaptors to job site within 12 hours of notification. These fittings are in addition to fittings called out on Drawing and must be available at all times.

E. Pipe Design Conditions:

1. Working pressure: 150 psi.

2. Hydrostatic field test pressure: 150 psi.

3. Maximum pressure due to surge: 225 psi.

4. Minimum pressure due to surge: 5 psi.

5. Unit weight of soil: 120 pcf minimum, unless otherwise specified.

6. Minimum trench width: O.D. of pipe + four (4) feet.

7. Pipe and Fittings: Designed to withstand most critical simultaneous application of external loads including construction loads and internal pressures.

8. Design: Based on minimum of AASHTO HL-93 loading, AREMA Cooper E-80 loads when under railroads, and depths of bury as indicated. Design pipe with Marston's earth loads for transition width trench for all heights of cover.

a. Calculate moments and thrusts in wall based on height of earth load, live load, water weight, and pipe weight.

b. For earth load heights up to 16 feet, use bedding sand as bedding material and use 90-degree Olander coefficients for earth load, live load, and water weight contained in pipe along with 15-degree Olander coefficients for pipe weight.

c. For earth load heights 16 feet and greater, use cement stabilized sand as bedding material below springline of pipe, and use 150-degree Olander coefficients for earth load, live load, and water weight contained in pipe along with a 15-degree Olander coefficient for pipe weight.

9. Groundwater Level: Assume below pipe for pipe design. Assume equal to natural ground surface for other conditions.

10. Design pipe for transmitting potable water, unless otherwise shown on Drawings.

11. Manufacture pipe for adverse environmental conditions in accordance with Section 7.5.5 of AWWA C304.

12. Design pipe for buried conditions and kept empty for up to 365 days.

13. Tunnel and Augered Sections: Provide constant outside diameter from bell to spigot end for pipe. Exclude structural benefits associated with primary liner. Design pipe and pipe joints to carry loads including but not limited to: overburden and lateral earth pressures, subsurface soil, grouting, other conditions of service, thrust of jacks, and stress anticipated during handling and installation.

F. Coatings and Linings:

1. Provide Portland cement; ASTM C 150, Type I or II. Provide one type of cement for entire project.

2. Water Absorption Test: ASTM C 497, Method A; perform on samples of cured mortar coating taken from each working shift. Cure mortar coating samples in same manner as pipe.

a. Test Value: Average minimum of 3 samples taken from same working shift, no greater than 9 percent for average value, 10 percent for individual value.

b. Test Frequency: Perform tests each working shift until conformance to absorption requirements has been established by 10 consecutive passing test results, at which time testing may be performed weekly. Resume testing for each working shift when absorption test results fail until conformance to absorption requirements is reestablished by 10 consecutive passing test results.

3. Apply one coat of primer to exposed steel parts of steel bell and spigot rings. Prior to coating, blast clean in accordance with SSPC-SP7 (Brush Off Blast Cleaning). Apply primer in accordance with manufacturer's recommendations.

4. Coat and line access inlets, service outlets, test inlets and air release/vacuum relief riser pipe with same coating and lining of water line in accordance with AWWA C 301, Section 4, unless otherwise indicated on Drawings.

5. Do not exceed two hours between application of first and last course when cement mortar is applied in more than one course; otherwise, do not defer placing of coating of any portion of pipe length. Verify cement mortar coating thickness on each size of pipe by nondestructive method before removing pipe from coating machine.

6. Remove and replace disbonded lining or coating. Reject pipe requiring patches larger than 100 square inches or 12 inches in greatest dimension. Allow no more than one patch on either lining or coating of pipe. Provide WELD-CRETE Probond Epoxy Bonding Agent ET-150, parts A and B; Sikadur 32 Hi-Mod, or approved equal bonding agent for pipe patching.

G. Fittings and Specials:

1. Design fittings to same internal and external loads as straight pipe.

2. Manufacture in accordance with Section 02518 - Steel Pipe and Fittings for Large Diameter Water Lines.

3. Provide fabricated bends or fittings with minimum radius of 2-1/2 times pipe diameter.

4. Design test plugs to withstand forces generated by hydrostatic test and test pressure from either side. Do not exceed 50 percent of minimum yield for design stresses due to hydrostatic pressure. Assume opposite side of plug does not contain water.

5. Provide no specials less than 4 feet in length unless indicated on Drawings or approved by Project Manager.

6. Butt Straps for Closure Piece: Provide at locations indicated on Drawings or authorized by Project Manager. Minimum 12inch-wide split butt strap; minimum plate thickness equal to thinnest member being joined; fabricated from material equal in chemical and physical properties to thinnest member being joined. Permit no angular deflection or joint offset at butt-strap joints.

7. Provide minimum 6inch welded outlet for inspecting each closure section, unless access manway is within 40 feet of closure section.

8. Provide Denso petroleum based tape or approved equal for exposed portions of nuts and bolts.

H. Joints:

1. AWWA C 301 rubber-gasketed or welded bell-and-spigot type except where flanged joints are required for valves and fittings as shown on Drawings. Refer to Section 02511 - Water Lines for details on joints and jointing.

2. Rubber-Gasketed Joints: Single weld bell and spigot ring onto steel cylinder. In thrust areas, double weld bell-and-spigot onto steel cylinder. Bond as shown on Drawings to provide electrical continuity along entire pipeline.

3. Restrained Joints: Restrain joints by welding or harnessing joints.

   a. Design Pressure: 1.5 times working pressure.

   b. Harnessed Joints: AWWA M 9, clamp or snap ring type, except where prohibited. Limit maximum size of snap ring joints to 30-inch diameter pipe.

   c. Groundwater Level: Assumed to be equal to natural ground surface.

   d. Provide restrained joint pipe with adequate cylinder thickness to transmit full thrust generated by internal pressure across joints.

      (1) Calculate distance of restrained joints based on resistance along each leg of bend with thrust based on bend angle.

      (2) Calculate cylinder thickness not to be less than that defined in following table:

Inside Diameter (inches)	Cylinder Thickness
Greater than 120	0.25 inch
102 to 120	4 gauge
90 to 96	6 gauge
72 to 84	8 gauge
48 to 66	10 gauge
Less than 48	12 gauge

      (3) Allow cylinder thickness to reduce linearly from maximum calculated thickness or from minimum cylinder thickness (as determined in Paragraph 2.01 H.3.d.1, whichever controls, to minimum thickness required by design over required length (as determined in Paragraph 2.01 H.3.d.1) of restrained joints.

4. Use only fully circumferentially welded joints in areas considered potentially petroleum contaminated, within tunnels and under foreign pipelines. Perform welding in accordance with Section 02511 – Water Lines.

5. Pipe Flanges: AWWA C 207 for standard steel flanges of pressure class corresponding to pipe class.

I. Pipe Lengths: Provide pipe sections in standard lengths with minimum length of 16 feet and maximum length of 25 feet, and as indicated on approved shop Drawings or approved by Project Manager. Gasketed joints are allowed on standard lengths of pipe. Non-standard pipe lengths must be approved by Project Manager and joints must be welded as specified herein to achieve equal to or greater than standard pipe length before gasketed joints can be used. Internally and externally mark pipe section with durable marking to show location and pipe pressure.

J. Hydrostatic Test of Cylinder: AWWA C 301, Section 4.6.4.3, at point of manufacture. Hold test for minimum 2 minutes for thorough inspection of cylinder. Repair or reject cylinders revealing leaks or cracks.

K. Transport fittings 42 inches in diameter and larger with end caps and stulls. Remove end caps just prior to installation. Remove stulls after completion of backfill operation.

L. Provide radius of curve as indicated on Drawings unless approved by Project Manager. Make curves and bends by deflecting joints, by use of beveled joints, or by combination of two methods, unless otherwise indicated on Drawings. Do not exceed deflection or joint offset angle recommended by pipe manufacturer. Provide beveled pipe sections of standard length used in curved alignment, except when shorter sections are required to limit radius of curvature. In such case, provide sections throughout curve of substantially equal length. When manufacturing straight pipe sections, manual welding is allowed for following:

1. Tack welding of coils and plates during continuous pipe making process.

2. Rewelding and repairing structural defects in plate and automatic machine welds.

3. Attaching new coil of steel to previous coil.

M. Prior to arrival on project site, identify pipe sections within limits of thrust restraint with permanent, brightly colored, and highly visible markings on outer pipe coating as approved by Project Manager.

2.02 PRESTRESSING WIRE

A. General:

1. Conform to requirement of ASTM A 648, AWWA C 301 and this specification.

2. Furnish test results from independent manufacturer (i.e., manufacturer with no legal or financial ties to pipe manufacturer). Tests must have been performed within 12 months prior to submittal or when supplier changes.

3. Test foreign manufactured wire by local independent laboratory.

4. Prestressing wire surface temperature: not more than 360 degrees at any point in drawing process. Audit surface temperature of wire throughout length of wire drawing process daily for each working shift producing ASTM A 648 wire.

5. Do not use wire with visible pitting or rust that cannot be wiped off.

6. Do not use wire that fails, for no observable mechanical reason other than tension force, during circumferential wrap. Do not splice, but reject this section of wire.

B. Perform mechanical tests per AWWA C301 - Steel Reinforcement except as modified below:

1. Retest coil for which failed torsion test sample has radial, spiral (that is, longitudinal) split visible to unaided eye or evidenced by abrupt offset in wire surface detectable with fingernail.

2. Test sample, for mechanical requirements, from 1 of each 10 consecutively produced coils or fraction thereof in each lot. Pipe manufacturer to establish procedures so samples are randomly selected from entire length of wire coils.

C. Perform hydrogen embrittlement sensitivity testing on samples of prestressing wire in accordance with ASTM A648 and A1032. Test one set of pre-qualified samples for each anticipated wire manufacturing source anticipated by pipe manufacturer for project. Perform tension, wrapping, and torsion on wire samples. Perform pre-qualification testing prior to pipe manufacturing and for each source of supply for wire. Do not use wire failing to conform to test requirements of specification. Acceptance criteria are according to ASTM A648, S1, and AWWA C301, 4.4.8.1. Utilize only wire that meets both of following:

1. Passed aforementioned test.

2. Manufactured from same source and manufacturing procedures.

2.03 GROUT FOR JOINTS AND SPECIAL APPLICATION

A. Joint Grout:

1. Cement Grout Mixture: One part cement to two parts of fine, sharp clean sand. Mix interior joint mortar with as little water as possible until very stiff but workable. Mix exterior joint mortar with water until it has consistency of thick cream.

2. Water: Potable water with total dissolved solids less than 1000 mg/1; ASTM D 512 chloride ions less than 100 mg/1 for slurry and mortar cure; ASTM D 1293 pH greater than 6.5. Use potable water with 250 ppm limit on chlorides and sulfates.

3. Portland Cement: ASTM C 150, Type I or II. Provide one type of cement for entire project.

4. Sand:

   a. Interior joints: ASTM C 35 fine graded plaster sand.

   b. Exterior joints: ASTM C 33 natural sand with 100 percent passing No. 16 sieve.

5. Mix cement grout to specific gravity of 19 lb/gallon or greater as measured by grout/slurry balance. Use balance manufactured grout/slurry by Baroid or approved equal. Perform test in presence of and at request of Project Manager. Add additional cement grout or water to mixed cement grout to bring mix to proper moisture content or specific gravity. Discard cement grout that has been mixed more than 20 minutes and is not at proper specific gravity or moisture content.

B. Provide approved Non-shrink Grout for Special Applications, Patches and Repairs.

1. Conform to requirements of ASTM C 1107, Non-shrink Grout.

2. Pre-blended factory-packaged material manufactured under rigid quality control.

3. Contain non-metallic natural aggregate, be non-staining and non-corrosive.

4. Meeting NSF 61 Standard suitable for use in contact with potable water supply.

5. Exterior: Highly flowable to fill joint wrapper without leaving voids or trapped air. Interior capable of being placed with plastic consistency.

6. Non-bleeding and non-segregating at fluid consistency.

7. Contain no chlorides or additives which may contribute to corrosion of prestressed concrete cylinder pipe.

8. Free of gas-producing, gas-releasing agents.

9. Resist attack by oil or water.

10. Mix, place, and cure in accordance with manufacturer's recommendations. Upon 72 hours notice, provide services of qualified representative of non-shrink grout manufacturer to aid in use of product under job conditions.

11. Mix non-shrink grout to specific gravity of 17.7 lb/gallon or greater as measured by grout/slurry balance. Use grout/slurry balance manufactured by Baroid or approved equal. Perform test in presence of and at request of Project Manager. Add additional cement grout or water to bring mix to proper moisture content or specific gravity. Discard grout that has been mixed more than 20 minutes and is not at proper specific gravity or moisture content.

12. Compressive strength: ASTM C 1107 2500 psi minimum 7-day unconfined; 5000 psi minimum 28-day unconfined.

C. Finished surface of lining and interior joint to be comparable to surface rubbed with No. 16 carborundum stone. Rub joint mortar sufficiently to bring paste to surface, to remove depressions and projections, and to produce smooth, dense surface. Add cement to form surface paste as necessary. Leave interior with clean, neat and uniform-appearing finish.

D. Joint Wrapper: Minimum width of 9 inches for 33-inch diameter and smaller; minimum width of 12 inches for diameters greater than 33-inch hemmed at edge to allow threading with minimum 5/8-inch-wide steel strap. Provide minimum 6-inch-wide wire Ethafoam strip sized, positioned, and sewn circumferential in center of wrapper.

2.04 CATHODIC PROTECTION

A. Connect each joint of pipe with bonding straps or approved devices to maintain continuity of current. Provide bonding straps free of foreign material.

B. Electrically isolate water line from other connections. Use insulating type joints or nonmetallic pipe unless otherwise indicated on Drawings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Conform to requirements of Section 02511 - Water Lines. Do not install pipe without approved lay schedule.

B. Manufacturer will make available services of representative, throughout project duration when deemed necessary by Project Manager, to advise aspects of installation including but not limited to handling, storing, cleaning and inspecting, coatings and linings repairs, and general construction methods affecting pipe.

C. Bedding and Backfilling:

1. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

2. Align pipe at proper grade prior to joint connection and do not shift after jointing operation has been completed.

3. Do not move trench support system (trench safety system) once bedding material is compacted.

4. Excavate outside specified trench section for bell holes, and for spaces sufficient to permit removal of slings. Provide bell holes at proper locations for unrestricted access to joint. Form bell holes large enough to facilitate joint wrapping and to permit visual examination of process. Enlargement of bell holes as required or directed by Project Manager. Subsequent backfilling thereof will not be considered as authorized additional excavation and backfill. Backfill bell holes and spaces to satisfaction of Project Manager.

5. Remove blocking after placing sufficient backfill to hold pipe in position.

6. Use cement-stabilized sand in areas of trench excavation 16 feet and greater, as bedding material up to springline of pipe.

D. Follow non-shrink grout manufacturer's specifications for non-shrink grouting.

E. Install each pipe section in sequence identified on lay schedule. Deviations from lay schedule sequence shall be approved by Project Manager and denoted on final lay schedule.

F. Use adequate surveying methods, procedures and employ competent surveying personnel to ensure pipe sections are laid to line and grade and within stipulated tolerances. Measure and record, in form approved by Project Manager, in-place survey data for pipe laid each day and submit copy of data to Project Manager at end of that day. Survey data to include unique pipe number, deflection or joint offset angle at pipe joint and whether beveled ends were used, invert elevation at pipe joint, deviation of joint from project line, deviation of joint from project grade, inside pipe joint lap measured at top, bottom, and at springline (each side).

G. Static Electricity:

1. Properly ground steel pipeline during construction as necessary to prevent build-up of static electricity.

2. Electrically test where required after installation of pipeline is complete.

3.02 CLOSURES AND APPROVED PIPE MODIFICATIONS

A. No modifications of standard pipe for closures will be permitted in field. No field cutting of pipe or exposure of prestressed wire is permitted without written approval from Project Manager.

B. Pipe manufacturer's representative and Project Manager to entirely witness closures and approved pipe modification efforts.

C. Provide minimum lap of 4 inches between member being joined and edge of butt strap. Weld on both interior and exterior, unless otherwise approved by Project Manager.

D. Provide full circumferential welds on joints required to be welded. Employ independent certified testing laboratory, approved by Project Manager, to perform weld tests on field welds. Include cost of testing in contract unit price for water line. Use magnetic particle test method for lap welds or X-ray methods for butt welds, for 100 percent of joint welds. Maintain records of tests. When defective weld is revealed, repair defective weld, and retest. Use wire and flux from same manufacturer throughout entire project.

E. Fill wrapper in field and allow excess grout water to seep out. Refill wrapper as necessary. When joint mortar level has stabilized and begun to mechanically stiffen, lap Ethafoam wrapper over top of joint, and secure in place.

F. Stretch test each gasket splice to twice its unstretched length and inspect for defects.

3.03 VISIBLE CRACKS

A. No visible cracks longer than 6 inches, measured to be within 15 degrees of line parallel to pipe longitudinal axis, are permitted except:

1. In surface laitance of centrifugally cast concrete,

2. In sections of pipe with steel reinforcing collars or wrappers, or

3. Within 12 inches of pipe ends.

B. Repair interior lining cracks that exceed 1/16-inch (0.0625 inches) wide.

C. Reject pipe with exterior coating cracks that exceed 0.01 inches wide.

D. Immediately remove pipe from site when pipe has cracks exceeding limitations and cracks are not repairable.

3.04 FIELD REPAIR PROCEDURES FOR COATING/LINING

A. Areas less than or equal to 6 inches in diameter: Patch honeycomb and minor defects in concrete surfaces with non-shrink grout conforming to section 2.03 B. Use only manual or small (low pressure) air chisels to chip away mortar coating or lining. Cut out unsatisfactory material and replace with non-shrink grout, securely bonded to existing coating or lining. Finish junctures between patches and existing concrete as inconspicuous as possible. Strike off non-shrink grout flush with surrounding surface after patch has stiffened sufficiently to allow for greatest portion of shrinkage. Finish surface in accordance with lining requirements.

B. Pipe with defective coating areas greater than 6 inches in diameter cannot be used. Immediately remove pipe from project.

C. Reject pipe when steel cylinder is dented while making field repair. Immediately remove pipe from project.

END OF SECTION

SECTION 02508

EXTRA STRENGTH CLAY PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Extra strength vitrified clay pipe for direct burial.

B. Vitrified clay pipe for jacking and microtunneling.

1.02 REALTED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02441 – Microtunneling

D. Section 02445 – Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels

E. Section 02531 – Gravity Sanitary Sewers

F. Section 02533 – Acceptance Testing for Sanitary Sewers

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for extra strength vitrified clay pipe under this section. Include cost in unit price work, as specified in the following sections:

a. Section 02441 - Microtunneling

b. Section 02445 - Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels.

c. Section 02531 - Gravity Sanitary Sewers.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 REFERENCES

A. ASTM C 12 – Standard Practice for Installing Vitrified Clay Pipe Lines.

B. ASTM C 301 – Standard Test Methods for Vitrified Clay Pipe.

C. ASTM C 425 – Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.

D. ASTM C 700 – Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.

E. ASTM C 828 – Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines.

F. ASTM C 1091 - Standard Test Method for Hydrostatic Infiltration Testing of Vitrified Clay Pipe Lines.

G. ASTM C 1208 - Standard Specification for Vitrified Clay Pipe and Joints for Use in Microtunneling, Sliplining, Pipe Bursting, and Tunnels.

H. ASTM D 1784 - Standard Classification System and Basis for Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

I. National Clay Pipe Institute (NCPI) – Vitrified Clay Pipe Engineering Manual.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit complete product data for pipe, fittings, gaskets and couplings for approval. Indicate conformance to appropriate reference standards.

C. Submit certificates by a testing laboratory, hired and paid by the manufacturer, that clay pipes meet applicable standards when tested in accordance with ASTM C 301.

D. Submit manufacturer technical catalog.

PART 2 PRODUCTS

2.01 VITRIFIED CLAY PIPE

A. Vitrified clay pipe for direct burial shall conform to ASTM C 700 requirements for extra strength clay pipe.

B. Approved manufacturers of extra strength clay pipe are:

1. Mission Clay Products Corporation

2. Dickey Company.

2.02 JOINTS

A. Joints for extra strength vitrified clay shall conform to ASTM C 425.

1. For clay pipe 21 inches in diameter and larger, conform to requirements for compression joints for bell-and-spigot pipe.

2. For clay pipe 18 inches in diameter and smaller, conform to requirements for compression couplings for plain-end pipe.

B. Joints for jacking, sliplining, and microtunneling pipe shall conform to ASTM C 1208.

2.03 GASKETS

A. When no contaminant is identified, furnish rubber or polyurethane elastomer gasket material conforming to standards listed above.

B. Pipe to be installed in potentially contaminated areas, especially where free product is found near the elevation of the proposed sewer, shall have the following gasket material for the noted contaminants:

CONTAMINANT	GASKET MATERIAL REQUIRED
Petroleum (diesel, gasoline)	Nitrile Rubber
Other contaminants	As recommended by the pipe manufacturer, Engineer of the Record and approved by City Engineer prior to installation

2.04 COMPRESSION COUPLINGS

A. The PVC collar material for compression couplings of plain-end pipe shall conform to requirements of ASTM D 1784, Class 12454-B.

B. Couplings for microtunneling and other pipe jacking methods shall be made with Type 316 stainless steel sleeve couplings that utilize elastomeric sealing gaskets as the sole means to maintain joint watertightness. The joints shall have the same outside diameter as the pipe so when the pipes are assembled, the joints are flush with the pipe outside surface.

PART 3 EXECUTION

3.01 INSTALLATION

A. Conform to installation requirements of:

1. Section 02531 - Gravity Sanitary Sewers; and

2. Section 02441 - Microtunneling or Section 02445 - Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels

B. Install pipe in accordance with ASTM C 12, the NCPI Vitrified Clay Pipe Engineering Manual, and manufacturer's recommendations.

3.02 ACCEPTANCE TESTING

A. Perform acceptance testing in accordance with Section 02533 - Acceptance Testing for Sanitary Sewer, and ASTM C 1091. Do not use procedures from ASTM C 828 unless authorized by Project Manager.

3.03 FIELD QUALITY CONTROL

A. The City may run tests on field samples following applicable ASTM standards at an independent laboratory to verify the required physical properties and characteristics of supplied materials. Provide product samples as requested by Project Manager.

END OF SECTION

SECTION 02509

FIBERGLASS REINFORCED PIPE FOR PRESSURE MAINS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Fiber Reinforced Pipe for buried water lines up to 30 inches in diameter, unless otherwise approved by Project Manager.

B. Fiber Reinforced Pipe for buried sanitary sewer force mains up to 16 inches in diameter, unless otherwise approved by Project Manager.

1.02 RELATED SECTIONS

A. Section 01270 - Measurement and Payment

B. Section 01330 - Submittal Procedures

C. Section 02317 - Excavation and Backfill for Utilities

D. Section 02441 – Microtunneling

E. Section 02445 - Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels

F. Section 02465 - Drilled Shaft Foundations

G. Section 02501 - Ductile Iron Pipe and Fittings

H. Section 02502 - Steel Pipe and Fittings

I. Section 02511 - Water Lines

J. Section 02514 - Disinfection of Water Lines

K. Section 02515 - Hydrostatic Testing of Pipelines

L. Section 02518 - Steel Pipe and Fittings for Large Diameter Water Lines

M. Section 02532 - Sanitary Sewer Force Mains

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for fiberglass pipe under this Section. Include cost in unit price for Work, as specified in Section 02511 - Water Lines and Section 02532 - Sanitary Sewer Force Mains.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 REFERENCES

A. AASHTO - Standard Specifications for Highway Bridges.

B. AREMA - Manual of Railway Engineering, Volume B, Chapter 15.

C. ASTM D696 - Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between −30°C and 30°C with a Vitreous Silica Dilatometer.

D. ASTM D 2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.

E. ASTM D 2992 – Standard Practice of Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass- Fiber-Reinforced-Thermosetting-Resin) Pipe and Fittings.

F. ASTM D 2996 - Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.

G. ASTM D 3262 - Standard Specification for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe.

H. ASTM D 3681 - Standard Test Method for Chemical Resistance of “Fiberglass” (Glass-Fiber- Reinforced Thermosetting-Resin) Pipe in a Deflected Condition.

I. ASTM D 3754 - Standard Specification for “Fiberglass” (Glass-Fiber Reinforced Thermosetting-Resin) Sewer and Industrial Pressure Pipe.

J. ASTM D 4161 - Standard Specification for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals.

K. ASTM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

L. AWWA C 950 – Fiberglass Pressure Pipe.

M. AWWA M 45 – Fiberglass Pipe Design.

N. ISO 14692 – Petroleum and Natural Gas Industries – Glass-Reinforced Plastics (GRP) Piping.

O. NSF/ANSI 61 - Drinking Water System Components - Health Effects.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Provide sufficient data for the Project Manager to properly evaluate the pipe.

C. Product data submittals shall include the following, as a minimum:

1. Details of the proposed pipe.

2. Properties and strengths of the pipe.

3. Details of pipe joint.

4. Pipe design analysis and thrust restraint calculations in accordance with AWWA M45 – Fiberglass Pipe Design, latest edition.

5. Instruction on storage, handling, transporting, and installation.

6. Standard catalog sheets.

D. Test Reports: Provide test reports upon request, certifying that the pipe has been tested in accordance with and exceeds minimum requirements of ASTM D 2412, ASTM D 2992 (if applicable), D 3262 and ASTM D 3681.

E. Certification from manufacturer that fiberglass pipe was hydrostatically tested at factory in accordance with AWWA C 950 and requirements of this section.

1. Hydrostatic Test Pressure: 150 psi

2. Test Duration: Two (2) minutes

F. An affidavit of compliance stating that all delivered materials comply with the requirements of these specifications as well as compliance with AWWA C950.

G. For pressure mains 24inches in diameter and larger, shop drawings signed and sealed by Professional Engineer registered in State of Texas showing:

1. Manufacturer's pipe design calculations including thrust restraint design.

2. Details of pictorial nature of critical features and specials indicating alignment and grade, laying dimensions, fabrication, fitting, flange, and fully dimensioned details, with plan view detailing pipe invert elevations, bends, and other critical features. Indicate station numbers for fittings corresponding to Drawings. Do not start production of pipe and fittings prior to review and approval by Project Manager. Provide final approved lay schedule on CD-ROM in Adobe Portable Document Format (*.PDF).

3. Certification from manufacturer that design was performed for project in accordance with requirements of this section. Certification to be signed and sealed by Professional Engineer registered in State of Texas.

H. Submit manufacturer technical catalog.

1.06 QUALITY CONTROL

A. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as required by Specifications. Material testing, inspection procedures, and manufacturing process are subject to inspection by Project Manager. Perform manufacturer's tests and inspections required by referenced standards and these Specifications.

B. Calibrate within last 12 months equipment such as scales, measuring devices, and other calibration tools used in manufacture of pipe. Affix tag recording date of last calibration on each device used in manufacture of pipe.

1.07 TESTING

A. Joints: Coupling joints shall be qualified per the tests of Section 7 of ASTM D 4161.

B. Provide pipes tested in accordance with AWWA C950 and ASTM D 3754 as applicable.

C. Hydrostatic Testing: AWWA C950, Section 5.1.2.1.1, at point of manufacture. Hold test for minimum 2 minutes for thorough inspection of pipe. Reject pipe revealing leaks or cracks.

PART 2 PRODUCTS

2.01 FIBERGLASS PIPE

A. Manufacture pipe by filament winding process to result in a dense, nonporous, corrosion- resistant, consistent composite structure to meet the operating conditions as shown on the Drawings.

1. Do not use stiffening ribs or rings.

2. The workmanship of the pipe shall be free of defects such as delaminations, indentations, pinholes, bubbles, cracks, pits, blisters, foreign inclusions, and resin- reduced areas. Reasons for these defects free workmanship is because of the serviceability and strength of the pipe could be compromised.

3. The pipe must be as uniform as commercially practicable in opacity, color, density as well as other physical properties.

4. Centrifugally cast fiberglass pipe may be used in lieu of filament-wound for pressure pipe with approval of Project Manager, however, this substitution will not be approved for water lines.

B. Furnish pipes in the diameters specified and within the tolerances specified below.

1. Tolerances:

a. Sanitary Sewer Force Mains: Diameter tolerances in accordance with AWWA C950.

b. Water Mains: Diameter tolerances in accordance with AWWA C950 for diameters up to 30 inches.

C. Lengths: Supply at least 90 percent of total footage of each size and class of pipe, excluding special order pipes in nominal lengths of 20 feet unless approved by Project Manager. No nominal lengths of less than four (4) feet may be used.

D. Wall Thickness: Provide minimum average wall thickness of stated design thickness. Provide minimum single point thickness not be less than 98 percent of stated design thickness for sanitary sewer applications and not less than 100 percent for water mains.

E. End Squareness: Provide pipe ends square to pipe axis with maximum tolerance of 1/8 inch.

F. Refer to list of Approved Products for acceptable manufacturers.

2.02 DESIGN CRITERIA

A. Design fiberglass pressure pipe according to AWWA Manual M 45 – Fiberglass Pipe Design, latest edition.

B. Sanitary Sewer Force Mains:

1. Provide minimum 150 psi Pressure Class. Stiffness class of FRP pipe shall satisfy design requirements, but shall not be less than 46 psi, when used in direct bury operation; 36 psi, when installed within a primary tunnel liner.

2. Pipe for Jacking: Govern stiffness class of FRP in a pipe jacking operation by either ring deflection or by a pipe design providing longitudinal strength required by the jacking method and shall satisfy design requirements stated below. Submit design calculations as required in Paragraph 1.05, Submittals.

a. Perform pipe stress calculations based on jacking loads to conform to Section 02441 - Microtunneling or Section 02445 - Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels

3. Calculate pipe deflection to ensure that predicted deflection will be less than 5 percent under long-term loading conditions (soil prism load) for the highest density of soil overburden and surcharge loads. Prepare deflection on calculations using long-term (drained) values for soil parameters contained in the geotechnical investigation report for the Project, or other site-specific data

4. Provide dual-angle, filament-wound fiberglass reinforced epoxy pipe with integral epoxy liner and exterior coating in sizes from 4inchs to 16inchs diameter. Conform to requirements of ASTM D 2996, depending on size and class of pipe required.

5. Hydrostatic design value shall be not less than 21,000 psi when tested in accordance with ASTM D 2992(B) and not less than 8000 psi when tested according to ASTM D 2992(A).

6. Burial depths for pipes with standard wall thickness shall be between 3 feet and 25 feet.

7. Joints: Heavy duty threaded coupling system with positive O-ring seals. For 4inches through 6inches diameters, provide mechanical joints with fast advance, acme-type threads. Male threaded portion of couplings shall lock the mechanical joints for couplings for pipe diameters of 8 inches through 16 inches. Axial movement of couplings shall allow up to 2 degrees of angular deflection without affecting O-ring seal integrity.

8. Pipes, fittings, and other components in this system shall be rated for service to 150 psig at 120 degrees F. Components shall be rated at or above design pressure of system.

C. Water Lines. At minimum, provide 150 psi Pressure Class and 46 psi Stiffness Class. Manufacturer to provide calculations in accordance with AWWA M 45 to determine the appropriate pressure class and stiffness class to withstand actual installation conditions, based on the following Design Criteria:

1. Working Pressure: 150 psi.

2. Hydrostatic Field Test Pressure: 150 psi.

3. Maximum Pressure Due to Surge: 225 psi.

4. Minimum Pressure Due to Surge: -10 psi

5. Unit Weight of Soil: 120 pcf.

6. Bedding constant (K) = 0.1.

7. Deflection lag factor (Dl) = 1.3

8. Minimum Trench Width: O.D. of pipe + four (4) feet.

9. Maximum allowable long term deflection not to exceed 5 percent of original pipe diameter.

10. Design:

a. Design to withstand most critical simultaneous application of external loads including construction loads and internal pressures.

b. Base on minimum of AASHTO HL-25 loading, AREMA Cooper E-80 loads when under railroads, and depths of bury as indicated.

c. Calculate earth loads and thrusts for restrained (tied) joints based on AWWA M45.

d. Groundwater Level: Assume groundwater elevation at ground surface.

e. Design pipe for buried conditions.

D. Tunnel and Augered Sections: Exclude structural benefits associated with primary liner. Design pipe and pipe joints to carry loads including but not limited to: Overburden and lateral earth pressures, subsurface soil, grouting, other conditions of service, thrust of jacks, and stress anticipated during handling and installation. Do not create grout holes with pipe.

2.03 MATERIALS

A. Resin Systems: The manufacturer shall use only polyester resin systems with a proven history of performance in this particular application. The historical data shall have been collected from applications of a composite material of similar construction and composition as the proposed product.

B. Glass Reinforcements: The reinforcing glass fibers used to manufacture the components shall be of highest quality commercial grade glass filaments with binder and sizing compatible with impregnating resins.

C. Fillers: Silica sand or other suitable materials may be used.

D. Additives: Resin additives, such as pigments, dyes, curing agents, thixotropic agents, and other coloring agents, if used, shall in no way be detrimental to the performance of the product nor impair visual inspection of the finished products.

E. Internal Liner Resin:

1. Water Lines: Manufacture using materials meeting NSF 61. Any material used within the pipe must comply with requirements of the Safe Drinking Water Act and other federal requirements. If transporting potable water, fiberglass pipe must be evaluated and certified for this specific use. The mark or seal of the laboratory that is responsible for evaluating the pipe must be included on the pipe.

2. Sanitary Sewer Force Mains: Fiberglass pipe shall have resin-rich liner of following thickness:

a. For nominal sizes 4 inches through 6 inches, conform to ASTM D 2996 RTRP 11CX 5430, with minimum liner thickness of 0.020 inch.

b. For nominal sizes 8 inches through 16 inches, conform to ASTM D 2996 RTRP 11FX 3210, with minimum liner thickness of 0.025 inch.

c. The coefficient of linear thermal expansion shall be 8.5 x 10-6 inch/inch/degrees F for 4-inch through 6-inch pipe and 12.0 x 16-6 inch/inch/degrees F for 8-inch through 16-inch pipe in accordance with ASTM D 696.

2.04 JOINTS

A. Gasketed Joints: Unless otherwise specified, field connect pipe with fiberglass sleeve couplings or confined o-ring bell-and-spigot joints that utilize elastomeric sealing gaskets as sole means to maintain joint water tightness. Joints shall meet performance requirements of ASTM D 4161.

1. Supply rubber gaskets from an approved gasket manufacturer in accordance with ASTM F 477, when no contaminant is identified and suitable for the service intended. Affix gaskets to pipe by means of a suitable adhesive, or install in such a manner so as to prevent the gasket from rolling out of the pre-cut groove in the pipe or sleeve coupling.

2. When pipe is to be installed in potentially contaminated areas, provide the following gasket materials for the noted contaminants.

CONTAMINANT	GASKET MATERIAL REQUIRED
Petroleum (diesel, gasoline)	Nitrile Rubber (for sanitary sewers) Viton (FKM) (for water lines)
Other Contaminants	As recommended by the pipe manufacturer

3. If required gasket material is not available for use, pipe other than fiberglass pipe must be used in potentially contaminated areas.

B. Restrained Joints: Utilize locking or butt-and-wrap (laminated) joints capable of withstanding internal pressure and longitudinal tensile loads.

1. Design restrained joint pipe using the allowable stress for combined biaxial loading determined in accordance with the trapezoidal design envelope design procedure of ISO 14692, latest edition. Provide test results or other verification of joint and thrust pipe design for approval by Project Manager with submittal of pipeline layout drawings.

2. Provide butt-and-wrap joints where restrained joints are called out on 66-inch diameter and larger.

3. Butt-and-Wrap Joints: Provide fiberglass reinforced overlay build up of minimum dimensions of 4 inches by 6 inches around circumference joints located at thrust source and sections of pipe located within thrust restraint limits.

4. Biaxial Lock Joint: Joints shall consist of plastic bar(s) inserted into circumferential void(s) around rubber gasket joint. Circumferential void is formed by matching recessed grooves on bell and spigot. Bar(s) shall fill void, forming an interference fit with bell and spigot to prevent joint from separating. Joint water-tightness is provided by joint gasket.

5. If centrifugally cast fiberglass pipe is provided with approval from Project Manager, and approved restrained joints are not available, provide external thrust restraint system in accordance with Paragraph 3.02 – External Thrust Restraints.

2.05 FITTINGS

A. Provide fittings for water mains capable of withstanding specified test pressures.

1. Outlets and Tees. Provide fiberglass pipe, ductile iron, or steel pipe when branch is less than 20 percent of diameter of main pipe and less than or equal to 8 inches diameter. Attach by glass reinforced overlays as approved by Project Manager.

2. Provide ductile iron or steel pipe bends and outlets or tees greater than eight (8) inches in diameter or which are greater than 20 percent of diameter of main pipe.

a. Use same materials (ductile iron or steel) throughout entire project.

b. Conform to Section 02518 - Steel Pipe and Fittings for Large Diameter Water Lines or Section 02501 - Ductile Iron Pipe and Fittings for other fittings and bends.

B. Provide fittings for force mains capable of withstanding specified test pressures.

1. Outlets and Tees. Provide fiberglass pipe or ductile iron pipe when branch is less than 20 percent of diameter of main pipe and less than or equal to 8-inch diameter. Attach by glass reinforced overlays as approved by Project Manager.

2. Provide ductile iron pipe bends and outlets or tees greater than eight (8) inches in diameter or which are greater than 20 percent of diameter of main pipe.

a. Use same materials (ductile iron) throughout entire project.

b. Conform to Section 02501 - Ductile Iron Pipe and Fittings for other fittings and bends.

C. Fiberglass Pipe Fittings. Created by filament-winding or cut and miter process as described in AWWA M 45.

1. Provide tolerance of angle of elbow and angle between main and leg of wye or tee to plus or minus 2 degrees. Provide tolerance on laying length of fitting to plus or minus 2 inches.

2.06 INSPECTION

A. The Project Manager shall be entitled to inspect pipes or witness the pipe manufacturing. Such inspection shall not relieve the manufacturer of the responsibilities to provide products that comply with the applicable standards and these Specifications.

B. Manufacturer's Notification: Should the Project Manager wish to see specific pipes during any phase of the manufacturing process, the manufacturer must provide the Project Manager with adequate advance notice of when and where the production of those pipes will take place.

C. Failure to Inspect: Should the Project Manager elect not to inspect the manufacturing, testing, or finished pipes, it in no way implies approval of products or tests.

2.07 PACKAGING, HANDLING, AND SHIPPING

A. Packing, handling, and shipping should be done in accordance with the manufacturer's recommendations.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install pipe and fittings in accordance with requirements of Section 02511 – Water Lines or 02532 - Sanitary Sewer Force Mains.

B. The manufacturer must supply a suitable qualified field service representative to be present periodically during the installation of pipe.

C. Pipe Bedding: Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

D. Pipe Handling: Use textile slings.

E. Jointing:

1. Clean ends of pipe and coupling components.

2. Check pipe ends and couplings for damage. Correct any damage found.

3. Coupling grooves must be completely free of dirt.

4. Apply joint lubricant to pipe ends and rubber seals of coupling. Use only lubricants approved by the pipe manufacturer.

5. Use suitable auxiliary equipment, such as a wire rope puller, to pull joints together.

6. Do not exceed forces recommended by the manufacturer for coupling pipe. If excessive force is required, remove coupling, determine source of problem, and correct it.

7. In the process of jointing the pipe, do not allow the deflection angle to exceed the deflection permitted by the manufacturer.

F. If pressure grouting of the pipe is conducted as part of a pipe-jacked tunnel installation, seal the grout holes with liner resin to a thickness equal to the pipe liner thickness or with a threaded plug for that purpose.

G. Tests:

1. Water Lines: Conform to requirements of Section 02514 – Disinfection of Water Lines and Section 02515 – Hydrostatic Testing of Pipelines.

2. Sanitary Sewer Force Mains: Conform to requirements of Section 02532 – Sanitary Sewer Force Mains.

3.02 EXTERNAL THRUST RESTRAINT

A. In areas of thrust restraint not using an approved restrained joint, such as with centrifugally cast fiberglass pipe, use one of three methods below. Submit system for approval by Project Manager.

1. Encased Design: For areas with restrained joint length of less than 20 feet from thrust source.

a. Provide thrust coupling as specified herein.

b. Use reinforced concrete to encase bend and pipe within area of thrust restraint. Encasement shall be of enough strength to accept 125% of designed pipe thrust.

c. Last four inches on both ends of encasement of fiberglass pipe shall be faced with minimum 1/4 inch thick rubber padding.

d. Locate sleeve coupling outside encased area.

2. H-Pile Design: System design and construction to conform to Section 02465 - Drilled Shaft Foundation and to be signed and sealed by Professional Engineer in State of Texas.

a. Provide thrust coupling as specified herein.

b. Use concrete pipe support to support entire bend. Pipe supports shall have cradle with minimum 120 degree support arc. Support arcs shall be faced with minimum 1/4 inch thick rubber padding.

c. Unless otherwise approved by Project Manager, install driven H-piles, with minimum of twelve (12) piles per individual support [three (3) piles on pipe cross-section axis by four (4) piles on pipe flow axis configuration] under concrete pipe support. Piles shall be of enough strength and depth to accept 125% of designed pipe thrust through shear resistance.

d. Anchor bends to pipe support in manner to prevent over stressing fiberglass reinforced pipe.

3. Use ductile iron or steel for fittings and pipe in thrust area, in accordance with requirements in Section 02501 - Ductile Iron Pipe and Fittings, Section 02502 - Steel Pipe and Fittings, and Section 02511 - Water Lines. Join fiberglass reinforced pipe to steel or ductile iron pipe outside of thrust area using fiberglass pipe manufacturer recommendation.

END OF SECTION

SECTION 02510

POLYPROPYLENE (PP) CORRUGATED WALL PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Polypropylene (PP) pipe for gravity sanitary sewers and drains, including fittings.

B. Polypropylene (PP) pipe for gravity storm sewers and culverts.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02531 – Gravity Sanitary Sewers

E. Section 02533 – Acceptance Testing for Sanitary Sewers

F. Section 02550 – Sliplining Sanitary Sewers

G. Section 02631 – Storm Sewers

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for PP pipe under this Section. Include cost in unit prices for work, as specified in following sections:

a. Section 02531 - Gravity Sanitary Sewers

b. Section 02631 – Storm Sewers

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

A. AASHTO - American Association of State Highway and Transportation Officials.

B. AASHTO's Product Evaluation and Audit Solutions – AASHTO's program to evaluate materials, products, and devices of common interest for use in highway and bridge construction.

C. Soil-tight Joints: Joints meeting the definition in AASHTO Standard Specifications for Highway Bridges, Section 26.4.2.4.

D. Watertight Joints: Joints meeting the requirements of ASTM D 3212.

1.05 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO), AASHTO LRFD Bridge Design Specifications, current edition.

B. AASHTO, Standard Specifications for Highway Bridges, current edition.

C. AASHTO M330 - Polypropylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter.

D. ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

E. ASTM D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.

F. ASTM F 477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

G. ASTM F 2764 - Standard Specification for 6 to 60 in. [150 to 1500 mm] Polypropylene (PP) Corrugated Double and Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications.

H. ASTM F 2881- Standard Specification for 12 to 60 in. [300 to 1500 mm] Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit shop drawings showing design of pipe and fittings indicating alignment and grade, pipe length, laying dimensions, fabrication, fittings, flanges, gasket material, and special details.

C. Submit detailed calculations for pipe design per AASHTO LRFD Bridge Design Specifications. Refer to Section 02631 – Storm Sewers submittal requirements for more details.

D. Submit details of Pipe Joints and jointing procedure for PP pipe.

E. Submit manufacturer technical catalog.

F. Submit manufacturer's installation specifications before beginning work. Include maximum fill depth and backfill requirements in manufacturer's installation specifications.

G. Submit a certificate of compliance with each shipment stating that the materials and assemblies fully comply with the requirements of the Contract.

1. Ensure that manufacturer's Certification of Compliance contains the following information:

a. Project Name.

b. Name of the Contractor.

c. Material description.

(1) Manufacturing plant

(2) Date of manufacture

(3) Pipe dimensions

(4) Pipe stiffness

(5) Pipe flattening

(6) Brittleness

(7) ASTM Resin Cell classification

(8) Workmanship

d. Typed or printed name of the person who signed the certification.

2. Provide the date and method of shipment from the product origin within the transmittal.

1.07 QUALITY ASSURANCE

A. Provide manufacturer's certificate of conformance to Specifications.

B. Furnish pipe and fittings that are homogeneous throughout and free from visible cracks, holes, foreign inclusions, or other injurious defects. Provide pipe as uniform as commercially practical in color, opacity, density, and other physical properties.

C. Project Manager reserves right to inspect pipes or witness pipe manufacturing. Inspection shall in no way relieve manufacturer of responsibilities to provide products that comply with applicable standards and these Specifications.

1. Manufacturer's Notification: Should Project Manager wish to witness manufacture of specific pipes, manufacturer shall provide Project Manager with minimum three weeks notice of when and where production of those specific pipes will take place.

2. Failure to Inspect. Approval of products or tests is not implied by Project Manager's decision not to inspect manufacturing, testing, or finished pipes.

D. Pipe manufacturer to provide services of experienced, competent, and authorized representative to visit site to advise and consult Contractor during jointing and installation of pipe.

E. Manufacturer Qualifications: Manufacturer shall specialize in manufacturing the products specified in this section with documented experience of minimum 5 years of pipe installations that have been in successful, continuous service for same type of service as proposed Work.

F. Manufacturers shall be AASHTO- Product Evaluation and Audit Solutions-certified. Qualified manufacturers must also maintain and submit a current AASHTO- Product Evaluation and Audit Solutions certificate of compliance.

1. For a list of AASHTO-Product Evaluation and Audit Solutions certified manufacturers, see the following webpage: https://transportation.org/product-evaluation-and-audit-solutions/.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide approved products listed on the City of Houston Approved Products List or approved equal.

B. Furnish corrugated-wall gravity sanitary sewer pipe with bell-and-spigot end construction conforming to ASTM D 3212. Joining will be accomplished with dual elastomeric gaskets in accordance with manufacturer's recommendations. Use integral bell-and-spigot gasketed joint designed so that when assembled, elastomeric gasket, contained in machined groove on pipe spigot, is compressed radially in pipe bell to form a positive seal. Design joint to avoid displacement of gasket when installed in accordance with manufacturer's recommendations.

C. Furnish corrugated-wall polypropylene (CPP) pipe for gravity storm sewer and storm sewer culvert pipe. Joints shall be installed such that connection of pipe sections will form continuous line free from irregularities in flow line.

D. Jointing:

1. Provide joints and fittings meeting the following requirements:

a. Integral Bell and Spigot with dual elastomeric gaskets. Bell shall overlap minimum of two corrugations of spigot end when fully engaged. Provide the spigot end with an O-ring gasket in accordance with 2.01.D.2.

b. Exterior Bell and Spigot. Fully weld the bell to the exterior of the pipe and overlap the spigot end so that the flow lines and ends match when fully engaged. Provide the spigot end with an O-ring gasket in accordance with 2.01.D.2.

c. Split Couplers. Used for gravity storm sewer Soil-Tight Joint connections only. Join pipe with coupling bands covering at least two full corrugations on the ends of each pipe being joined.

2. Gaskets:

a. Meet requirements of ASTM F 477. Use gasket molded into circular form or extruded to proper section and then spliced into circular form. When no contaminant is identified, use gaskets of properly cured, high-grade elastomeric compound. Basic polymer shall be natural rubber, synthetic elastomer, or blend of both.

b. PP Pipes are not allowed to be installed in potentially contaminated areas, unless approved by City Engineer.

CONTAMINANT	GASKET MATERIAL REQUIRED
Petroleum (diesel, gasoline)	Nitrile Rubber
Other Contaminants	As recommended by pipe manufacturer

3. Lubricant. Use lubricant for assembly of gasketed joints which has no detrimental effect on gasket or on pipe, in accordance with manufacturer's recommendations.

4. Diameters 12-inch through 48-inch shall have a reinforced bell with a polymer composite band installed by the manufacturer.

2.02 MATERIALS FOR SANITARY SEWER

A. Pipe and Fittings: Polypropylene compound for pipe and fitting production shall be impact modified copolymer meeting the material requirements of ASTM F 2764.

2.03 MATERIALS FOR GRAVITY STORM SEWERS AND STORM SEWER CULVERTS

A. Pipe and Fittings:

1. Polypropylene compound for pipe and fittings production shall be impact modified copolymer meeting the material requirements of ASTM F 2881 and AASHTO M330.

2. Provide Type S pipes (outer corrugated wall with smooth inner liner).

3. Section Properties shall meet the following requirements:

   a. Provide the minimum wall thickness of the inner walls for Type S pipe as specified in AASHTO M 330, Section 7.2.2. Meet the pipe stiffness at 5% deflection requirement as specified in AASHTO M 330, Section 7.4. The minimum section properties must meet the 75- yr. design life requirements in the AASHTO LRFD Bridge Design Specifications, Section 12.

4. Pipe size shall not exceed 48-inches in diameter.

2.04 TEST METHODS FOR SANITARY SEWER

A. Conditioning

1. Conditioning of samples prior to and during tests is subject to approval by Project Manager. When referee tests are required, condition specimens in accordance with ASTM F 2764, section 7.1.1.

B. Flattening

1. Flatten three specimens of pipe, prepared in accordance with ASTM F 2764, section 7.5.

C. Joint Tightness

1. Test for joint tightness in accordance with ASTM D 3212.

D. Purpose of Tests

1. Flattening and joint tightness tests are not intended to be routine quality control tests, but rather to qualify pipe to a specified level of performance.

2.05 TEST METHODS FOR GRAVITY STORM SEWERS AND STORM CULVERTS

A. All testing and material requirements shall be in accordance with ASTM F 2881.

B. Mandrel Testing: Use a mandrel to test flexible pipe for deflection. Refer to Section 02533 – Acceptance Testing for Sanitary Sewers for the mandrel and test requirements.

2.06 MARKING

A. Mark each standard and random length of pipe in compliance with these Specifications with following information:

1. Pipe size.

2. Pipe class.

3. Production code.

4. Material designation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Conform to requirements of following Sections:

1. Section 02550 – Slip lining Sanitary Sewers.

2. Section 02531 - Gravity Sanitary Sewers.

3. Section 02533 - Acceptance Testing for Sanitary Sewers.

B. Install pipe in accordance with the manufacturers recommended installation procedure and ASTM D 2321.

C. Install the joints so that the connection of the pipe sections forms a continuous line free from irregularities in the flow line. For Storm sewer applications, if no joint type is specified in the Contract documents, provide a Soil-Tight Joint meeting the requirements of this specification.

D. Unless otherwise authorized, start laying pipe on the bedding at the outlet end with the separate sections firmly joined together. Hoist and lower sections of pipe into the trench without damaging the pipe or disturbing the bedding or the sides of the trench. Remove and re-lay any pipe that is not in alignment or that shows excessive settlement after laying, at no expense to the City.

E. PP pipe is not approved in applications requiring augering of pipe.

F. Bedding and backfill:

1. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

2. Inspect inside periphery of pipe for local or unequal deformation caused by improper construction methods during backfilling. Stop work and address backfilling technique if measured deflection of pipe exceeds 5% or there are other issues found effecting quality of pipe installation.

3. To validate pipe installation methods, perform an initial quality control inspection after first installation of each size of pipe is completed on the project. Notify the Engineer of Record and Project Manager when this inspection takes place.

G. Use only workmen trained in the installation of PP Pipe.

H. Cutting pipe: Comply with pipe manufacturer's recommendations. After cutting, leave end pipe in accordance with manufacturer's recommendations.

I. Store pipe above ground on adequate blocking. Always keep pipe clean and fully drained during storage. Provide proper equipment for hoisting and lowering the pipe into the trench without damaging the pipe or disturbing the bedding or the walls of the trench. Any protective covering of gaskets should remain until the pipe is ready for installation.

J. Multi-barrel installations are not allowed.

END OF SECTION

SECTION 02511

WATER LINES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Installation of water lines.

B. Specifications identify requirements for both small diameter water lines and large diameter water lines. When specifications for large diameter water lines differ from those for small diameter water lines, large diameter specifications will govern for large diameter pipe.

1.02 RELATED SECTIONS

A. Section 01110 – Summary of Work

B. Section 01270 – Measurement and Payment

C. Section 01321 - Construction Photographs

D. Section 01330 – Submittal Procedures

E. Section 01740 – Site Restoration

F. Section 02105 – Chemical Sampling and Analysis

G. Section 02221 – Removing Existing Pavements, Structures, Wood, and Demolition Debris

H. Section 02317 – Excavation and Backfill for Utilities

I. Section 02501 – Ductile Iron Pipe and Fittings

J. Section 02502 – Steel Pipe and Fittings

K. Section 02506 – Polyvinyl Chloride Pipe

L. Section 02507 – Prestressed Concrete Cylinder Pipe

M. Section 02509 – Fiberglass Reinforced Pipe for Pressure Mains

N. Section 02514 – Disinfection of Water Lines

O. Section 02515 – Hydrostatic Testing of Pipelines

P. Section 02518 – Steel Pipe and Fittings for Large Diameter Water Lines

Q. Section 02528 – Polyethylene Encasement/Wrap

R. Section 02613 – Bar Wrapped Steel Cylinder Pipe

S. Section 03315 – Concrete for Utility Construction

T. Section 15640 – Joint Bonding and Electrical Isolation

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. Payment for water lines will be on a linear foot basis for each size of pipe installed. Separate pay items will be included for water lines installed by open-cut, by trenchless construction or by aerial crossing. No separate payment will be made for restrained joints, welded joints, thrust blocks, casing, bends, fittings, manways, pipe within limits of offset section, pipe within limits of Potentially Petroleum Contaminated Area (PPCA) or within limits of Fault Hazard Zone (FHZ).

   a. Mains: Measure along axis of pipe and include fittings and valves.

   b. Branch Pipe: Measure from axis of water line to end of branch.

   c. Small diameter water line (20-inch diameter and smaller): No separate payment for valves. Include in unit price work for water lines.

   d. For PVC pipe, install tracer wire. Include in unit price work for water lines.

2. Payment for interconnection is on lump sum basis for each interconnection identified on Drawings. Payment will include tapping sleeve and valves piping, connections and other related work necessary for construction as shown on Drawings or specified herein.

3. Payment for removal of existing internal elliptical or dished head plug is on unit price basis for each internal elliptical or dished head plug removed. Payment will include deletion of plug, drainage or dewatering of water lines, repair of damaged linings, rechlorination and items incidental to operation.

4. Payment for plug and clamp is on a unit price basis for each size of pipe.

5. Payment for drainline connection with service manhole is on unit price basis for each drainline shown on drawings. Payment includes valve, access manhole and connection.

6. Payment for cylindrical corrosion barriers is on a unit price basis for each pipe fitting installed with one or more barriers.

7. When directed by Project Manager to install extra fittings as required to avoid unforeseen obstacles, payment will be based on the following:

   a. Each extra fitting requested by Project Manager and delivered to jobsite will be paid according to unit price for "Extra Fittings in Place."

   b. Payment will include and be full compensation for items necessary for installation and operation of water line.

8. No separate payment will be made for installation of water line marker. Include cost in unit price for water lines.

9. No separate payment will be made for bell protection system for PVC pipe. Include cost in related unit price work.

10. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum): If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM A 36 - Standard Specification for Carbon Structural Steel.

B. ASTM A 193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.

C. ASTM A 536 - Standard Specification for Ductile Iron Castings.

D. ASTM A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

E. ASTM B 21 - Standard Specification for Naval Brass Rod, Bar, and Shapes.

F. ASTM B 98 - Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.

G. ASTM B 301 - Standard Specification for Free-Cutting Copper Rod, Bar, Wire, and Shapes.

H. ASTM B 584 - Standard Specification for Copper Alloy Sand Casting for General Application.

I. ASTM E 165 - Standard Practice for Liquid Penetrant Testing for General Industry.

J. ASTM E 709 - Standard Guide for Magnetic Particle Testing.

K. ASTM F 1674 - Standard Test Method for Joint Restraint Products for Use with PVC Pipe.

L. AWWA C 111/ANSI A 21.11 - Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

M. AWWA C 206 - Standard for Field Welding of Steel Water Pipe.

N. AWWA C 207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 Inches through 144 Inches.

O. AWWA C 210 - Liquid Epoxy Coatings and Linings for Steel Water Pipe and Fittings.

P. AWWA C 222 - Polyurethane Coatings and Linings for Steel Water Pipe and Fittings.

Q. NSF/ANSI 61 - Drinking Water System Components - Health Components.

R. OSHA 29 CFR 1926.1101 - Asbestos.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Conform to submittal requirements of applicable Section for type of pipe used.

C. Photographs: Submit photographs conforming to requirements of Section 01321 - Construction Photographs prior to commencement of construction.

D. Submit videotapes conforming to requirements of Section 01323 - Construction Videotapes, if applicable.

E. Submit Lone Star notification transmittal number prior to beginning excavation.

F. Submit, a minimum of 15 days before beginning pipe laying operations, layout drawing identifying proposed sections for disinfecting, hydrostatic testing and site restoration for entire project for review and approval. Layout drawing to identify sequence of sections for:

1. Disinfection; not to exceed 4,000 linear feet per section.

2. Hydrostatic testing and transfer of services; to immediately follow sequence of disinfected section.

3. Site restoration; not to exceed limits specified; sequence in order of disturbance.

G. For water lines to be field welded, submit proof of certification of field welders per AWWA C206. Indicate certified procedures and position each welder is qualified to perform. Provide documentation of the most recent weld qualification test date and continuity of use in each process for which the welder or welding operator is required.

PART 2 PRODUCTS

2.01 PIPE MATERIALS

A. Install pipe materials which conform to following:

1. Section 02501 - Ductile Iron Pipe and Fittings.

2. Section 02502 - Steel Pipe and Fittings. Water line piping within plant site and aerial crossings to be welded joint steel pipe with flange or approved restraint joint connections, unless otherwise shown on Drawings.

3. Section 02506 - Polyvinyl Chloride Pipe.

4. Section 02507 - Prestressed Concrete Cylinder Pipe.

5. Section 02509 – Fiberglass Reinforced Pipe for Pressure Mains

6. Section 02518 - Steel Pipe and Fittings for Large Diameter Water Lines.

7. Section 02613 - Bar Wrapped Steel Cylinder Pipe.

B. Conform to American National Standards Institute/National Sanitation Foundation (ANSI/NSF) Standard 61 and have certified by an organization accredited by ANSI.

C. Type of pipe materials used is Contractor's option unless specifically identified on Drawings.

D. Provide minimum of 3/8 inch inside joint recess between ends of pipe in straight pipe sections.

2.02 WELDED JOINT PROTECTION FITTING FOR SMALL DIAMETER STEEL PIPE

A. Cylindrical Corrosion Barrier: Provide approved cylindrical corrosion barrier.

B. O-rings: Conform to National Sanitary Foundation requirements.

2.03 RESTRAINED JOINTS

A. Ductile-Iron Pipe: See Section 02501 - Ductile Iron Pipe and Fittings.

B. PVC Pipe: See Section 02506 - Polyvinyl Chloride Pipe. Perform hydrostatic testing in accordance with ASTM F 1674.

C. Prestressed Concrete Cylinder Pipe, Bar-Wrapped Pipe and Steel Pipe: Welded joints (see Paragraph 3.06.C).

D. Except for trenchless installation, restrained Joints where required on DIP and PVC pipe are allowed with the following requirements as an alternative to the pipe with an integral restrained joint system:

1. Restraint Devices: Manufacture of high-strength ductile iron, ASTM A 536. Working pressure rating twice that of design test pressure.

2. Bolts and Connecting Hardware: High-strength low-alloy material in accordance with ANSI A21.11/AWWA C111.

E. For ductile iron or PVC pipes in augered holes, provide restrained joints that are integral to both the bell and spigot ends, and do not extend beyond or increase the outside diameter of the bell.

F. For small diameter water lines crossing under sanitary sewer lines or laterals, provide ductile iron pipe with locking or bolted type restrained joints.

2.04 COUPLINGS AND APPURTENANCES FOR LARGE DIAMETER WATERLINE

A. Flexible (Dresser-type) Couplings:

1. Install where shown on Drawings or where allowed by Project Manager for Contractor's convenience. Use galvanized flexible couplings when installed on galvanized pipe which is cement lined, or when underground. Provide gaskets manufactured from neoprene or Buna-N.

2. For steel pipe, provide approved sleeve-type flexible couplings. Thickness of middle ring equal to or greater than thickness of pipe wall.

3. Provide approved flanged adapter couplings for steel pipe.

4. Use ASTM A193 Grade B7 high strength steel bolts and ASTM A194 heavy hex nuts where flexible couplings are installed underground. Mark bolts and nuts according to ASTM. Provide cadmium plated hardware. Coat entire coupling with Denso or approved equal petrolatum-based tape.

B. Flap Valves: Provide approved flap valves on discharge of manhole drainline as shown on Drawings.

1. Body and Flap: ASTM A 126-B cast iron.

2. Seats: ASTM B 21-CA482 or ASTM B 301-CA145 bronze.

3. Resilient Seat:

4. Hinge Arms: ASTM B 584-CA865 high tensile bronze.

5. Hinge Pins: ASTM B 98-CA655 silicon bronze.

2.05 COUPLINGS AND APPURTENANCES FOR LARGE DIAMETER WATERLINE

A. Install Flexible Expansion Joints at locations indicated on drawings, within limits of Fault Hazard Zone (FHZ), in accordance with the manufacturer's recommendation.

2.06 CASING FOR OPEN CUT

A. For water line by open cut in casing, casing used shall conform to Section 02502 – Steel Pipe and Fittings.

PART 3 EXECUTION

3.01 PREPARATION

A. Conform to applicable installation specifications for types of pipe used.

B. Employ workmen who are skilled and experienced in laying pipe of type and joint configuration being furnished. Provide watertight pipe and pipe joints.

C. Lay pipe to lines and grades shown on Drawings.

D. Confirm 9 feet minimum separation from gravity sanitary sewers and manholes or separation of 4 feet minimum from force mains as specified in this Section in all directions unless special design is provided on Drawings.

E. Where above clearances cannot be attained, and special design has not been provided on Drawings, obtain direction from Project Manager before proceeding with construction.

F. Inform Project Manager if unmetered sprinkler or fire line connections exist which are not shown on Drawings. Make transfer only after approval by Project Manager.

G. For projects involving multiple subdivisions or locations, limit water line installation to maximum of two project site locations. Maximizing two pipe installation crews shall be permitted, unless otherwise approved by Project Manager.

H. City of Houston Drinking Water Operations will handle, at no cost to Contractor, operations involving opening and closing valves for wet connections and for chlorination. Contractor is responsible for handling necessary installations and removal of blow-offs, chlorination and testing taps, and risers.

I. If asbestos-cement (A.C.) pipe is encountered, follow safety practices outlined in OSHA 29 CFR 1926.1101 – Asbestos. Refer to Section 02221 - Removing Existing Pavements, Structures, Wood, and Demolition Debris for removing and disposing of A.C. Pipe.

J. For pipe diameters 36 inches and greater, clearly mark each section of pipe and fitting with unique designation on inside of pipe along with pressure class. Locate unique identifying mark minimum of 5 feet away from either end of each section of pipe. Provide one unique identifying mark in middle of each fitting. Place markings at consistent locations. Use permanent black paint and minimum letter height of 4 inches to mark designations.

K. Contractor is responsible for assuring chosen manufacturer fulfills requirements for extra fittings and, therefore, is responsible for costs due to downtime if requirements are not met.

L. Do not remove plugs or clamps during months of peak water demands; June, July and August, unless otherwise approved by Project Manager.

3.02 HANDLING, CLEANING AND INSPECTION

A. Handling:

1. Place pipe along project site where storm water or other water will not enter or pass through pipe.

2. Load, transport, unload, and otherwise handle pipe and fittings to prevent damage of any kind. Handle and transport pipe with equipment designed, constructed and arranged to prevent damage to pipe, lining and coating. Do not permit bare chains, hooks, metal bars, or narrow skids or cradles to come in contact with coatings. Where required, provide pipe fittings with sufficient interior strutting or cross bracing to prevent deflection under their own weight.

3. Hoist pipe from trench side into trench by means of sling of smooth steel cable, canvas, leather, nylon or similar material.

4. For large diameter water lines, handle pipe only by means of sling of canvas, leather, nylon, or similar material. Slings shall be wide enough so as to. not tear or wrinkle tape layers.

5. Use precautions to prevent injury to pipe, protective linings and coatings.

a. Package stacked pipe on timbers. Place protective pads under banding straps at time of packaging.

b. Pad fork trucks with carpet or other suitable material. Use nylon straps around pipe for lift when relocating pipe with crane or backhoe.

c. Do not lift pipe using hooks at each end of pipe.

d. Do not place debris, tools, clothing, or other materials on pipe.

e. Place pipe on timbers, tires or soil berms at the jobsite. Do not place pipe directly on ground.

6. Repair damage to pipe or protective lining and coating before final acceptance.

7. For cement mortar lined and coated steel pipe and PCCP, permit no visible cracks wider than 1/16”

   a. In surface laitance of centrifugally cast mortar.

   b. In sections of pipe with steel reinforcing collars or wrappers.

   c. Within 12 inches of pipe ends.

8. Repair pipe with visible cracks that exceed project specifications. If cracks cannot be repaired to specification remove from project site.

B. Cleaning: Thoroughly clean and dry interior of pipe and fittings of foreign matter before installation, and keep interior clean until Work has been accepted. Keep joint contact surfaces clean until jointing is completed. Do not place debris, tools, clothing or other materials in pipe. After pipe laying and joining operations are completed, clean inside of pipe and remove debris.

C. Inspection: Before installation, inspect each pipe and fitting for defects. Reject defective, damaged or unsound pipe and fittings and remove them from site.

3.03 EARTHWORK

A. Conform to applicable provisions of Section 02317 - Excavation and Backfill for Utilities.

3.04 PIPE CUTTING

A. Cut pipe 12 inches and smaller with standard wheel pipe cutters. Cut pipe larger than 12 inches in manner approved by Project Manager. Make cuts smooth and at right angles to axis of pipe. Bevel plain end with heavy file or grinder to remove sharp edges.

3.05 PIPING INSTALLATION

A. General Requirements:

1. When trench width below top of pipe becomes 4 feet wider than specified, install higher class of pipe or improved bedding, as determined by Project Manager. No additional payment will be made for higher class of pipe or improved bedding.

2. Lay pipe in subgrade free of water.

3. Properly form bedding to fully support bell without wedging or blocking up bell.

4. Open Cut Construction: Cover or backfill laid pipe if pipe laying operations are interrupted and during non-working hours. Place backfill carefully and simultaneously on each side of pipe to avoid lateral displacement of pipe and damage to joints. If adjustment of pipe is required after it has been laid, remove and re-lay as new pipe. Lay not more than 50 feet of pipe in trench ahead of backfilling operations.

5. Prevent damage to coating when placing backfill. Use backfill material free of large rocks or stones, or other material which could damage coatings.

B. Install pipe continuously and uninterrupted. Obtain approval of Project Manager prior to skipping any portion of Work.

1. Before assembling couplings, lightly coat pipe ends and outside of gaskets with pipe lubricant, cup grease or liquid vegetable soap to facilitate installation.

2. Prior to proceeding with critical tie-ins, submit sequence of work based on findings from "critical location" effort.

3. Use adequate surveying methods and equipment; employ personnel competent in use of this equipment. Horizontal and vertical deviations from alignment as indicated on Drawings shall not exceed 0.10 feet. Measure and record "as-built" horizontal alignment and vertical grade at maximum of every 100 feet on record drawings.

4. For large diameter water lines, survey line and grade at each pipe joint at the joint invert by competent personnel. Use adequate surveying methods and equipment to record x, y, z coordinates for each joint on the As-Built drawings and provide a list of pipe mark numbers with surveyed coordinates in tabular format along with As-Built drawings. Line and grade shall not deviate by more than 0.10 feet from alignment on record drawings.

C. Protection of Pipeline: Securely place stoppers or bulkheads in openings and in end of line when construction is stopped temporarily and at end of each day's work.

D. Perform Critical Location as shown on Drawings. Refer to Section 02317 - Excavation and Backfill for Utilities for additional requirements at critical locations.

E. Assessment of deflection may be measured by Project Manager at location along pipe. Arithmetical averages of deflection or similar average measurements will not be deemed as meeting intent of standard. Refer to pipe material specifications for maximum allowable pipe deflection.

F. Perform following additional procedures when working on plant sites.

1. At least 72 hours prior to each plant shutdown or connection, schedule coordination meeting with Project Manager and Water Production personnel. At this meeting, present proposed sequencing of Work and verification of readiness to complete Work as required and within time permitted. Do not proceed with Work until Project Manager agrees key personnel, equipment and materials are on hand to complete Work.

2. Prior to fully excavating around existing piping, excavate as minimal as possible to confirm type and condition of existing joints. Verify size, type, and condition of pipe prior to ordering materials or fully mobilizing for Work.

3. Do not proceed with connections to existing piping and identified critical stages of work unless approved by Project Manager and City's Utility Maintenance Division operator is present to observe.

4. Coordinate with City Drinking Water Operations to obtain reduction in operating pressures prior to performing connections to existing piping.

5. Make connections to existing piping only when two valves are closed off between connection and source of water pressure. Do not make connection relying solely on one valve, unless otherwise approved by Project Manager.

6. Perform critical stages of Work identified on Drawings at night or during low water demand months as specified in Section 01110 - Summary of Work.

7. Excavation equipment used on plant sites to have smooth bucket; no teeth or side cutters.

8. Submit to Project Manager Lone Star Notification transmittal number prior to beginning excavation.

9. Before each "dig" with mechanical excavator, probe ground to determine potential obstructions. Repeat procedure until existing pipe is located or excavation reaches desired elevation. Perform excavations within one foot to existing piping by hand methods.

10. Provide adequate notice to Project Manager and pipe manufacturer's representative when connecting or modifying existing prestressed or pretension concrete cylinder pipe.

11. Provide field surveyed (horizontal and vertical elevations) "as-builts" of new construction and existing underground utilities encountered. Submit in accordance with Section 01330 - Submittal Procedures.

12. Prior to performing plant work to be done on weekend, provide list of sites and contact person with phone numbers to Project Manager by noon on Thursday of week. Contact person must be accessible during weekend, have Houston Metro Area phone number, and be authorized to make emergency decisions.

13. No night work or plant shutdown will be scheduled to begin two working days before or after designated City Holidays.

G. Maintain water services at all times to all customers, fire hydrants and interconnections. Provide temporary connections and temporary bypass as necessary for construction. No additional payment will be made for temporary connections unless specified on the drawings.

H. For tie-ins to existing water lines, provide necessary material on hand to facilitate connection prior to shutting down existing water line. Prior to requesting shut down of existing water line connection, provide minimum two-week notice to City Project Manager.

I. For exposed portions of piping within manholes or vaults, including outlets, flanges, blind flanges, nuts, bolts, valves, actuators, and piping, apply finish coat after installation is complete. Provide cycloaliphatic amine epoxy in light blue color. Follow manufacturer's procedures for preparing surface and applying coating. Submit coating manufacturer's product data sheet and color sample to Project Manager for review.

3.06 JOINTS AND JOINTING

A. Rubber Gasketed Bell-and-Spigot Joints for Concrete Cylinder Pipe, Bar Wrapped Pipe PVC, Steel, and DIP:

1. After rubber gasket is placed in spigot groove of pipe, equalize rubber gasket cross section by inserting tool or bar recommended by manufacturer under rubber gasket and moving it around periphery of pipe spigot.

2. Lubricate gaskets with nontoxic water-soluble lubricant before pipe units are joined.

3. Fit pipe units together in manner to avoid twisting or otherwise displacing or damaging rubber gasket.

4. After pipe sections are joined, check each gasket to ensure that no displacement of gasket has occurred. If displacement has occurred, remove pipe section and remake joint as for new pipe. Remove old gasket, and replace before remaking joint.

5. Provide means to prevent full engagement of spigot into bell in accordance with Paragraph 2.01 D. For PVC pipe, means may consist of an approved bell insertion protection system.

B. Flanged Joints where required on Concrete Cylinder Pipe, Bar Wrapped Pipe, Ductile Iron Pipe, or Steel Pipe:

1. AWWA C 207. Prior to installation of bolts, accurately center and align flanged joints to prevent over stressing of flanges, pipe and equipment. Align bolt holes to straddle vertical, horizontal or north-south center line. Do not exceed 3/64 inch per foot inclination of flange face from true alignment.

2. Use ring type or full-face gaskets for flanged joints. Provide gasket material in accordance with AWWA C207 . Cut gaskets at factory to proper dimensions. In PPCA areas, provide gasket material in accordance with Section 02105 – Chemical Sampling and Analysis.

3. Provide ASTM A193 Grade B7 high strength steel stud bolts with ASTM A194 heavy hex nuts. Use cadmium-plated steel hardware underground. Mark nuts and bolts according to ASTM. Tighten bolts progressively to prevent unbalanced stress. Maintain at all times approximately same distance between two flanges at points around flanges. Tighten bolts alternately (180˚ apart) until all are evenly tight. Draw bolts tight to ensure proper seating of gaskets. Provide Denso petrolatum-based tape or approved equal for all exposed portions of nuts, bolts and pipe hardware.

4. Isolation Joints:

    a. Provide full-face Type “E” gasket. For 30-inch diameter and greater, provide Pyrox G-10 material and EPDM sealing element. For 24-inch diameter and smaller, provide Phenolic material and EPDM sealing element. Provide full-length bolt isolating sleeves and washers. Provide matching steel washers on both sides of each insulating washer on every bolt. Furnish kits in accordance with Section 15640 - Joint Bonding and Electrical Isolation.

C. Welded Joints (Concrete Cylinder Pipe, Bar Wrapped Pipe, Steel Pipe):

1. Prior to starting work, provide certification of qualification for welders employed on project for type of work procedures and positions involved.

2. Steel Pipe Joints: AWWA C 206. See Section 02502 - Steel Pipe and Fittings or Section 02518 - Steel Pipe and Fittings for Large Diameter Water Lines. Refer to Contract Drawings for joint details. For interior welded joints, complete backfilling before welding. For exterior field-welded joints, provide adequate working room under and beside pipe. Use exterior welds for 30-inch and smaller.

3. Concrete Pipe Joints: See Section 02507 – Prestressed Concrete Cylinder Pipe or Section 02613 - Bar Wrapped Steel Cylinder Pipe. Refer to Contract Drawings for joint details. Align piping and equipment so that no part is offset more than 1/8 inch. Set fittings and joints square and true, and preserve alignment during welding operation. For butt-welded joints, align abutting ends to minimize offset between surfaces. For pipe of same nominal wall thickness, do not exceed 1/16 inch offset. Use line-up clamps for this purpose; however, take care to avoid damage to linings and coatings.

4. Welding Rods: Compatible with metal to be welded to obtain strongest bond, E-70XX.

5. Deposit metal in successive layers to provide 1 to 3 passes or beads as required to complete the structural weld or control heat in the weld after backfill joint.

6. Deposit no more than 1/4 inch of metal on each pass. Thoroughly clean each individual pass with wire brush or hammer to remove dirt, slag or flux.

7. Do not weld under weather condition that would impair strength of weld, such as wet surface, rain or snow, dust or high winds, unless work is properly protected.

8. Make tack weld of same material and by same procedure as completed weld. Otherwise, remove tack welds during welding operation.

9. Remove dirt, scale, and other foreign matter from inside piping before tying in sections, fittings, or valves.

10. Welded Joints for Large Diameter Water Lines:

    a. Use exterior welds for 30-inch diameter and smaller.

    b. Employ an independent certified testing laboratory, approved by Project Manager, to perform weld acceptance tests on welded joints. Include cost of such testing and associated work to accommodate testing in contract unit price bid for water line. Furnish copies of test reports to Project Manager for review. Project Manager has final decision as to suitability of welds tested.

        (1) Weld acceptance criteria:

            (a) Conduct in accordance with ASTM E165 - Standard Test Method for Liquid Penetrant Examination and ASTM E709 - Standard Guide for Magnetic Particle Examination. Use X-ray methods for butt welds, for 100 percent of joint welds.

            (b) Examine welded surfaces for the following defects:

I. Cracking.

II. Lack of fusion/penetration.

III. Slag which exceeds one-third (t) where (t) equals material thickness.

IV. Porosity/Relevant rounded indications greater than 3/16 inch; rounded indication is one of circular or elliptical shape with length equal to or less than three times its width.

V. Relevant linear indications in which length of linear indication exceeds three times its width.

VI. Four or more relevant 1/16-inch rounded indications in line separated by 1/16 inch or less edge to edge.

11. After pipe is joined and prior to start of welding procedure, make spigot and bell essentially concentric by jacking, shimming or tacking to obtain clearance tolerance around periphery of joint except for deflected joints.

12. Furnish each welder employed steel stencil for marking welds, so work of each welder can be identified. Mark pipe with assigned stencil adjacent to weld. When welder leaves job, stencil must be voided and not duplicated. Welder making defective welds must discontinue work and leave project site. Welder may return to project site only after recertification.

13. Scaffolding: Do not drag scaffolding or other items along interior of pipe.

14. Provide cylindrical corrosion barriers for polyurethane or epoxy-lined steel pipe 24-inch diameter and smaller, unless minimum wall thickness is 0.5 inch or greater.

    a. In addition to welding requirements contained here in Paragraph 3.06, conform to protection fitting manufacturer's installation recommendations.

    b. Provide services of technical representative of manufacturer available on site at beginning of pipe laying operations. Representative to train welders and advise regarding installation and general construction methods. Welders must have 12 months prior experience All steel pipe is to have cutback 3/4 inch to no greater than 1 inch of internal diameter coating from weld bevel.

c. Furnish steel fittings with cylindrical corrosion barriers with shop welded extensions to end of fittings. Extension length to measure no less than diameter of pipe. Shop apply lining in accordance with AWWA C 210 or AWWA C 222.

d. All steel pipe receiving field adjustments are to be cold cut using standard practices and equipment. No cutting using torch is to be allowed.

D. Harnessed Joints (Concrete Cylinder Pipe, Bar Wrapped Pipe or Steel Pipe):

1. Use of snap-ring type restrained joints on pipe is limited to 20-inch through 48-inch diameters.

2. Position snap-ring joint bolt on top (12 o'clock portion). Provide minimum 1/2-inch joint recess. Use joint "diapers" minimum of 12 inches wide.

3. For field adjustments with deflections or joint offsets beyond manufacturer's recommendations:

a. Field trim spigot.

b. Do not engage ring.

4. Harnessed joints are not permitted in areas defined on Drawings as potentially petroleum contaminated material, in tunnels, or at bend greater than 5 degrees.

5. Install harness type joints including snap rings at straight sections of pipe.

E. Restrained Joints:

1. For existing water lines and water lines less than 16 inches in diameter, restrain pipe joints with concrete thrust blocks unless otherwise shown on Drawings.

2. Thrust restraint lengths shown on Drawings are minimum anticipated lengths. These lengths are based on deflections or joint offsets indicated and on use of prestressed concrete cylinder pipe for large diameter lines and ductile iron pipe for small diameter lines. Adjustments in deflections or joint offsets or use of other pipe material may result in reduction or increase of thrust lengths.

3. Pipe manufacturer or representative to perform thrust restraint calculations in accordance with latest revision of applicable standard for pipe material chosen. Submit calculations for all pipe materials sealed by a registered Professional Engineer in State of Texas for review by Project Manager. Make adjustments in thrust restraint lengths at no additional cost to City.

4. Include buoyancy conditions for soil unit weight when computing thrust restraint calculations.

5. Passive resistance of soil will not be permitted in calculation of thrust restraint for some pipe materials.

6. For 16-inch lines and larger use minimum 16-foot length of pipe in and out of joints made up of beveled pipe where restraint joint lengths are not identified on Drawings. Otherwise, provide restraint joints for a minimum length of 16 feet on each side of beveled joints.

7. Installation.

   a. Install restrained joints mechanism in accordance with manufacturer's recommendations.

   b. Examine and clean mechanism; remove dirt, debris and other foreign material.

   c. Apply gasket and joint NSF 61 FDA food grade approved lubricant.

   d. Verify gasket is evenly seated.

   e. Do not over stab pipe into mechanism.

8. Prevent any lateral movement of thrust restraints throughout pressure testing and operation.

9. Place 2500 psi concrete conforming to Section 03315 - Concrete for Utility Construction, for blocking at each change in direction of existing water lines, to brace pipe against undisturbed trench walls. Finish placement of concrete blocking, made from Type I cement, 4 days prior to hydrostatic testing of pipeline. Test may be made 2 days after completion of blocking if Type II cement is used.

F. Joint Grout (Concrete Cylinder Pipe, Bar Wrapped Pipe, Mortar Coated Steel Pipe):

1. Mix cement grout mixture by machine when more than 1/2 cubic yard is required. When less than 1/2 cubic yard is required, grout may be hand mixed. Mix grout only in quantities for immediate use. Place grout within 20 minutes after mixing. Discard grout that has set. Retempering of grout by any means is not permitted.

2. Prepare grout in small batches to prevent stiffening before it is used. Do not use grout which has become so stiff that proper placement cannot be assured without retempering. Use grout for filling grooves of such consistency that it will adhere to ends of pipe.

3. Surface Preparation: Remove defective concrete, laitance, dirt, oil, grease and other foreign material from concrete surfaces with wire brush or hammer to sound, clean surface. Remove rust and foreign materials from metal surfaces in contact with grout.

4. Follow established procedures for hot and cold weather concrete placement.

5. Complete joint grout operations and backfilling of pipe trenches as closely as practical to pipe laying operations. Allow grouted exterior joints to cure at least 1 hour before compacting backfill.

6. Grouting Exterior Joint Space: Hold wrapper in place on both sides of joint with minimum 5/8-inch-wide steel straps or bands. Place no additional bedding or backfill material on either side of pipe until after grout band is filled and grout has mechanically stiffened. Pull ends of wrapper together at top of pipe to form access hole. Pour grout down one side of pipe until it rises on other side. Rod or puddle grout to ensure complete filling of joint recess. Agitate for 15 minutes to allow excess water to seep through joint band. When necessary, add more grout to fill joint completely. Protect gap at top of joint band from backfill by allowing grout to stiffen or by covering with structurally protective material. Do not remove band from joint. Proceed with placement of additional bedding and backfill material.

7. Interior Joints for Pipe 24 Inches and Smaller: Circumferentially butter bell with grout prior to insertion of spigot, strike off flush surplus grout inside pipe by pulling filled burlap bag or inflated ball through pipe with rope. After joint is engaged, finish off joint grout smooth and clean. Use swab approved by Project Manager for 20-inch pipe and smaller.

8. Protect exposed interior surfaces of steel joint bands by pointing with grout. Remove and replace improperly cured or otherwise defective grout.

9. Strike off grout on interior joints and make smooth with inside diameter of pipe.

10. When installed in tunnel or encasement pipe and clearance within casing does not permit outside grout to be placed in normal manner, apply flexible sealer, such as Flex Protex or equal, to outside joint prior to joint engagement. Clean and prime surfaces receiving sealer in accordance with manufacturer's recommendations. Apply sufficient quantities of sealer to assure complete protection of steel in joint area. Fill interior of joint with grout in normal manner after joint closure.

11. Interior Joints for Water Lines 30 Inches and Larger: Clean joint space, wet joint surfaces, fill with stiff grout and trowel smooth and flush with inside surfaces of pipe using steel trowel so that surface is smooth. Accomplish grouting at end of each work day. Obtain written acceptance from Project Manager of inside joints before proceeding with next day's pipe laying operation. During inspection, insure no delamination of joint mortar has occurred by striking joint mortar lining with rubber mallet. Remove and replace delaminated mortar lining.

12. Work which requires heavy equipment to be over water line must be completed before mortar is applied to interior joints.

G. Large Diameter Water Main Joint Testing: In addition to testing individual joints with feeler gauge approximately 1/2 inch wide and 0.015-inch thick, use other joint testing procedure approved or recommended by pipe manufacturer which will help ensure watertight installation prior to backfilling. Perform tests at no additional cost to City.

H. Make curves and bends by deflecting or offsetting joints or other method as recommended by manufacturer and approved by Project Manager. Submit details of other methods of providing curves and bends which exceed manufacturer's recommended deflection or joint offset prior to installation.

1. Deflection of pipe joints shall not exceed maximum deflection recommended by pipe manufacturer, unless otherwise indicated on Drawings.

2. If deflection exceeds that specified but is less than 5 percent, repair entire deflected pipe section such that maximum deflection allowed is not exceeded.

3. If deflection is equal to or exceeds 5 percent from that specified, remove entire portion of deflected pipe section and install new pipe.

4. Replace, repair, or reapply coatings and linings as required.

5. Assessment of deflection may be measured by Project Manager at location along pipe. Arithmetical averages of deflection or similar average measurement methods will not be deemed as meeting intent of standard.

6. When rubber gasketed pipe is laid on curve, join pipe in straight alignment and then deflect or offset to curved alignment.

I. Closures Sections and Approved Field Modifications to Steel, Concrete Cylinder Pipe, Bar Wrapped Pipe and Fittings:

1. For large diameter water lines, provide minimum overlap of 4 inches on each side for butt-strap closures.

2. For pipe diameters 36 inches and greater, perform field welds on interior and exterior of pipe.

3. Apply welded-wire fabric reinforcement to interior and exterior of exposed interior and exterior surfaces greater than 6 inches in diameter. Welded-wire fabric: minimum W1; maximum spacing 2 inches by 4 inches; 3/8 inch from surface of steel plate or middle third of lining or coating thickness for mortar thickness less than 3/4 inch.

4. Fill exposed interior and exterior surfaces with nonshrink grout.

3.07 CATHODIC PROTECTION APPURTENANCES

A. Where identified on Drawings, modify pipe for cathodic protection as detailed on Drawings and specified. Unless otherwise noted, provide insulation kits including test stations at connections to existing water system or at locations to isolate one type of cathodic system from another type, between water line, access manhole piping and other major openings in water line, or as shown on Drawings.

B. Bond joints for pipe installed in tunnel or open cut, except where insulating flanges are provided. Weld strap, wire or clip between bell and spigot of each joint or as shown on Drawings. No additional bonding required where joints are welded for thrust restraint. Repair coatings as specified by appropriate AWWA standard, as recommended by manufacturer, and as approved by Project Manager.

C. Bonding Strap or Clip: Free of foreign material that may increase contact resistance between wire and strap or clip.

3.08 SECURING, SUPPORTING AND ANCHORING

A. Support piping, as shown on Drawings and as specified in this Section, to maintain line and grade and prevent transfer of stress to adjacent structures.

B. Where shown on Drawings, anchor pipe fittings and bends installed on water line by welding consecutive joints of pipe together to distance each side of fitting. Restrained length, as shown on Drawings, assumes that installation of pipe and subsequent hydrostatic testing begin upstream and proceed downstream, with respect to normal flow of water in pipe. If installation and testing differs from this assumption, submit for approval revised method of restraining pipe joints upstream and downstream of device used to test against (block valve, blind flange or dished head plug).

C. Use adequate temporary blocking of fittings when making connections to distribution system and during hydrostatic tests. Use sufficient anchorage and blocking to resist stresses and forces encountered while tapping existing water line.

3.09 POLYETHYLENE WRAP FOR DUCTILE IRON PIPE

A. Conform to requirements of Section 02528 - Polyethylene Encasement/Wrap.

3.10 CLEANUP AND RESTORATION

A. Provide cleanup and restoration crews to work closely behind pipe laying crews and, where necessary, during disinfection and hydrostatic testing, service transfers, abandonment of old water lines, backfill and surface restoration.

B. Unless otherwise approved by Project Manager, comply with the following:

1. Once water line is installed to limits approved in layout submitted, immediately begin preparatory work for disinfection effort.

2. No later than three days after completing disinfection preparatory work, submit to City appropriate request for disinfection.

3. If City fails to perform initial disinfection of lines in accordance with Section 02514 - Disinfection of Water Lines, within seven days from submission of appropriate request, and if approved by Project Manager, pipe laying operations may continue beyond approved limits until the City responds.

4. Immediately after transfer of services, begin abandonment of old water lines and site restoration.

5. Do not exceed a total of 50 percent of total project linear feet of disturbed right-of- way and easement until site is restored in accordance with Section 01740 - Site Restoration.

6. Exceeding any of the above footage limitations shall be considered a material breach of the Contract and subject to termination in accordance with the General Conditions.

C. For large diameter water lines, do not install more than 2,000 linear feet of water line, without previous 2,000 linear feet being restored in accordance with Section 01740 - Site Restoration. Schedule paving crews so repaving work will not lag behind pipe laying work by more than 1,000 linear feet. Failure to comply with this requirement shall be considered a material breach of the Contract and subject to termination in accordance with the General Conditions.

3.11 CLEANING PIPING SYSTEMS

A. Remove construction debris or foreign material and thoroughly broom clean and flush piping systems. Provide temporary connections, equipment and labor for cleaning. City must inspect water line for cleanliness prior to filling.

3.12 DISINFECTION OF WATER LINES

A. Conform to requirements of Section 02514 - Disinfection of Water Lines.

3.13 FIELD HYDROSTATIC TESTS

A. Conform to requirements of Section 02515 - Hydrostatic Testing of Pipelines.

END OF SECTION

SECTION 02512

WATER TAP AND SERVICE LINE INSTALLATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Tapping existing mains and furnishing and installing new service lines for water.

B. Relocation of existing small water meters.

C. Specifications identify requirements for both small-diameter (less than or equal to 20 inches) water lines and large-diameter (greater than 20 inches) water lines. When specifications for large-diameter water lines differ from those for small- diameter water lines, paragraphs for large-diameter water lines will govern for large-diameter pipe.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 02085 – Valve Boxes, Meter Boxes, and Meter Vaults

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02503 – Copper Tubing

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for water taps and copper service lines 3/4 inch through 1 inch is on unit price basis for each installation. Separate measurements will be made for "short side", "long side" and "extra-long side" connections as defined in Paragraph 1.05, Definitions.

2. Payment for water taps and service lines 1-1/2 inch through 2-inch is on unit price basis for each installation. Separate measurements will be made for "short side", "long side" and "extra-long side" connections as defined in Paragraph 1.05, Definitions.

3. Payment for "short side, "long side" and "extra-long side" includes locating water line, tap installation and connection to meter and restoring site.

4. Payment for each small meter includes labor, materials, and equipment to relocate existing small meter.

5. No additional payment will be made for bedding, backfill, compaction, push under pavement, etc.

6. Refer to Section 01270 - Measurement and Payment for unit price procedures

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM B 418 - Standard Specification for Cast and Wrought Galvanic Zinc Anodes.

B. AWWA C 800 - Standard for Underground Service Line Valves and Fittings.

C. AWWA C 900 - Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 12 in. (100 mm through 300 mm), for Water Transmission and Distribution.

D. AWWA C 105 – Polyethylene Encasement for Ductile-Iron Pipe Systems.

1.05 DEFINITIONS

A. Short Side Connection: Service line connecting proposed curb stop, located inside water meter box, to water line on same side of street.

B. Long Side Connection: Service line connecting proposed curb stop, located inside water meter box, to water line on opposite side of street or from center of streets where supply line is located in street center such as boulevards and streets with esplanades. Distance not to exceed 60 linear feet (at right angles to water line).

C. Extra Long Side Connection: Service line connecting proposed curb stop, located inside water meter box, to water line on opposite side of street or from center of streets where supply line is located in street center such as boulevards and streets with esplanades. Distance greater than 60 linear feet (at right angles to water line).

PART 2 PRODUCTS

2.01 MATERIALS

A. Copper Tubing: In accordance with Section 02503 - Copper Tubing. Polybutylene tubing is not permitted.

B. Corporation Stops: AWWA C 800 as modified in this Section:

1. Inlet End: AWWA standard thread.

2. Valve Body: Tapered plug type, O-ring seat ball type, or rubber seat ball type.

3. Outlet End: Flared-copper connection for use with Type K, soft copper or compression type fitting.

C. Provide taps for water line types and sizes in accordance with pipe tapping schedule located at end of this Section.

D. Dual Strap Saddles: Red brass body and straps; ductile-iron; vinyl-coated body and straps; or ductile-iron, vinyl-coated body and stainless-steel straps.

E. Taps for PVC Water Lines: Use dual-strap or single, wide-band strap saddles which provide full support around circumference of pipe and bearing area of sufficient width along axis of pipe, 2 inches minimum, ensuring that pipe will not be distorted when saddle is tightened. Provide approved stainless-steel tapping saddle with AWWA standard thread.

F. Taps for Steel Pipe: Not allowed, unless specifically approved by Project Manager. Use saddle only when tap is approved on steel pipe.

G. Curb Stops and Brass Fittings: AWWA C 800 as modified in this Section.

1. Inlet End: Flared copper connection or compression-type fitting

2. Valve Body: Straight-through or angled, meter-stop design equipped with following:

a. O-ring seal straight plug type.

b. Rubber seat ball type.

3. Outlet End: Female, iron-pipe thread or swivel-nut, meter-spud thread on 3/4-inch and 1-inch stops and 2-hole flange on 1 1/2 and 2-inch sizes.

4. Fittings: Provide approved fittings. Use same size open end wrenches and tapping machines as used with respective Mueller fittings.

5. Factory Testing of Brass Fittings:

a. Submerge in water for 10 seconds at 85 psi with stop in both closed and open positions.

b. Reject fitting that shows air leakage. Project Manager may confirm tests locally. Entire lot from which samples were taken will be rejected when random sampling discloses unsatisfactory fittings.

H. Angle Stops: In accordance with AWWA C 800; ground-key, stop type with bronze lock- wing head stop cap; inlet and outlet threads conform to application tables of AWWA C 800; and inlets flared connection or compression.

1. Outlet for 3/4-inch and 1-inch size: Meter swivel nut with saddle support.

2. Outlet for 1 1/2-inch through 2-inch size: O-ring sealed meter flange, iron pipe threads.

I. Fittings: In accordance with AWWA C 800 and following:

1. Castings: Smooth, free from burrs, scales, blisters, sand holes, and defects which would make them unfit for intended use.

2. Nuts: Smooth cast and has symmetrical hexagonal wrench flats.

3. Flare-Joint Fittings: Smooth cast. Machine seating surfaces for metal-to-metal seal to proper taper or curve, free from pits or protrusions.

4. Thread fittings, of all types, shall have N.P.T. or AWWA threads, and protect male threaded ends in shipment by plastic coating, or approved equal.

5. Compression tube fittings shall have Buna-N beveled gasket.

6. Stamp of manufacturer's name or trademark and of fitting size on body.

PART 3 EXECUTION

3.01 GENERAL

A. For service lines and lateral connections larger than those allowed in Pipe Tapping Schedule, branch connections and multiple taps may be used. Space corporation stops minimum of 2 feet apart.

B. Tapped collars of appropriate sizes: Approved in new construction only provided they are set at right angles to proposed meter location.

C. Use tapping machine manufactured for pressure tapping purposes for 2-inch and smaller service taps on pressurized water lines.

D. For new meter or when existing meter conflicts with proposed pavement improvements, locate water meters one foot inside street right-of-way, or when this is not feasible, one foot on curb side of sidewalk. Contact Project Manager when major landscaping or trees conflict with service line and meter box location. No additional payment will be made for work on customer side of meter.

E. New location and installation of existing small meter shall conform to requirements of this Section.

F. Successfully perform hydrostatic and disinfection testing prior to installing service taps and lines.

3.02 SERVICE INSTALLATION

A. Set service taps at right angles to proposed meter location and locate taps in upper pipe segment within 45 degrees of pipe springline.

B. Install service lines in accordance with Section 02317 - Excavation and Backfill for Utilities.

C. Lay service lines with minimum of 30 inches of cover as measured from top of curb or, in absence of curbs, from centerline elevation of crowned streets or roads. Provide minimum of 18 inches of cover below flow line of ditches to service lines.

D. Service lines across existing street (push-unders): Pull service line through prepared hole under paving. Use only full lengths of tubing. Take care not to damage copper tubing when pulling it through hole. Compression-type union is only permitted when span underneath pavement cannot be accomplished with a full standard length of tubing. Use one compression-type union for each full length of tubing.

E. Maintain service lines free of dirt and foreign matter.

F. Install service lines so that top of meter will be 4 to 6 inches below finished grade.

G. Anticipate existing sanitary sewers to have cement stabilized sand backfill to bottom of pavement. Include cost of such crossings in unit price for services.

H. When copper line must be installed in cement stabilized sand use an 8 MIL polyethylene encasement tubing in accordance with AWWA C105.

3.03 CURB STOP INSTALLATION

A. Set curb stops or angle stops at outer end of service line inside of meter box. Secure opening in curb stop to prevent unwanted material from entering. In close quarters, make S-curve in field. Do not flatten tube. In 3/4-inch and 1-inch services, install meter coupling, swivel-nut, or curb stop ahead of meter. Install straight meter coupling on outlet end of meter.

3.04 GALVANIC CORROSION CONTROL

A. For 1-1 /2 inch and 2 inch meters utilizing two bolt flanges, install 2.5 ounce sacrificial zinc anode caps meeting ASTM B 418 requirements on the end of each bolt on both outlet and inlet side of the meter connection.

3.05 SEQUENCE OF OPERATIONS

A. Open trench for proposed service line in accordance with Section 02317 - Excavation and Backfill for Utilities.

B. Install curb stop on meter end of service line.

C. With curb stop open and prior to connecting service line to meter in slack position, open corporation stop and flush service line thoroughly. Close curb stop, leaving corporation stop in full-open position.

D. Check service line for apparent leaks. Repair leaks before proceeding.

E. Schedule inspection with Project Manager prior to backfilling. After inspection, backfill in accordance with Section 02317 - Excavation and Backfill for Utilities.

F. Install meter box centered over meter with top of lid flush with finished grade. Meter box: Refer to Section 02085 - Valve Boxes, Meter Boxes, and Meter Vaults.

Table 02512-1

PIPE TAPPING SCHEDULE				
WATERLINE TYPE AND DIAMETER	SERVICE SIZE			
	3/4"	1"	1-1/2"	2"
4" Cast Iron or Ductile Iron	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
4" Asbestos Cement	WBSS	WBSS	DSS, WBSS	DSS, WBSS
4" PVC (AWWA C900)	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
6" and 8" Cast Iron or Ductile Iron	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
6" and 8" Asbestos Cement	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
6" and 8" Cast Iron or Ductile Iron	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
6" and 8" PVC (AWWA C900)	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
12" Cast Iron or Ductile Iron	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
12" Asbestos Cement	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
12" PVC (AWWA C900)	DSS, WBSS	DSS, WBSS	DSS, WBSS	DSS, WBSS
16" and Up Cast Iron or Ductile Iron	DWBSS	DWBSS	DWBSS	DWBSS
16" and Up Asbestos Cement	DWBSS	DWBSS	DWBSS	DWBSS
16" and Up PVC (AWWA C900)	DWBSS	DWBSS	DWBSS	DWBSS

DSS - DUAL STRAP SADDLES
WBSS - WIDE BAND STRAP SADDLES DWBSS - DUAL WIDE BAND STRAP SADDLES

END OF SECTION

SECTION 02513

WET CONNECTIONS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Wet connections for new water lines and service lines to existing water lines.

1.02 RELATED SECTIONS

A. Section 01270 - Measurement and Payment

B. Section 02221 - Removing Existing Pavements, Structures, Wood, and Demolition Debris

C. Section 02501 - Ductile Iron Pipe and Fittings

D. Section 02502 - Steel Pipe and Fittings

E. Section 02503 - Copper Tubing

F. Section 02504 - Fiberglass Reinforced Pipe

G. Section 02505 - High Density Polyethylene (HDPE) Solid and Profile Wall Pipe

H. Section 02506 - Polyvinyl Chloride Pipe

I. Section 02507 - Prestressed Concrete Cylinder Pipe

J. Section 02508 - Extra Strength Clay Pipe

K. Section 02509 - Fiberglass Reinforced Pipe for Pressure Mains

L. Section 02510 - Polypropylene (PP) Corrugated Wall Pipe

M. Section 02511 - Water Lines

N. Section 02512 - Water Tap and Service Line Installation

O. Section 02513 - Wet Connections

P. Section 02514 - Disinfection of Water Lines

Q. Section 02515 - Hydrostatic Testing of Pipelines

R. Section 02516 - Cut, Plug, and Abandonment of Water Line

S. Section 02517 - Water Line in Tunnels

T. Section 02518 - Steel Pipe and Fittings for Large Diameter Water Lines

U. Section 02520 - Fire Hydrants

V. Section 02521 - Gate Valves

W. Section 02522 - Butterfly Valves

X. Section 02523 - Pressure Reducing Valves

Y. Section 02524 - Air Release and Vacuum Relief Valves

Z. Section 02525 - Tapping Sleeves and Valves

AA. Section 02526 - Water Meters

BB. Section 02527 - Polyurethane Coatings on Steel or Ductile Iron Pipe

CC. Section 02528 - Polyethylene Encasement/Wrap

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for wet connections shown on Drawings is on unit price basis for each wet connection. Separate payment will be made for each size of water line.

2. No compensation will be given for extra work or for damages occurring as result of incomplete shutoff.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AWWA C 800 - Standard for Underground Service Line Valves and Fittings.

B. OSHA 29 CFR 1926.1101 - Asbestos.

1.05 DEFINITIONS

A. Wet connections consist of isolating sections of pipe to be connected with existing valves, draining isolated sections, and completing connections.

B. Connection of 2-inch or smaller lines, which may be referred to on Drawings as "2-inch standard connections" or "gooseneck connections" will be measured as 2-inch wet connections. This item is not to be used as part of 2-inch service line.

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe shall conform to requirements of applicable portions of Sections 02501 through 02528 related to piping materials and to water distribution.

B. Corporation cocks and saddles shall conform to requirements of Section 02512 - Water Tap and Service Line Installation.

C. Valves shall conform to requirements of Section 02521 - Gate Valves.

D. Brass fittings shall conform to requirements of AWWA C 800.

PART 3 EXECUTION

3.01 CONNECTION OPERATIONS

A. Plan wet connections in manner and at hours with least inconvenience public. Notify Project Manager at least 72 hours in advance of making connections.

B. Do not operate valves on water lines in use by City. City of Houston Utility Operations Division will handle, at no cost to Contractor, operations involving opening and closing valves for wet connections.

C. Conduct connection operations when Inspector is at job site. Connection work shall progress without interruption until complete once existing water lines have been cut or plugs have been removed for making connections.

3.02 2-INCH WET CONNECTIONS

A. Use corporation cocks, saddles, copper tubing as required for line and grade adjustment, and brass fittings necessary to adapt to existing water line. Use 2-inch valves when indicated on Drawings for 2-inch copper gooseneck connections.

3.03 CONNECTION TO ASBESTOS-CEMENT (AC) PIPE

A. Notify Project Manager when AC pipe is encountered.

B. Refer to Section 02221 – Removing Existing Pavements and Structures for crew training, safety precautions, and AC pipe removal requirements.

C. Protocol:

1. Mechanically excavate to no more than 6 in. of AC Pipe. Carefully uncover the remainder of pipe by hand or with shovel.

2. Keep pipe adequately wet before and during work.

3. Place 2 layers of 6 mil polyethylene sheeting under the asbestos pipe to prevent soil contamination.

4. Use hand tools to remove collars. Replace minimum 6 ft. section of pipe. Use of power tools is prohibited.

5. Do not crush AC pipe in place. Remove waste AC pipe.

END OF SECTION

SECTION 02514

DISINFECTION OF WATER LINES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Disinfection of new potable water lines.

B. Disinfection of repair part used in wet connection, tapping sleeve and valves, clamps, valves and other related repairs.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01454 – Testing Laboratory Services

C. Section 02317 – Excavation and Backfill for Utilities

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for disinfection of water lines under this Section. Include cost in unit price of water lines being disinfected.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Adjusting Payment for Retesting.

1. Subsequent disinfection operations which may be necessary due to nonconforming or incomplete construction will be charged to Contractor. Charges will be deducted from retainage amounts when construction estimates are processed for final payment.

2. Total charge will consist of base charge of $135.00 plus footage charge based on number of feet of specified diameter pipe in construction project. Footage charge is as follows:

Size of Pipe	Charge per Linear Foot
2 inch to 4 inch	$0.03
6 inch	$0.04
8 inch	$0.05
10 inch to 12 inch	$0.07
16 inch to 20 inch	$0.09
24 inch to 30 inch	$0.13
32 inch to 48 inch	$0.16
54 inch	$0.20
60 inch	$0.22
66 inch	$0.31
72 inch to 84 inch	$0.40
90 inch to 96 inch	$0.58
108 inch	$0.75
120 inch or larger	$1.00

C. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AWWA C 651 - Standard for Disinfecting Water Mains.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 CONDUCTING DISINFECTION

A. Promptly disinfect water lines constructed before tests are conducted on water lines and before water lines are connected to City water distribution system.

B. Water for disinfection and flushing will be furnished by City without charge.

C. Unless otherwise provided in Contract Documents, City will conduct disinfection operations assisted by Contractor.

D. Coordinate chlorination operations through Project Manager.

E. Chlorine Disinfection for Connections and/or Repairs to Existing Mains less than or equal to 20-feet in length. When directed by Project Manager, follow procedures for disinfection by swabbing as listed below.

1. Comply with requirements of AWWA C 651 – Standard for Disinfecting Water Mains.

2. Minimize entry of contaminants into existing pipe by using temporary caps or other means. Dewater excavation and prevent entry of dirty water into pipe. Examine interior of existing pipe and remove pieces of pipe, scale, and other debris.

3. Coordinate with Project Manager for operation of valves and flushing line as necessary to complete disinfection procedures.

4. Prior to isolation of water line, take chlorine residual test upstream of repair location, record results.

5. Use appropriate personal protective equipment including rubber gloves and goggles. When necessary, use respiratory protection.

6. Mix a solution of 2 oz. of calcium hypochlorite (65% available chlorine) and 1 gallons of water, or 1 gallon of 5 percent bleach and 4 gallons of water.

7. Thoroughly swab new pieces of pipe, couplings, clamps, sleeves, and other components of pipe connection or repair using clean rags saturated with mixture or sprayer. A clean mop saturated with mixture may be used for longer pieces of pipe. Swab existing pipe exposed inside excavation.

8. After repair or connection is complete in place, coordinate with Project Manager to flush area of repair until water is clear. Obtain chlorine residual from downstream source. Compare results with previous chlorine residual standard.

9. If downstream chlorine results are higher than the upstream results, continue flushing until the downstream results equals the initial upstream result.

10. If downstream residuals are equal to or lower than upstream results, co-ordinate with Project Manager to re-isolate line segment and re-swab newly installed pipe and fittings. Return to step 8.

11. When chlorine residual downstream of repair equals the initial upstream results, slowly and fully open all valves isolated and proceed to backfill per Section 02317 - Excavation and Backfill for Utilities.

3.02 PREPARATION

A. Provide temporary blind flanges, cast-iron sleeves, plugs, necessary service taps, copper service leads, risers and jumpers of sizes, location and materials, and other items needed to facilitate disinfection of new water lines prior to connection to City water distribution system. Normally, each valved section of water line requires two each 3/4-inch taps. A 2-inch minimum blow-off is required for water lines up to and including 6-inch diameter.

B. Use fire hydrants as blow-offs to flush newly constructed water lines 8-inch diameters and above. Where fire hydrants are not available on water lines, install temporary blow-off valves as approved by Project Manager and remove promptly upon successful completion of disinfection and testing.

C. Slowly fill each section of pipe with water in manner approved by Project Manager. Average water velocity when filling pipeline should be less than one foot per second and shall not, under any circumstance, exceed 2 feet per second. Before beginning disinfection operations, expel air from pipeline.

D. Backfill excavations immediately after installation of risers or blow-offs.

E. Install blow-off valves at end of water line to facilitate flushing of dead-end water lines. Install permanent blow-off valves according to drawings.

3.03 DISINFECTION BY CITY PERSONNEL

A. Correct problems that may prevent disinfection operations prior to advising Project Manager to perform disinfection work. When disinfection work cannot be performed due to covered up valves, missing valve stacks, inoperative fire hydrants or other nonconforming construction, charge will be levied against Contractor for each trip made by City personnel.

B. Notify and coordinate with Project Manager minimum of 72 hours before disinfection work is to be performed. Assist City personnel during disinfection operations.

3.04 DISINFECTION BY CONTRACTOR

A. The following procedure will be used when disinfection by Contractor is required by Contract Documents:

1. Use not less than 100 parts of chlorine per million parts of water.

2. Introduce chlorinating material to water lines in accordance with AWWA C 651.

3. After contact period of not less than 24 hours, flush system with clean water until residual chlorine is no greater than 1.0 parts per million parts of water.

4. Open and close valves in lines being sterilized several times during contact period.

5. If chemical compound is used for sterilizing agent, place in pipes as directed by Project Manager.

3.05 BACTERIOLOGICAL TESTING

A. After disinfection and flushing of water lines, bacteriological tests will be performed by City or testing laboratory in accordance with Section 01454 - Testing Laboratory Services. When test results indicate need for additional disinfection of water lines based upon Texas Department of Health requirements, assist City with additional disinfection operations.

3.06 COMPLETION

A. Upon completion of disinfection and testing, remove risers except those approved for use in subsequent hydrostatic testing, and backfill excavation promptly.

END OF SECTION

SECTION 02515

HYDROSTATIC TESTING OF PIPELINES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Field hydrostatic testing of newly installed water pipelines.

1.02 RELATED SECTIONS

A. Section 01270 - Measurement and Payment

B. Section 02514 - Disinfection of Water Lines

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for hydrostatic testing of pipelines under this Section. Include cost in unit price of pipelines being tested.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 PREPARATION

A. Disinfect water system pipelines prior to hydrostatic testing.

B. Hydrostatically test newly installed water pipelines after disinfection, when required, and before connecting to City water distribution system.

C. Water for testing will be charged to Contractor in accordance with City Ordinances. Prior to hydrostatic testing, obtain a transient meter from the City Deposit is required for transient meter.

D. Test pipelines with maximum lengths between valves, or plugs, according to the following criteria.

1. 2,000 linear feet for small diameter pipelines (20-inches in diameters or smaller).

2. 4,000 linear feet for large diameter pipelines (24-inches in diameters or larger).

E. Conduct hydrostatic tests in presence of Project Manager.

3.02 TEST PROCEDURES

A. Furnish, install, and operate connections, pump, meter and gages necessary for hydrostatic testing.

B. Allow pipeline to sit minimum of 24 hours from time it is initially disinfected until testing begins, to allow pipe wall or lining material to absorb water. Periods of up to 7 days may be required for mortar lining to become saturated.

C. For small diameter pipelines, expel air and apply minimum test pressure of 125 psi. For large diameter water lines, expel air and apply minimum test pressure of 150 psi.

D. Begin test by 9:00 a.m. unless otherwise approved by Project Manager. Maintain test pressure for 8 hours. When large quantity of water is required to maintain pressure during test, discontinue testing until cause of water loss is identified and corrected.

E. Keep valves inside pressure reducing stations closed during hydrostatic pressure test.

3.03 ALLOWABLE LEAKAGE FOR WATERLINES

A. During hydrostatic tests, no leakage will be allowed for sections of water lines consisting of welded joints.

B. Maximum allowable leakage for water lines with rubber gasketed joints: 3.19 gallons per inch nominal diameter per mile of pipe per 24 hours while testing.

C. For meter run installation, when work cannot be isolated and line fails pressure test, visual inspection of work by Project Manager for leakage during pressure test may be used to fulfill requirements of this section.

3.04 CORRECTION FOR FAILED TESTS

A. Repair joints showing visible leaks on surface regardless of total leakage shown on test. Check valves and fittings to ensure that no leakage occurs that could affect or invalidate test. Remove cracked or defective pipes, fittings, and valves discovered during pressure test and replace with new items.

B. Project Manager may require failed lines to be disinfected after repair and prior to retesting. Conduct and pay for subsequent disinfection operations in accordance with requirements of Section 02514 - Disinfection of Water Lines. Pay for water required for additional disinfection and retesting.

C. Repeat test until satisfactory results are obtained.

3.05 COMPLETION

A. Upon satisfactory completion of testing, remove risers remaining from disinfection and hydrostatic testing, and backfill excavation promptly.

END OF SECTION

SECTION 02516

CUT, PLUG AND ABANDONMENT OF WATER LINES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Cut, plug and abandonment of water lines.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02951 – Pavement Repair and Restoration

E. Section 03315 – Concrete for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for cut, plug, and abandonment of water lines is on a unit price basis for each cut, plug, and abandonment performed. Separate payment will be made for each size of water line.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit product data for proposed plugs and clamps for approval.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete for reaction blocks: Class B conforming to requirements of Section 03315 - Concrete for Utility Construction.

B. Plugs and clamps: Applicable for type of pipe to be plugged.

PART 3 EXECUTION

3.01 APPLICATION

A. Do not begin cut, plug and abandonment operations until replacement water line has been constructed, disinfected, tested, and service lines have been transferred to replacement water line.

B. Install plug, clamp, and concrete reaction block and make cut at location shown on Drawings.

C. Main to be abandoned shall not be valved off and shall not be cut or plugged other than at supply water line or as shown on Drawings.

D. After water line to be abandoned has been cut and plugged, check for other sources feeding abandoned water line. When sources are found, notify Project Manager immediately. Cut and plug abandoned water line at point of other feed as directed by Project Manager.

E. Plug or cap ends or openings in abandoned water line in manner approved by Project Manager.

F. Remove and dispose of surface identifications such as valve boxes and fire hydrants. Valve boxes in improved streets, other than shell, may be filled with concrete after removing cap.

G. Backfill excavations in accordance with Section 02317 - Excavation and Backfill for Utilities.

H. Repair street surfaces in accordance with Section 02951- Pavement Repair and Restoration.

END OF SECTION

SECTION 02517

WATER LINE IN TUNNELS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Handling, transporting, and installing water line in primary liner tunnels, including invert cleanup and blocking and water line in casings that will be backfilled with concrete or grout.

1.02 REALTED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02425 – Tunnel Excavation and Primary Liner

D. Section 02431 – Tunnel Grout

E. Section 02447 – Installation of Water Lines by Slurry Bore

F. Section 02511 – Water Lines

G. Section 02518 – Steel Pipe and Fittings for Large Diameter Water Lines

H. Section 03315 – Concrete for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment of water line installed by tunneling is by linear foot along center line of completed water line as designated on Drawings.

2. Payment for installation of water line in tunnel constructed according to Section 02425 - Tunnel Excavation and Primary Liner will be authorized by Project Manager in three parts. Pay estimates for partial payments will be made as measured above according to following schedule:

a. 60 percent of installation will be authorized when excavation and primary liner installation is complete.

b. 95 percent of installation will be authorized when water line installation and grouting is complete.

c. 100 percent of installation will be authorized when section successfully hydrostatically tested.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work is in this Section is included in total Stipulated Price.

1.04 REFERENCE STANDARDS

A. ASME B 40.1 - Pressure Gauge and Gauge Attachments.

1.05 SUBMITTALS

A. Submit work plan including following information in accordance with Section 01330 - Submittals.

1. Method of transporting pipes into tunnel.

2. Method of hoisting and positioning pipe in tunnel.

3. Method of jointing and aligning pipe.

4. Method of supporting and blocking pipe.

5. Tunnel ventilation while setting pipe and completing joints, when applicable.

6. Material, equipment and procedures for grout placement and other information required by Section 02431 - Tunnel Grout.

B. Submit results of tunnel primary liner survey in accordance with Paragraph 3.02, Tunnel Survey.

C. Submit results of installed water line survey in accordance with Paragraph 3.10, As-built Survey and Installation Tolerances.

1.06 PROCEDURES

A. Joints: Prepare joints as recommended by pipe manufacturer and in accordance with Section 02511 - Water Lines.

B. Handling: Handle, store, and transport pipe in accordance with pipe manufacturer's recommendations and to prevent damage to pipe ends, pipe barrel, steel reinforcement, and pipe protective linings.

C. Grouting: Perform grouting of annular space between water line and tunnel liner to fill voids with grout, without dislocating or damaging pipe.

PART 2 PRODUCTS

2.01 ANNULAR GROUT

A. Specified in Section 02431 - Tunnel Grout

2.02 CONCRETE

A. Meeting requirement of Section 03315 - Concrete for Utility Construction, Class B concrete.

2.03 PIPE MATERIAL AND FITTINGS

A. Manufacture and deliver pipe material and fittings as described in Section 02511 - Water Lines.

2.04 SPACERS

A. Unless otherwise noted on Drawings, use casing spacers between water line and casing tunnel liner for water lines less than 24 inches in diameter. Refer to Paragraph 3.01 for exception. See Section 02447 – Installation of Water Lines by Slurry Bore for spacer requirements and installation.

PART 3 EXECUTION

3.01 APPLICATION

A. Grout in place, tunnels for water lines with diameters of 36-inches or greater. When tunnel liner plate is used, grout water line in place regardless of water line diameter.

3.02 TUNNEL SURVEY

A. Prior to installing water line in tunnel: Perform survey of tunnel in accordance with Paragraph 3.10B. Verify tunnel has been constructed within specified tolerances for line, grade, and roundness and water line to be placed in tunnel can be placed in conformance with tolerances specified. Should misalignment of tunnel preclude proper installation of water line, notify Project Manager of proposed correction method. Project Manager will make final decision on acceptability of correction.

3.03 PIPE TRANSPORT

A. Transport pipe in tunnel for final placement so that no damage occurs to pipe ends or pipe barrel and interior lining or exterior coating. Repair pipe damaged during transport or final placement in tunnel in manner acceptable to Project Manager prior to joining. Remove damaged pipe from tunnel and replace, when directed by Project Manager, at no additional cost to City.

3.04 TUNNEL CLEANUP

A. Remove temporary tunnel utilities, loose material, dirt, and debris prior to pipe placement. Broom clean concrete invert. Control seepage and remove standing water in invert.

B. Temporary construction tracks or pipe skids may be left in place when they do not interfere with alignment of water line, short circuit cathodic protection system, or interfere with final placement of annular grout.

3.05 INVERT PIPE SUPPORT

A. Construct invert pipe support of screeded concrete, steel beam, or other method, as approved, to final grade of outside of water line. Secure invert support to primary liner to prevent movement. Cure concrete support minimum of 48 hours prior to setting pipe. Maintain minimum of 4-inches clearance between outside of water line and steel beam or steel member.

3.06 JOINING PIPE IN TUNNELS

A. Lay pipe in accordance with pipe manufacturer's recommendations, and as specified in this Section. Join pipe segments so as to properly compress gaskets and allow for correct final positioning of pipe for line and grade. Closely align pipe and bring loosely together by means of hydraulic jacks, locomotives, pipe mobiles, or winches. Once pipes have been loosely joined, pull home by means of hydraulic tugger or other similar methods suitably protecting pipe and joints against damage. Impact joining, such as ramming with locomotives or other mechanical equipment, is not permitted.

3.07 SUPPORTING PIPE IN TUNNEL AND BULKHEADS

A. Develop and submit pipe supporting system that will prevent water line from floating and deforming beyond specified limits. Loads imposed on pipe, primary liner and surrounding soil during grouting shall be determined by Registered Professional Engineer in State of Texas. Show essential details in plan for supporting system. Position water line in tunnel to allow minimum of 4 inches of grout to be placed between water line and tunnel primary liner or casing.

B. Wooden support blocks are not allowed.

C. Prevent pipe from floating during backfill operations by properly installed supporting. Remove and replace segment of pipe which is distorted or moved from final line and grade.

D. Secure supporting in place so that it cannot be dislodged during adjacent pipe laying and during grouting operations.

E. Construct bulkheads of material, compatible with grout, to withstand imposed grout pressure without leakage. Provide bulkheads at frequency to allow completion of grouting in continuous operation and to permit timely removal of pipe and grout which may be needed as result of pipe distortion or movement. Modifications to bulkhead spacing will be reviewed by Project Manager. Provide adequate venting for bulkheads.

F. Contractor may use mortar bands, casing spacers or blocking to support pipe in tunnel.

G. If mortar bands are used, mortar coating must be used. Refer to Section 02518 – Steel Pipe and Fittings for Large Diameter Water Lines for requirements.

3.08 ANNULAR GROUT

A. Fill annular void between water line and tunnel primary liner or casing with grout, in accordance with Section 02431 - Tunnel Grout.

B. Test annular grout material, equipment, and procedures in accordance with approved submittal. Perform test on first 200 feet of water line to be backfilled. When grout does not totally fill annular space or other problems occur, correct defects in first test section and adjust method or mix and rerun test on next 200 feet. Repeat procedure as necessary.

C. Placement:

1. Placement Limits: Predetermine limits of each grout placement stage by size and capacity of batching equipment and initial set time of proposed grout. Under no circumstances shall placement at grout port continue longer than period of time for mix to take initial set. Locate grout hole spacing and locations according to number of stages necessary to backfill tunnel liner. Do not install another lift until proper set has been attained. Placement procedures shall be approved by admixture or additive manufacturers.

2. Equipment - Pumps: Pumping equipment must be of sufficient size and capacity to place grout to distances and volumes compatible with batching and mixing equipment. Maintain equipment and clean thoroughly each day. No hydrocarbons shall enter pumping chamber. Under no circumstances shall grout be pumped in excess of 1000 linear feet without prior approval by Project Manager. Pumping test and verification testing of resulting grout quality will be required for approval.

3. Slickline: Convey grout to point of placement in clean steel or rubber hoses designed to handle safely, pump pressure and volumes during placement. Do not allow hardened grout or concrete to obstruct or coat steel pipe or hose internally.

4. Grout Connections: Grout connections shall be sized minimum of 2-inch inside diameter, consisting of grout hose attached immediately to pressure gauge. Gauged pumping pressure shall not exceed water line manufacturer's recommendations. Monitor grout pressure.

5. Gauges:

a. Type: Instrument oil-filled and attached to saddle-type diaphragm seal (gauge saver) to prevent clogging with grout.

b. Calibration: Certified and calibrated in accordance with ASME B 40.1.

c. Range: Not more than 100 percent greater than design grout pressure.

d. Accuracy: No more than one-half percent error over full range of gauge.

e. Fitting: Attach gauge to valve immediately attached to grout port in tunnel liner. Provide T-fitting in injection line for sampling.

6. Limit pressure on annular space to prevent damage to pipe or liner. Define limiting and estimated required pressure range. Provide and monitor open ended, high point tap or equivalent vent at bulkhead opposite point of grouting.

7. Pump grout until grout within 5 percent of specified density discharges from end opposite injection point to ensure grout is not diluted by extraneous water in annulus.

8. Drilling of access holes from surface to facilitate grouting shall not be allowed.

9. Communication: There shall be constant communications via telephone between headerman at point of injection and pump, batch plant, and supervisor. Under no circumstance shall grouting continue without continuity of communications.

10. The headerman at point of placement shall advise batch plant of variations of density and make corrections as necessary. Record and submit to Project Manager for each days pour variations and corrections.

D. Delay grouting until all significant differential movement has stopped as determined by monitoring.

E. Remove bulkheads unless constructed of masonry.

F. Repair or replace damage or distortion to water line.

3.09 GROUTING JOINTS

A. Materials and procedures for filling interior joint recesses shall conform to Section 02511 - Water Lines.

3.10 AS-BUILT SURVEY AND INSTALLATION TOLERANCES

A. Perform as-built survey on installed water line. Determine horizontal and vertical location for invert of each pipe joint.

B. Acceptable tolerances: Within plus or minus 3 inches of horizontal alignment, within plus or minus 2 inches of vertical alignment.

END OF SECTION

SECTION 02518

STEEL PIPE AND FITTINGS FOR LARGE DIAMETER WATER LINES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Large diameter (24 inches and greater) steel pipe and fittings for water lines and pumping facilities.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02425 – Tunnel Excavation and Primary Liner

E. Section 02502 – Steel Pipe and Fittings

F. Section 02511 – Water Lines

G. Section 02527 – Polyurethane Coatings on Steel or Ductile Iron Pipe

H. Section 02529 – Tape Coatings on Steel Pipe

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for steel pipe and fittings under this Section. Include cost in unit price for water lines, pumping facilities, and encasement sleeves.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AASHTO - Standard Specifications for Highway Bridges.

B. AREMA - Manual for Railway Engineering, Volume II, Chapter 15.

C. ASME Boiler & Pressure Vessel Code (BPVC) Section VIII – Rules for Construction of Pressure Vessels, Division 1

D. ASTM A 36 - Standard Specification for Carbon Structural Steel.

E. ASTM A 53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

F. ASTM A 135 - Standard Specification for Electric-Resistance-Welded Steel Pipe.

G. ASTM A 139 - Standard Specification for Electric-Fusion (ARC) - Welded Steel Pipe (NPS 4 and Over).

H. ASTM A 1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.

I. ASTM C 33 - Standard Specification for Concrete Aggregates.

J. ASTM C 35 - Standard Specification for Inorganic Aggregates for Use in Gypsum Plaster.

K. ASTM C 150 - Standard Specification for Portland Cement.

L. ASTM C 494 - Standard Specification for Chemical Admixtures for Concrete.

M. ASTM C 595 - Standard Specification for Blended Hydraulic Cements.

N. ASTM C 881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

O. ASTM C 1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).

P. ASTM D 512 - Standard Test Methods for Chloride Ion in Water.

Q. ASTM A 1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

R. ASTM A 1018 - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.

S. ASTM D 1293 - Standard Test Methods for pH of Water.

T. ASTM D 3363 - Standard Test Method for Film Hardness by Pencil Test.

U. ASTM D 4541 - Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Tests.

V. ASTM D 4752 - Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub.

W. AWWA C 200 - Steel Water Pipe 6 in. and Larger.

X. AWWA C 205 - Cement-Mortar Protective Lining and Coating for Steel Water Pipe4 in. (100 mm) and Larger-Shop Applied.

Y. AWWA C 206 - Standard for Field Welding of Steel Water Pipe.

Z. AWWA C 207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 in. through 144 in.

AA. AWWA C 208 - Dimensions for Fabricated Steel Water Pipe Fittings; Addendum C 208A.

BB. AWWA C 210 - Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.

CC. AWWA C 216 – Heat-Shrinkable Cross-Linked Polyolefin Coatings for Steel Water Pipe and Fittings.

DD. AWWA C 217 – Microcrystalline Wax and Petrolatum Tape Coating Systems for Steel Water Pipe and Fittings.

EE. AWWA C222 – Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings.

FF. AWWA C 602 - Cement-Mortar Lining of Water Pipelines in Place - 4 in. (100 mm) and Larger.

GG. AWWA C 604 – Installation of Buried Steel Water Pipe – 4 In. (100 mm) and Larger.

HH. AWWA M 11 - Steel Pipe-A Guide for Design and Installation.

II. ISO 9001 – International Organization for Standardization – Quality Management Systems.

JJ. NSF/ANSI 61 – Drinking Water Systems Components Health Effects.

KK. SPFA – Steel Plate Fabricators Association

LL. SSPC Good Painting Practice, Volume 1.

MM. SSPC SP 1 - Solvent Cleaning.

NN. SSPC SP 5/NACE No. 1 - White Metal Blast Cleaning.

OO. SSPC SP 6/NACE No. 3 - Commercial Blast Cleaning.

PP. SSPC SP 10/NACE No. 2 - Near-White Blast Cleaning.

QQ. SSPC VIS 1 - Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning:.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit shop drawings signed and sealed by Professional Engineer registered in State of Texas showing following:

1. Manufacturer's pipe design and thrust restraint calculations based on AWWA M11, latest edition.

2. Provide lay schedule of pictorial nature indicating alignment and grade, laying dimensions, welding procedures, fabrication, fitting, flange, and special details, with plan view of each pipe segment sketched, detailing pipe invert elevations, horizontal bends, welded joints, and other critical features. Indicate station numbers for pipe and fittings corresponding to Drawings. Do not start production of pipe and fittings prior to review and approval by Project Manager. Provide final approved lay schedule on CD-ROM in Adobe portable document format (*.PDF).

3. Include hot tapping procedure.

4. Submit certification from manufacturer that design was performed for project in accordance with requirements of this section. Certification to be signed and sealed by professional Engineer registered in State of Texas.

C. Submit manufacturer's certifications that pipe and fittings have been hydrostatically tested at factory in accordance with AWWA C 200, paragraph 5.2.

D. Submit certification from NACE Certified Coatings Inspector, under supervision of inspector having Level III certification for coatings and linings, that steel pipe furnished on project was properly inspected and defective coatings detected properly repaired.

E. Submit inspection procedures to be used by manufacturer and for quality control and assurance for materials and welding. Submit, at least 30 days prior to repair work, procedures that describe in detail shop and field work to be performed. Repair defects such as substandard welds, excessive radial offsets (misalignment), pitting, gouges, cracks, etc.

F. Submit following for non-shrink grout for special applications:

1. Manufacturer's technical literature including specifications for mixing, placing, and curing grout.

2. Results of tests performed by certified independent testing laboratory showing conformance to ASTM C 1107, Non-shrink Grout and requirements of this specification.

3. Certification product is suitable for use in contact with potable water.

G. Submit proof of certification for welders. Indicate certified procedures and position each welder is qualified to perform. Provide documentation of the most recent weld qualification test date and continuity of use in each process for which the welder or welding operator is required.

H. Within 45 calendar days after manufacturing of all pipe, submit affidavit of compliance that materials and work furnished comply with applicable requirements of referenced standards and these specifications. Make available copy of physical and chemical testing reports.

I. Within 45 days of manufacturing of all pipe, submit manufacturer's affidavits that coatings and linings comply with applicable requirements of this Section and:

1. Polyurethane coatings were applied in accordance with manufacturer's recommendation applied and allowed to cure at temperature 5 degrees above dew point.

2. Mortar coatings and linings were applied and allowed to cure at temperature above 32 degrees F.

3. Test Results:

a. Compressive strength (7 and 28 day) test results for mortar coating.

b. Hydrostatic testing, magnetic particle and non-destructive weld test reports as required.

J. Prior to start of field-applied cement mortar lining operation, submit comprehensive plan which identifies and describes as minimum:

1. Equipment used for batching, weighing, mixing, transporting and placing mortar.

2. Qualifications and specific experience of machine operators.

3. Source and type of cement, pozzolan, sand and admixtures used and certifications from suppliers that materials meet specifications.

4. Mix proportions to be used and slump limits (max. and min.).

5. A quality control plan which identifies quality control material tests and documented inspections necessary to ensure compliance with specified requirements.

K. Submit certification showing calibration within last 12 months for equipment such as scales, measuring devices, and calibration tools used in manufacture of pipe. Each device used in manufacture of pipe is required to have tag recording date of last calibration. Devices are subject to inspection by Project Manager.

1.06 QUALITY CONTROL

A. Provide pipe as the product from a single manufacturer who has had not less than five (5) years successful experience manufacturing pipe, fittings and specials with coatings and linings as specified. Pipe and fitting manufacturing operations shall be performed at one location by the same manufacturer, unless otherwise approved by Project Manager.

B. The manufacturer of pipe and fittings shall be certified either under SPFA or ISO 9001 quality certification program for steel pipe and accessory manufacturing.

C. Approved steel pipe manufacturers are as follows:

1. American SpiralWeld Pipe

2. Northwest Pipe

3. Thompson Pipe Group

4. Mid America Pipe

D. Manufacturer to provide permanent quality control department and laboratory facility capable of performing inspections and testing as required by specifications. Material testing, inspection procedures, and manufacturing process are subject to inspection by Project Engineer. Perform manufacturer's tests and inspections required by referenced standards and these specifications, including the following. Correct nonconforming conditions.

1. Steel Plate and Coils. Review mill certifications for conformance to requirements of specifications; perform physical and chemical testing of each heat of steel for conformance to applicable ASTM standards.

2. Pipe:

a. Inspect thickness, circumference, roundness, strength and size of seam welds (spiral or longitudinal), and squareness of pipe ends to verify compliance with AWWA C200.

(1) Pipe roundness to be within ± 1%.

(2) Frequency of production weld tests in accordance with AWWA C200 paragraph 4.10.4.6. Conduct weld tests at a maximum interval of once per 3,000 feet of weld.

(3) Provide certified test reports for factory welds on fittings from a certified welding inspector that may be in-house or third-party.

b. Inspect physical dimensions and overall conditions of all joints for compliance with AWWA C200, approved submittals, and Specifications.

c. Hydrostatically test finished pipe section to 75 percent of specified minimum yield strength of steel being used with zero leakage.

d. Perform Charpy V-Notch (CVN) Test in accordance with AWWA C200.

3. Linings:

a. Inspect unlined pipe for overall condition of inside barrel. Maintain inside barrel free of corrosive products, oil, grease, dirt, chemical, and deleterious material.

b. Inspect lined pipe for physical dimensions and overall condition of lining, visible surface defects, thickness of lining, and adhesion to steel surface (for polyurethane or epoxy lining).

c. Review certifications by manufacturers of lining components for conformance to AWWA standards and these Specifications.

4. Coatings: Measure temperature and dew point of ambient air before applying coatings. Inspect physical dimensions and overall condition of coatings. Inspect for visible surface defects, thickness, and adhesion of coating to surface and between layers.

5. Gaskets: Randomly test rubber cord for diameter, tensile strength, elongation, compression set, hardness, and specific gravity after oven aging on one out of 100 gaskets. Stretch test each gasket splice to twice its unstretched length and inspect for defects.

6. Final Inspection:

a. Before shipment, inspect finished pipe, fittings, specials and accessories for markings, metal, coating thickness, lining thickness (if shop applied), joint dimensions, and roundness.

b. Inspect for coating placement and defects. Test exterior coating for holidays.

c. Inspect linings for thickness, pitting, scarring, and adhesion.

E. Shop-applied coatings and linings; provide services of qualified and certified coating and lining in house inspector, outside inspection service, or testing laboratory with qualified coating inspectors. Perform inspection by NACE trained inspectors under supervision of NACE Level III Certified Coatings Inspector.

F. Ensure workmen engaged in manufacturing are qualified and experienced in performance of their specific duties.

G. Cast four standard test cylinders each day for each 50 cubic yards of mortar coating or portion thereof for each coating and lining placed in a day. Perform compressive strength test at 28 days. No cylinder test result will be less than 80 percent of specified strength.

H. Dented steel cylinders may result in rejection of pipe if it cannot be repaired per AWWA C200 and to the satisfaction of the Project Manager.

I. Make available copy of physical and chemical testing reports for steel cylinders and provide reports at request of Project Manager.

J. Check physical dimensions of pipe and fittings. Physical dimensions to include at least pipe lengths, pipe I.D., pipe O.D. and bend angles.

K. Owner's representative shall have access to the work as it is in preparation or progress, and the pipe manufacturer shall provide proper facilities for access and for inspection. Material, fabricated parts, and pipe, which are discovered to be defective, or which do not conform to the requirements of this Section shall be subject to rejection at any time prior to Owner's representative final acceptance of the product.

L. Manufacturer's Technician Required for Pipe Installation

1. During the construction period, the pipe manufacturer shall furnish the services of a factory trained, qualified, job experienced technician to advise and instruct the Contractor and Owner's representative as necessary to assure the proper handling, storage, joint assembly, lining and coating repair of the pipe. The technician shall advise the Contractor in pipe laying operations and shall instruct construction personnel in proper joint assembly and joint inspection procedures. The technician shall be on-site full time during the first two-weeks of pipe laying and thereafter as requested by the Owner's representative.

2. The pipe manufacturer shall provide services of the coating manufacturer's qualified representative and a qualified representative from the heat shrink sleeve manufacturer of a period of not less than two weeks at the beginning of actual pipe laying operations to advise Contractor and Owner's representative regrading installation including handling and storage, cleaning, and inspecting, coating repairs, field applied coating, heat shrink installation procedures and general construction methods and how they may affect the pipe coating.

3. The manufacturer's representative shall be required to return if, in the opinion of the Owner's representative, the coating, lining, or the Contractor's construction methods do not comply with the Contract Documents.

1.07 QUALITY ASSURANCE

A. Project Manager may witness manufacture and fabrication of pipe and appurtenances. Independent testing laboratory under contract to Project Manager may perform tests at direction of Project Manager to verify compliance with these specifications. Provide assistance to accomplish such testing, including equipment and personnel, at no additional cost to City.

PART 2 PRODUCTS

2.01 STEEL PIPE

A. Furnish pipe, fittings, coating and linings all by one manufacturer and produced in one facility. Do not ship over salt water.

B. Furnish pipe smaller than 24-inch in accordance with Section 02502 - Steel Pipe and Fittings.

C. Fabricate and supply miscellaneous steel pipe and fittings in accordance with AWWA C200, AWWA C207, AWWA C208, AWWA M11 and ASME BPVC except as modified herein. Steel to be minimum of ASTM A 36, ASTM 1018 Grade 36, ASTM A 53 Grade B, ASTM A 135 Grade B, ASTM A1011 or ASTM A 139 Grade B.

D. Provide pipe sections in lengths no greater than 50 feet and no less than 20 feet except as required for special fittings or closure sections.

E. Provide shop-coated and shop-lined steel pipe with minimum of one coat of shop-applied primer approved for use in potable water transmission on all exposed steel surfaces. Provide primer compatible with coating system and in accordance with coating manufacturer's recommendations.

F. Provide closure sections and short sections of steel pipe not less than 4 feet in length unless indicated on Drawings or specifically permitted by Project Manager.

G. Square flanges with pipe with bolt holes straddling both horizontal and vertical axis. Provide 1/2-inch gap between pipe ends to be coupled with sleeve coupling unless otherwise indicated on Drawings.

1. Provide standard ring flanges, conforming to AWWA C207, Class D.

2. Apply Denso petroleum-based tape or approved equal to exposed portions of nuts and bolts.

H. Pipe Design Conditions:

1. Design: Design pipe and fittings to withstand most critical simultaneous application of external loads and internal pressures. Base design on minimum of AASHTO HL-93 loading or AREMA E-80 loads as appropriate and depths of bury as indicated on Drawings. Design pipes with Marston's earth loads for transition width trench for all heights of cover.

2. Groundwater Level: Design for most critical ground water level condition.

3. Working pressure = 150 psi.

4. Hydrostatic field test pressure = 150 psi.

5. Maximum total pressure due to surge = 225 psi.

6. Minimum pressure due to surge = -5 psi.

7. Modulus of elasticity (E) = 30,000,000 psi.

8. Maximum deflection from specified diameter: Two (2) percent for mortar coating; three percent for flexible coatings and three percent for mortar lining.

9. Design stress due to working pressure to be no greater than 50 percent of minimum yield, and stress not to exceed 18,000 psi for mortar coated pipe.

10. Design stress due to maximum hydraulic surge pressure to be no greater than 75 percent of minimum yield, and stress not to exceed 27,000 psi for mortar coated pipe.

11. Modulus of soil reaction (E') < 1500 psi. If E' > 1000 psi, do not use silty sand (SM) for embedment.

12. Unit weight of fill (w) > 120 pcf.

13. Deflection lag factor (D1) = 1.2.

14. Bedding constant (K) = 0.1.

15. Fully saturated soil conditions: hw = h = depth of cover above top of pipe.

16. Do not allow diameter (D) over thickness (t) ratio to be greater than 230.

17. Provide minimum inside clear diameter for tunnel liners or casing in accordance with Section 02425LD- Tunnel Excavation and Primary Liner.

18. Exclude structural benefits associated with primary liner in design of pipe in tunnel installations.

    a. Design pipe and joints to carry loads including overburden and lateral earth pressures, subsurface soil and water loads, grouting, other conditions of service, thrust of jacks, and stresses anticipated during handling and construction loads during installation of pipe.

    b. Do not use internal removable stiffeners for pipe in tunnel, unless approved by Project Manager.

    c. External welded steel stiffeners will be permitted in design calculations for steel pipe, provided wall thickness is minimum of 1/2-inch. Minimum clearances specified between exterior pipe wall and tunnel liner applies to distance between outside diameter of external welded stiffener and tunnel liner.

19. Nominal Allowable Steel-wall Thickness for Water Lines: Provide in accordance with following table for HL-93 live loads and depths of cover of up to 16 feet. Net internal diameter (including inside linings) to be no less than net inside diameter listed. Contractor to review design for conditions more extreme than those indicated by this specification and design accordingly. Submittal of design calculations will be required for review. Pipe wall not to be less than that defined in following table.

Net Inside Diameter (Inches)	Minimum Wall Thickness (Inches)	
	Flexible Coating	Mortar Coating
108	0.500	N/A
102	0.500	N/A
96	0.484	0.464
90	0.454	0.430
84	0.423	0.395
78	0.393	0.359
72	0.362	0.320
66	0.333	0.295
60	0.301	0.268
54	0.271	0.250
48	0.235	0.215
42	0.207	0.189
36	0.178	0.163
30	0.149	0.136
24	0.149	0.136

I. Fittings for Water Lines: Fabricate in accordance with AWWA M11, and AWWA C208.

1. Wall Thickness: Equal to or greater than pipe to which fitting is to be welded.

2. Elbows: 2-piece for 0 degrees to 22-1/2 degrees; 3-piece for 23 degrees to 45 degrees; 4-piece for 46 degrees to 67-1/2 degrees; and 5-piece for 68 degrees to 90 degrees, unless otherwise shown on Drawings. Radius: Minimum radius of two and one-half times pipe diameter unless otherwise approved by Project Manager.

3. Outlets: Reinforced in accordance with AWWA M11, Chapter 9, AWWA C200, and AWWA C208. Provide interior lining and exterior coating in accordance with paragraphs on coating and lining and matching pipe to access inlets, service outlets, test inlets, and air-vacuum valve and other outlets, including riser pipes.

4. Butt Straps for Closure Piece: Minimum 12-inch-wide split butt strap; minimum plate thickness equal to thinnest member being joined; fabricated using material listed in Paragraph 2.01.C to thinnest member being joined. Provide minimum lap of 4 inches between member being joined and edge of butt strap, welded on both inside and outside, unless otherwise approved by Project Manager. Provide minimum 6-inch welded outlet for inspecting each closure section, unless access manway is within 40 feet of closure section.

5. Reducers: Provide in accordance with AWWA M11 and AWWA C208.

6. Dished Head Plugs: Design in accordance with AWWA M11, latest edition. Design to withstand field hydrostatic test pressure from either side of plug. The allowable design stress shall be equal to 50 percent of the minimum specified yield strength of the head material, or 18,000 psi, whichever is less. Pipe on opposite side of hydrostatic test may or may not contain water.

J. Joints:

1. Standard field joint for steel pipe: AWWA M11 and AWWA C200. Rubber gasket Carnegie shape joint or rolled-groove rubber gasket and O-ring joint, in accordance with Contract Drawings, 66-inch maximum diameter. Joints may be lap-welded slip type in accordance with AWWA C200, except where flanged joints or butt strap joints are required.

2. Provide welded butt joints on above-ground piping, tee fitting supported on pier foundation, field welds for risers including vertical portion of crossover piping, and where noted on Drawings.

3. Pipe Manufacturer: Minimum of 5 years of successful service with proposed rubber gasket field joint and submit results from joint tests. Tests which may be required include tensile strength or yield tests of base material and spiral welded sections, flattening tests, chemical analysis, impact and hardness tests. Project Manager’s decision as to acceptability of joint is final.

4. Pipe installed via tunnel to be capable of withstanding jacking forces.

5. Design restrained joints for test pressure or maximum surge pressure as specified, whichever is greater. Only minimum restrained joint lengths for prestressed concrete cylinder pipe are shown on Drawings.

6. Provide full circumferential welds at joints required to be welded.

7. Rubber Gasketed Bell-and-Spigot Joints.

8. Bells: Formed by either expansion of pipe end, which stretches steel past its elastic limit, or by attaching sized weld-on bell rings. Spigot ends: Sized prior to rolling gasket groove. Joints: Interchangeable and match up during installation, even if used out of sequence. Weld-on bell rings: AWWA M11; AWWA C200; attached with single or double, full thickness fillet welds (double weld in areas of thrust restraint).

9. Provide bells and spigots with dimensions and tolerances in accordance with AWWA C200, as modified herein. Difference in diameter between I.D. of bell and O.D. of spigot shoulder at point of full engagement with allowable deflection range of 0.00 inch to 0.04 inch as measured on circumference with diameter tape. Minimum thickness of completed bell ring is equal to thickness of pipe wall in barrel of pipe between joint ends.

    a. Furnish joint suitable for safe working pressure equal to class of pipe and will operate satisfactorily with deflection, tangent of which is not to exceed 3/4-inch/D where D is outside diameter of pipe in inches or with pull-out of 3/4-inch.

    b. Design clearance between bells and gasketed spigots so, when joint is assembled, it will be self-centered and gasket will be restrained or confined to annular space in such manner that movement of pipe or hydrostatic pressure cannot displace it. Compression of gasket when joint is completed will not be dependent upon water pressure in pipe and will provide watertight joints under operating conditions when properly installed.

    c. Use of an expanded bell with a Carnegie-style spigot is not allowed.

K. Contractor must maintain on site or in plant enough fittings to satisfy the following requirements:

Line Diameter	Required Bends*
20 and 24 inches	Four 45-degree bends per 5,000 LF of water line
> 24 inches	Four 22.5-degree bends per 10,000 LF of water line
*Based on total length of contract (minimum of four). Any combination of bends may be substituted at manufacturer's option (i.e. two 22.5-degree bends are equivalent to one 45-degree bend) and will be counted as one fitting.	

L. Contractor must be capable of delivering bends to job site within 48 hours of notification. Use fittings at direction of Project Manager where unforeseen obstacles are encountered during construction. These fittings are in addition to fittings called out on Drawings and must be available at all times. Use same product throughout entire project.

M. Perform x-ray, ultrasonic, magnetic particle, or dye penetrant testing per AWWA C200 of manual welds on special pipe and fittings.

N. Hydrostatic Test of Pipe:

1. AWWA C200, paragraph 5.2.1, at point of manufacture. Hold test pressure for minimum 2 minutes and conduct thorough inspection of entire weld length on pipe. Repair or reject pipe revealing leaks or cracks.

2. Calibrate pressure gauges within one year prior to testing as specified in Section 1.05 K.

O. Provide forged steel threaded outlets of approved design where required for use in passing hose or lead wires into pipe. Tap plugs with standard pipe threads and weld to pipe in approved manner and use solid forged steel plugs for closure.

P. Flanges:

1. Conform to requirements of Section 02511 – Water Lines.

Q. Make curves and bends by deflecting joints, or by using mitered joints, or by combination of two methods, unless otherwise indicated on Drawings or permitted by Project Manager. Do not exceed deflection or joint offset angle at joint as recommended by pipe manufacturer. Make penetration of spigot into bell at all points of circumference at least equal to minimum required penetration shown on Drawings. Mitered pipe sections used in curved alignment to be of standard length except when shorter sections are required to limit radius of curvature, in which case all sections throughout curve are to be of equal length. Do not allow miter to exceed 5 degrees.

2.02 INTERNAL LINING SYSTEMS FOR STEEL PIPE, ALL INSTALLATIONS

A. Supply steel pipe with cement-mortar lining, capable of conveying water at temperatures up to 140 degrees F.

B. For all exposed (wetted) steel parts of flanges, blind flanges, bolts, access manhole covers, provide epoxy or polyurethane lining, as specified, unless otherwise noted or that may interfere with sealing surfaces.

C. Provide linings conforming to American National Standards Institute/National Sanitation Foundation (NSF/ANSI) Standard 61, and certification to be from organization accredited by ANSI.

D. Epoxy Lining:

1. AWWA C210, color White or Off-White, or approved equal otherwise approved by Project Manager. To be applied in factory. Perform field repairs in accordance with manufacturer’s recommendations. Submit field repair procedures to Project Manager for review. Provide materials from same manufacturer.

a. Protect interior surface with liquid two-part chemically cured epoxy coating specified for interior surfaces.

Surface Preparation	SSPC-SP10 Near White Blast Clean surface profile.
Finish Coat	AWWA C210. Provide Devoe Bar- Rust 233H or approved equal

2. Provide dry film thicknesses (DFT) in accordance with product's manufacturer recommendations. Do not exceed maximum DFT as recommended by manufacturer.

3. Factory testing: In accordance with AWWA C210.

E. Shop-applied Cement-mortar Lining (for pipe s 120 inches in diameter):

1. AWWA C205; except as specified herein: 3/4-inch minimum thickness for pipe diameters 96-inches and larger, 1/2-inch minimum thickness for pipe diameters 42 inches to 84-inch; 3/8-inch minimum thickness for pipe diameters 36 inches and smaller. Cut back lining from joint ends no more than 2 inches to facilitate joining and welding of pipe.

2. Apply cement-mortar lining to inside of pipe by centrifugally spinning. For special sections (shape of which precludes application by spinning method) accomplish by mechanical placement or pneumatic placement and finish to produce smooth, dense surface comparable to centrifugally spinning.

3. Use galvanized wire mesh when shop-applied mortar is not applied by machine. Do not extend wire mesh across welded portion of mitered fittings. Crimp mesh to provide integral "chair" so wire does not fully rest against steel cylinder.

4. Make repairs of cement-mortar lining for widths exceeding 6 inches by bonding to steel and adjacent faces of lining with bonding agent conforming to ASTM C 881, Type II.

5. Restrict usage of sprinkler heads during moist curing to prevent over-spraying onto lining. No alternative curing methods are allowed.

6. Satisfy Project Manager that above requirements can be accomplished by manufacturer prior to shipment of pipe.

F. Field-applied Cement-mortar Lining (for pipe > 48 inches in diameter): Provide field-applied internal cement-mortar linings in accordance with AWWA C602, latest edition, except as modified in this Section.

1. Lining: Applied in one-course application of cement-mortar by machine that centrifugally places mortar against wall of pipe and mechanically trowel lining to smooth finish.

2. Steel pipe, fittings, receive cement-mortar lining.

3. Cement-mortar for Lining.

    a. Cement-mortar: Dense, smooth, and of uniform quality and consistency to assure efficient machine operation and uniform cement-mortar lining on pipe wall.

    b. Water-cement Ratio: Kept as low as possible; consistent with proper plasticity for application, allowing slight variations dependent upon temperature, length of haul for mortar, and moisture condition in pipe.

    c. Mortar: Mixture of one part cement with not less than one or more than 1-1/2 parts of dry screened sand, by volume. After determining mixture, control materials to within plus or minus 2-1/2 percent by weight throughout entire work.

    d. Comply with following materials for cement-mortar:

        (1) Provide Type II low-alkali Portland cement conforming to ASTM C 150, or Type IP (MS) Portland-Pozzolan cement conforming to ASTM C 595, unless otherwise specified. Conform to low alkali requirements of Table IA of ASTM C 150. Type IP (MS) cement to contain no more than 20 percent Pozzolan, to be inter-ground with clinker.

        (2) Use suitable facilities approved by Project Manager when available for handling and weighing bulk cement. Otherwise, deliver cement in original unopened sacks that have been filled by manufacturer. Plainly mark sacks with manufacturer's name or brand, cement type lot number and weight. Discard unused cement. Use unopened bags of cement for each new batch.

        (3) Material Storage: Store cement to permit ready access for inspection and sampling. Protect cement and sand against contamination or moisture. Do not use and remove from site cement delivered with evidence of contamination or otherwise unsuitable. Store admixtures in accordance with manufacturer's directions.

        (4) Use Portland cement of same brand and type unless otherwise approved by Project Manager.

        (5) Pozzolanic Material: AWWA C602, Paragraph 4.3.3.

(6) Sand: AWWA C205, paragraph 4.2.3, except gradation of sand to yield fineness modulus of approximately 1.7; having no material coarser than that passing No. 16 sieve. Submit certification for compliance of sand with these specifications at least 10 calendar days before start of lining placement.

(7) Water: Clean; free of deleterious amounts of acids, alkalis or organic materials; total dissolved solids less than 1000 mg/l; ASTM D 512 chloride ions less than 100 mg/l for slurry and mortar cure; ASTM D 1293 pH greater than 6.5.

2.03 EXTERNAL COATING SYSTEM FOR STEEL PIPE INSTALLED ABOVE-GROUND AND IN VAULTS (EXPOSED)

A. Provide approved epoxy and polyurethane coating system as designated below. Materials provided shall be from same manufacturer.

Surface Preparation	SSPC SP 10 Near White Blast Clean surface profile as recommended by manufacturer
Intermediate Coat	Chemical Resistant Epoxy, or approved equal DFT as recommended by manufacturer
Finish Coat	Polyurethane, or approved equal DFT as recommended by manufacturer

B. Total Allowable Dry Film Thickness for System: as recommended by manufacturer.

C. Factory testing: In accordance with AWWA C210.

2.04 EXTERNAL COATING SYSTEMS FOR BURIED STEEL PIPE

A. Supply pipe with one of the following coatings:

1. Tape Coating: Conform to requirements of Section 02529 – Tape Coatings on Steel Pipe.

2. Cement-mortar Coating: For 84-inch diameter and smaller unless otherwise shown on Contract Drawings. AWWA C205; shop-applied, cement-mortar coating except as modified in this Section; 1-inch minimum thickness; cut back coating from joint ends no more than 2 inches to facilitate joining and welding of pipe.

3. Polyurethane Coating: See Section 02527 - Polyurethane Coatings on Steel or Ductile Iron Pipe for requirements for use of polyurethane coating system.

B. Heat Shrink Joint Sleeves for Tape and Polyurethane Coating: Provide heat shrink, cross-linked polyolefin wrap or sleeve with a mastic sealant, suitable for pipeline operating temperature, in accordance with AWWA C216. Provide Aqua-Shield by Canusa-CPS, Covalence by Seal for Life, or approved equal. Where weld-after-backfill procedures are used, conform to manufacturer's recommendations for installation.

C. Provide shop-applied primer on coating holdback areas at joint in accordance with Article 2.03 above.

2.05 EXTERNAL COATING SYSTEM FOR STEEL PIPE IN TUNNEL, CASING

A. Provide exterior coating system of pipe in tunnel, without annular grout, a minimum of 50 mils of polyurethane coating in accordance with Section 02527 - Polyurethane Coatings for Steel or Ductile Iron Pipe.

B. For water lines in tunnel where annular grout will be used, shop coat external surfaces of steel pipe with epoxy in accordance with Article 2.03 of this Section, or polyurethane in accordance with Section 02527 – Polyurethane Coatings for Steel or Ductile Iron Pipe.

C. If mortar bands are used to support pipe inside tunnel liner or casing, provide mortar coating with mortar bands integrated into mortar coating. If connecting pipe on each side of tunnel has tape or polyurethane coating, provide epoxy or polyurethane under mortar coating throughout pipe inside tunnel liner or casing.

2.06 GROUT FOR JOINTS AND SPECIAL APPLICATIONS

A. Cement Grout Mixture: One part cement to two parts of fine, sharp, clean sand. Mix interior joint mortar with as little water as possible until very stiff but workable. Mix exterior joint mortar with water until it has consistency of thick cream. Mix cement grout to specific gravity of 19 lb/gallon or greater as measured by grout/slurry balance. Use balance manufactured grout/slurry by Baroid or approved equal. Perform test in presence of and at request of Project Manager. Add additional cement grout or water to mixed cement grout to bring mix to proper moisture content or specific gravity. Discard cement grout that has been mixed more than 20 minutes and is not at proper specific gravity or moisture content.

1. Portland Cement: ASTM C 150, Type II. Provide one type of cement for entire project.

2. Sand:

   a. Interior Joints: ASTM C 35 fine graded plaster sand.

   b. Exterior Joints: ASTM C 33; natural sand with 100 percent passing No. 16 sieve.

3. Water:

a. Potable water with total dissolved solids less than 1000 mg/l;

b. ASTM D 512 chloride ions less than 100 mg/l for slurry and mortar cure;

c. ASTM D 1293 pH greater than 6.5.

d. Use potable water with 250 ppm limit on chlorides and sulfates.

B. Provide approved Non-shrink Grout for Special Applications, Patches and Repairs.

1. Conform to requirements of ASTM C 1107, Non-shrink Grout.

2. Pre-blended factory-packaged material manufactured under rigid quality control, suitable for use in joints of prestressed concrete cylinder pipe.

3. Contain non-metallic natural aggregate and be nonstaining and noncorrosive.

4. Meeting NSF/ANSI 61 Standard suitable for use in contact with potable water supply.

5. Compressive Strength: ASTM C 1107, 2,500 psi minimum 7-day unconfined; 5,000 psi minimum 28-day unconfined.

6. Non-bleeding and non-segregating at fluid consistency.

7. Contain no chlorides or additives which may contribute to corrosion of steel pipe.

8. Free of gas-producing, gas-releasing agents.

9. Resist attack by oil or water.

10. Mix, place, and cure in accordance with manufacturer's instructions and recommendations. Upon 72 hours notice, provide services of qualified representative of non-shrink grout manufacturer to aid in assuring proper use of product under job conditions. Representative to be on site when product is first used.

11. Mix cement grout to specific gravity of 17.7 lb/gallon or greater as measured by grout/slurry balance. Use balance manufactured grout/slurry by Baroid or approved equal. Perform test in presence of and at request of Project Manager. Add additional cement grout to mixed cement grout or water to bring mix to proper moisture content or specific gravity. Discard cement grout that has been mixed more than 20 minutes and is not at proper specific gravity or moisture content.

12. Compressive Strength: ASTM C 1107, 2,500 psi minimum 7-day unconfined; 5,000 psi minimum 28-day unconfined.

C. Finished surface of lining and interior joint to be comparable to surface rubbed with No. 16 Carborundum stone. Rub joint mortar sufficiently to bring paste to surface, to remove depressions and projections, and to produce smooth, dense surface. Add cement to form surface paste as necessary. Leave interior with clean, neat and uniform-appearing finish.

D. Joint Wrapper: Minimum width of 9-inches for 33-inch diameter and smaller; minimum width of 12-inches for diameters greater than 33-inch hemmed at edge to allow threading with minimum 5/8-inch-wide steel strap. Provide minimum 6-inch-wide Ethafoam strip sized, positioned, and sewn such that two circumferential edges of Ethafoam are 1-1/2-inches from outer edge of wrapper.

PART 3 EXECUTION

3.01 PIPING INSTALLATION

A. Conform to applicable provisions of Section 02511 - Water Lines, except as modified in this Section.

B. Comply with following:

1. Make available services of manufacturer's representative when deemed necessary by Project Manager. Representative to advise in aspects of installation, including but not limited to handling and storing, cleaning and inspecting, coating and lining repair, and general construction methods as applicable to pipe.

2. Handling and Storage: Install padded struts or stulls prior to shipping, horizontally and vertically, as proposed by manufacturer and approved by Project Manager. Spiders: Installed in joint ends of fittings. Stulls to remain in place, horizontally and vertically positioned under following conditions:

   a. During storage and shipping.

   b. Until welding is complete.

3. Install stulls prior to placement of pipe, bends, and fittings to prevent deflection during installation. Provide stulls consisting of timber struts with end blocks shaped to fit curvature of interior surface of pipe or other appropriate configuration and material. Firmly edge and secure stulls to blocks so that they will remain intact position during handling and installation. Provide stulls adequate to resist handling loads encountered without structural failure to stull members or damage to pipe. Repair and or reject and remove from site pipe that arrives at site with defects in lining, including sand pockets, voids, and oversanded areas. Repairs must be made to the satisfaction of the Project Manager to be accepted.

4. Store pipe at job site with securely fastened plastic endcaps to maintain moist pipe interior. Promptly replace damaged endcaps to avoid shrinkage or cracking of cement-mortar lining.

5. Immediately replace damaged plastic end caps. Do not leave uncapped for more than 4 hours.

6. Bedding and Backfilling:

    a. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

    b. Align pipe at proper grade prior to joint connection and do not shift after jointing operation has been completed.

    c. Take necessary precautions during bedding and backfilling operations to prevent deformation or deflection of cylindrical shape of pipe by more than allowable pipe deflection. Do not move trench support system (trench safety system) once bedding material is compacted.

    d. Excavate outside specified trench section for bell holes, and for spaces sufficient to permit removal of slings. Provide bell holes at proper locations for unrestricted access to joint. Form bell holes large enough to facilitate joint wrapping and to permit visual examination of process. Enlargement of bell holes as required or directed by Project Manager. Subsequent backfilling thereof will not be considered as authorized additional excavation and backfill. Backfill bell holes and spaces to satisfaction of Project Manager.

    e. Blocking may be removed 24 hours after placing backfill to top of pavement or natural ground level.

7. Pipe Deflection: After backfill is complete, test pipe for excessive deflection by measuring actual inside vertical diameter. For maximum deflection allowable, see Article 2.01.

    a. Deflection may be measured by Project Manager at location along pipe. Arithmetical averages of deflection are not acceptable.

    b. If deflection exceeds that specified, contractor shall do one of the following:

        (1) Remove backfill and side support. Reround the pipe and properly replace compacted backfill and side support. Review cement mortar lining to assure that no harmful damage has occurred.

(2) Remove entire portion of deflected pipe section and install new pipe as directed by Project Manager at no additional cost to City.

8. Move pipe in such manner not to damage pipe or coating. Do not roll pipe nor drag on ground. Use a minimum of two wide non-abrasive slings or belts to lift and lower pipe. Handle pipe using a spreader bar. Provide adequate spacing of pipe supports to prevent cracking or damage to lining or coating. Inspect and repair coating abrasions before pipe is lowered into trench.

9. Use of dogs, clips, lugs, or equivalent devices welded to steel pipe for purpose of forcing it into position will not be permitted unless approved by Project Manager. Remove foreign matter and protective material from surfaces that are to be in contact at joints. Leave surfaces of joint areas thoroughly clean for metal-to-metal contact of field joints.

C. Static Electricity:

1. Properly ground steel pipeline during construction as necessary to prevent build-up of static electricity.

2. Electrically test where required after installation of pipeline is complete.

D. Use adequate surveying methods, procedures and employ competent surveying personnel to ensure pipe sections are laid to line and grade and within stipulated tolerances. Measure and record, in form approved by Project Manager, and submit copy of data to Project Manager at end of that day. Survey data to include unique pipe number, deflection or offset angle at pipe joint and whether beveled ends were used, invert elevation at pipe joint, deviation of joint from project line, deviation of joint from project grade, inside pipe joint lap measured at top, bottom, and at springline (each side).

E. Any time that laying of additional pipe is stopped for more than eight hours, plug ends of installed pipe and take proper precautions against flotation of pipe segments.

3.02 EXTERNAL COATING SYSTEM FOR STEEL PIPE INSTALLED ABOVE GROUND AND IN VAULTS (EXPOSED) AND EPOXY INTERNAL LINING SYSTEM

A. Safety: Paints, coatings, and linings specified in this Section are hazardous materials. Vapors may be toxic or explosive. Protective equipment, approved by appropriate regulatory agency, is mandatory for personnel involved in painting, coating, and lining operations.

B. Workmanship:

1. Application: By qualified and experienced workers who are knowledgeable in surface preparation and application of high-performance industrial coatings.

2. Paint Application Procedures: SSPC Good Painting Practices, Volume 1.

C. Surface Preparation:

1. Use abrasive blasting to prepare surfaces.

2. Schedule cleaning and painting so that detrimental amounts of dust or other contaminants do not fall on wet, newly-painted surfaces. Protect surfaces not intended to be painted from effects of cleaning and painting operations.

3. Prior to blasting, clean surfaces to be coated or lined of grease, oil and dirt by steaming or detergent cleaning in accordance with SSPC SP 1.

4. Metal and Weld Preparation: Remove surface defects such as gouges, pits, welding and torch-cut slag, welding flux and spatter by grinding to 1/4-inch minimum radius.

5. Abrasive Material:

a. Blast only as much steel as can be coated within same day of blasting.

b. Use sharp, angular, properly graded abrasive capable of producing depth of profile specified herein. Transport abrasive to jobsite in moisture-proof bags or airtight bulk containers. Copper slag abrasives are not acceptable.

c. After abrasive blast cleaning, verify surface profile with replica tape such as Tes-Tex Coarse or Extra Coarse Press-O-Film Tape, or approved equal. Furnish tapes to Project Manager.

d. Do not blast if metal surface may become wet before priming commences, or when metal surface is less than 5 degrees F above dew point.

6. Evaluate degree of cleanliness for surface preparation with use of SSPC Pictorial Surface Preparation Standards for Painting Steel Surfaces, SSPC- Vis 1.

7. Remove dust and abrasive residue from freshly blasted surfaces by brushing or blowing with clean, dry air. Test cleanliness by placing 3/4-inch by 4-inch piece of clear Scotch-type tape on blasted surface, then removing and placing tape on 3x5 white index card. Reclean areas exhibiting dust or residue.

D. Coating and Lining Application:

1. Environmental Conditions: Do not apply when metal temperature is less than 50 degrees F; when ambient temperature is less than 5 degrees F above dew point; when expected weather conditions are such that ambient temperature will drop below 40 degrees F within 6 hours after application; or when relative humidity is above 85 percent. Measure relative humidity and dew point by use of sling psychrometer or similar in conjunction with U.S. Department of Commerce Weather Bureau Psychometric Tables. Provide dehumidifiers for field-applied coatings and linings to maintain proper humidity levels.

2. Application Procedures:

   a. Apply in accordance with manufacturer's recommendations and requirements of this Section. Provide finish free of runs, sags, curtains, pinholes, orange peel, fish eyes, excessive overspray, or delaminations.

   b. Thin materials only with manufacturer's recommended thinners. Thin only amount required to adjust viscosity for temperature variations, proper atomization and flow-out. Mix material components using mechanical mixers.

   c. Discard catalyzed materials remaining at end of day.

3. Thoroughly dry pipe before primer is applied. Apply primer immediately after cleaning surface. Apply succeeding coats before contamination of undersurface occurs.

4. Cure minimum of 24 hours at 77 degrees F before successive coats are applied. During curing process, provide forced-air ventilation in volume sufficient to maintain solvent vapor levels below published threshold limit value. Apply successive coats within recoat threshold time as recommended by coating or lining manufacturer on printed technical data sheets or through written communications. Brush blast joints of pipe which have been shop primed and are to receive intermediate and finish coats in field prior to application of additional coats. After interior coats are applied, provide forced-air ventilation in sufficient volume and for sufficient length of time to ensure proper curing before filling pipe with water.

3.03 EXTERNAL COATING SYSTEM FOR BURIED STEEL PIPE

A. Polyurethane Coating System:

1. Conform to requirements of Section 02527 – Polyurethane Coatings for Steel or Ductile Iron Pipe.

B. Tape Coating System:

1. Conform to requirements of Specification Section 02529 – Tape Coatings on Steel Pipe.

2. Heat Shrink Joint Sleeves:

   a. Provide field-applied shrink-wrap coating system for coating field joints, tie-ins and other field welded joints. Apply heat-shrink sleeves prior to internal welding of pipe using approved procedure compatible with coating system. Install heat-shrink joint sleeves in accordance with manufacturer's recommendations. Provide services of technical representative of manufacturer available on site at beginning of pipe laying operations. Representative to advise Contractor and Project Manager regarding installation, repairs, and general construction methods.

3. Do not expose tape coatings or heat-shrink joint sleeves to harmful ultraviolet light for longer than recommended by the coating manufacturer.

4. At option of Project Manager, coating system and application may be tested and inspected.

3.04 JOINTS AND JOINTING

A. Rubber Gasketed Bell-and-Spigot Joints:

1. Use O-ring gasket with sufficient volume to approximately fill area of groove and gasket material in accordance with AWWA C200. Check each splice in gasket by stretching gasket to at least twice original length of gasket. Visually check stretched splice by rotating 360 degrees. Reject splices showing visible separation or cracks.

2. Equalize rubber gasket cross section after rubber gasket is placed in spigot groove of pipe by inserting tool or bar such as large screwdriver under rubber gasket and moving it around periphery of pipe spigot. Lubricate gaskets with nontoxic water-soluble lubricant before pipe units are joined. Fit pipes together in manner to avoid twisting or otherwise displacing or damaging rubber gasket. Check gaskets after pipe sections are joined with feeler gauge to ensure that no displacement of gasket has occurred at point around circumference after joining. If displacement has occurred, remove pipe section and remake joint as if for new pipe. Remove old gasket and replace before remaking joint.

B. Welded Joints:

1. For welded lap joints, conform to requirements of Section 02511 - Water Lines.

2. Butt joints to be complete penetration for entire circumference.

C. Flanged Joints: Conform to requirements of Section 02511 - Water Lines.

D. Joint Grouting and Testing: Conform to requirements of Section 02511 - Water Lines.

E. Do not allow steel plugs for threaded outlets to project beyond inner surface of pipe shell and seal weld by at least two passes. Apply weld around outside of plug after it has been inserted in final position. Coat outlets and plugs inside and outside as required at field joints on pipe.

3.05 FIELD-APPLIED CEMENT-MORTAR LINING

A. Entrances Into Pipeline:

1. Establish means to permit entry and exit of labor, materials and equipment necessary for progress of work, as approved by Project Manager.

2. Provide dikes and channeling for diversion of flood and drainage waters away from these openings in pipeline. Use temporary airtight covers over openings to provide proper curing conditions in completed sections of lined pipe. Where operation of equipment requires that end of pipe be left open, install temporary bulkhead inside pipe to eliminate direct draft through pipe over completed sections.

3. Brace closure sections of pipeline left out to facilitate field lining above ground to conform as nearly as possible to shape of pipe in ground and then place cement-mortar lining by machine or hand trowel to same thickness as in adjoining machine-lined sections. Bulkhead sections immediately after being lined to maintain proper curing conditions for period of not less than 48 hours before sections are installed in pipeline. Install these sections of steel pipe.

4. Coat exterior surface of buttstraps and uncoated exterior surface area of steel pipe within excavations in accordance with specifications. Place cement-mortar lining inside areas of joints in accordance with specifications.

B. Mixing of Cement-mortar: Mix ingredients for cement-mortar for not less than 90 seconds and not more than 6 minutes; use mortar promptly after mixing for lining pipe. Do not use mortar that has attained its initial set for lining. Do not retemper mortar. Add water to mix last.

C. Placing Cement-mortar Lining:

1. Complete joint work, backfill and welding before cement-mortar lining begins. After cement-mortar lining has cured, hydrostatic testing of pipe can begin.

2. Provide provisions necessary for Project Manager to conduct inspections of work in safe and thorough manner during and after initial application of mortar and after necessary repairs made. Include, as minimum, space on application machine, and adequate lighting to inspect gross surface areas.

3. Comply with ASTM C 494 and with manufacturer's recommendations when using chemical admixtures, bonding agents, accelerators, and other additives.

4. Remove dirt, debris, oil, grease and loose mill scale and rust from interior surfaces of pipe, and scrape or brush surface with stiff bristle brush and/or water blast as may be necessary, and approved by Project Manager, to ensure clean surfaces for successful application of cement-mortar lining. Interior surfaces to be approved by Project Manager prior to placing lining.

5. Provide cement-mortar lining uniform in thickness along entire length of pipe. Provide cement-mortar no less than 1/2-inch over all surfaces with tolerance of plus 1/8-inch, and no allowance for minus tolerance.

6. Mechanically control travel of machine and rates of discharge of mortar to produce uniform thickness of lining without segregation around perimeter and along length of pipe.

7. Check finished surface by placing 12-inch straightedge parallel to axis of pipe along surface of straight section of lining. At no point will space between lined surface and straightedge be greater than 1/16-inch.

8. Provide smooth finished surface, within tolerances specified. Repair or replace surface irregularities including corrugations, ripples, or pits in any direction, to satisfaction of Project Manager. Remove defective lining material, including sand pockets, voids, oversanded areas, blisters, delaminations, or unbounded areas, cracked areas, irregular surfaces, and unsatisfactory thin spots. Remove to pipe wall and area repaired to full thickness of mortar lining.

9. Repair cracks 1/16-inch and larger to satisfaction of Project Manager.

10. Place cement-mortar lining by machine having following features:

    a. An applicator head which can be centered within pipe and which will centrifugally project mortar against wall of pipe at high velocity producing dense, uniformly distributed mortar on wall of pipe.

    b. Equipped with mechanically driven, rotating steel trowels that immediately follow applicator, providing smooth, hard surface without spiral shoulders. Compensate for torque so that machine will sit true in pipe and trowel faces will not vary in angle with mortar face during complete 360-degree cycle. Clean trowels at frequent intervals to prevent accumulated mortar from obtaining initial set resulting in sanded or unglazed finish. Continuously operate trowels during application of cement-mortar and forward progress of lining machine.

c. Design applicator so that nothing will come in contact with troweled surface until it has attained final set, and so that forward progress of machine and mechanical placing of mortar can be controlled to assure uniform thickness of lining.

11. Immediately prior to application of cement-mortar lining, sweep and clean off slime, dirt, loose rust, loose mill scale, and other foreign materials. Free interior surface of pipe after cleaning of accumulated water on pipe wall or at joints.

12. Cement-mortar Lining: Adhere to steel at all points; provide consistent thickness except that lining of bell end of pipe where lining is to be thicker in order to fill depression and make smooth surface.

13. After receiving its finish troweling, do not roughen lining by rebound material or by mortar direct from machine.

14. Temporarily close outlets in pipeline with easily removable stoppers to prevent spun mortar from being thrown into such openings. After lining is applied, remove stoppers from outlets and repair lining damaged by removal of stoppers. Point outlet openings up to provide smooth flow.

D. Hand Finishing:

1. Repair defective areas in machine-applied lining and unlined joints by hand patching to yield lining equal to that required for machine-applied troweled lining.

2. Provide non-shrink grout for patching or lining joints as specified in this Section.

3. Clean defective areas of loose foreign material and moisten with water just prior to application of hand-applied mortar.

4. Use steel finishing trowels for hand application of cement-mortar.

5. Complete hand finishing required in given pipe section not later than day following machine application of mortar lining to that particular pipe section, whether normal working day or otherwise. Slow down or stop machine application of mortar lining to allow time for hand patching.

E. Curing of Lining: Begin curing operations immediately after completing any portion of mortar lining. Close pipe by airtight bulkheads, and maintain moist atmosphere in completed section of pipe to keep lining damp and to prevent evaporation of entrained water from mortar lining. Humidify air introduced into pipe for ventilating or curing purposes and maintain moist atmosphere inside pipe until Project Manager accepts Work.

3.06 COATINGS AND LININGS INSPECTION RESPONSIBILITIES

A. Contractor is responsible for quality control of coatings and linings applications and testing and inspection stipulated in this Section. Project Manager is responsible for quality assurance and reserves right to inspect or acquire services of independent third-party inspector who is fully knowledgeable and qualified to inspect surface preparation and application of high-performance coatings at phases of coatings and linings, field- or shop-applied. Contractor is responsible for proper application and performance of coatings and linings whether or not Project Manager provides such inspection.

B. Cement Mortar Lining and Joint Finish: Finished surface of lining and joint to be comparable to surface rubbed with No. 16 Carborundum stone. Rub joint mortar sufficiently to bring paste to surface, to remove depressions and projections, and to produce smooth, dense surface. Add cement to form surface paste as necessary. Leave interior with clean, neat and uniform-appearing finish.

3.07 FIELD REPAIR PROCEDURES AND SPECIAL FITTINGS APPLICATION FOR CEMENT MORTAR LINING

A. Areas less than or equal to 6 inches in diameter: Patch honeycomb and minor defects in concrete surfaces with non-shrink grout. Repair defects by cutting out unsatisfactory material and replacing with non-shrink grout, securely bonded to existing concrete. Finish to make junctures between patches and existing concrete as inconspicuous as possible. After each patch has stiffened sufficiently to allow for greatest portion of shrinkage, strike off grout flush with surrounding surface.

B. Areas greater than 6 inches in diameter:

1. Remove defective lining down to bare steel by chipping, making sure care is taken to prevent further lining damage. Ends of lining where defective lining is removed are to be left square and uniform, not feathered.

2. Clean bare steel with wire brush to remove loose or other foreign matter.

3. Remove existing wire reinforcement and replace. Overlap new reinforcement to existing reinforcement by 1/2-inch. Secure reinforcement, against wall of pipe, at frequent intervals, by tack welding to pipe.

4. Prepare cement mortar mixture. Mixture to compose of ASTM C 150, Portland Type II cement, sand, and water. Proportions of sand to cement not to exceed 3 parts sand to 1 part cement, by weight. Use only enough water to obtain proper placement characteristics. Set-up time before mixture is to be discarded is to be no longer than 30 minutes. Non-shrink grout may also be used. Do not use combination of cement mortar and non-shrink grout within same repair.

5. Apply WELD-CRETE, or approved equal, concrete bonding agent to bare steel and interface of existing lining. After bonding agent is applied to steel and lining, new mix must be applied within 10 minutes.

6. Apply cement mortar to repair area 1/2-inch thick, then hand trowel to achieve smooth dense finish, making sure wire is not left exposed. To ensure proper thickness while placing new mortar, check thickness with 1/2-inch-long wire gauge.

7. Curing: Place plastic sheeting over repair area; use tape to adhere plastic to area surrounding repair area. Let cure for 4 days, then remove plastic sheeting.

END OF SECTION

SECTION 02520

FIRE HYDRANTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Fire hydrants.

B. Adjustment of fire hydrants and gate valves.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01576 – Waste Material Disposal

D. Section 02501 – Ductile Iron Pipe and Fittings

E. Section 02502 – Steel Pipe and Fittings

F. Section 02506 – Polyvinyl Chloride Pipe

G. Section 02511 – Water Lines

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment is on a unit price basis for each fire hydrant assembly, including 6-inch gate valve and box, installed regardless of barrel depth.

2. Payment for fire hydrant branches (leads) is on linear foot basis for each branch installed. Separate pay items are used for open-cut and augured branches.

3. Payment for salvaged fire hydrants is on unit price basis for each fire hydrant removed and returned to City's Maintenance Quadrant Stock yard.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AWWA C 502 – Standard for Dry Barrel fire Hydrants (Latest Edition).

B. AWWA C 550 - Protective Interior Coatings for Valves and Hydrants

C. SSPC SP2 - Hand Tool Cleaning

D. SSPC SP3 - Power Tool Cleaning

E. SSPC SP10 - Near-White Metal Blast Cleaning

F. SSPC SP11 - Power Tool Cleaning to Bare Metal

G. SSPC Paint 42 – Epoxy Polyamide/Polyamidoamine Primer, Performance-Based

H. SSPC Paint 36 – Two-Component Weatherable Aliphatic Polyurethane Topcoat, Performance-Based

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit name of hydrant manufacturer, type of bonnet paint, and engineering control drawing number for hydrant proposed for use.

PART 2 PRODUCTS

2.01 HYDRANTS

A. Provide fire hydrants in conformance with AWWA C 502, Standard for Dry Barrel Fire Hydrants (Latest Edition). Hydrants are approved by the City for issuance of a Certificate of Responsibility. Only hydrants with current Certification of Responsibility will be allowed in City of Houston projects. Approved fire hydrants are listed under City's Approved Water Product List.

https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards#agency-links-1486

B. The Project Manager may, at any time prior to or during installation of hydrants, randomly select furnished hydrant for disassembly and laboratory inspection, at City expense, to verify compliance with Specifications. When hydrant is found to be non-compliant, replace, at Contractor's expense, hydrants, with hydrants that comply with Specifications.

C. Provide lower hydrant barrel fabricated from Ductile Iron Pipe as single piece, connected to upper hydrant barrel by means of joint coupling that will provide three hundred sixty degree (360) rotation of upper barrel.

2.02 LEADS

A. Branches (Leads): Conform to requirements of Section 02501 - Ductile Iron Pipe and Fittings, Section 02502 - Steel Pipe and Fittings, and Section 02506 - Polyvinyl Chloride Pipe.

2.03 HYDRANT PAINTING

A. New hydrants and refurbished hydrants shall be shop coated as specified herein. Exterior Above Traffic Flange (Including Bolts & Nuts). Bolts and nuts (both above and below ground) shall conform to AWWA C-502 Section 4.11 and shall be stainless steel, cadmium plated, or zinc coated.

1. Surface preparation to be in accordance with SSPC-SP 10 (NACE 2) near white blast cleaned surface.

2. Coat with a liquid or powder epoxy primer and two part polyurethane or TGIC polyester top coat system with total dry film thickness (DFT) of not to exceed 20 mils as follows:

a. Prime Coat - Liquid or powder epoxy primer with a total dry film thickness (DFT) of 4-6 mils, OR cathodic epoxy electro-coat (e-coat) with a (DFT) of 0.5-1.0 mils.

b. Intermediate Coat – Intermediate coat not required.

c. Finish Coat - Two part polyurethane enamel to be in general conformance with SSPC Paint Specification No. 36 or TGIC polyester system, with a total dry film thickness (DFT) 1.5-3.0 mils. Install color coded finish coating of bonnet in field.

d. Bonnet Paint - Field apply finish coat of Silicone Alkyd Resin Enamel to be in general conformance with SSPC Paint Specification No. 21. Dry film thickness of 2 - 3 mils. Bonnet colors are to be as specified in Paragraph 3.01 to designate the appropriate size of water supply line.

3. Colors - Primer: Manufacturer’s standard color. Finish coat of hydrant body: Federal Standard Color #15187 (Blue) or equivalent. Bonnet and Connection caps: Finished coated white. Paint white band of finish coat two (2) inches in width on hydrant body approximately six inches (6") above and parallel to traffic flange.

B. Field Maintenance Painting (Exterior Above Traffic Flange)

1. Surface Preparation to be in accordance with SSPC - SP2, Hand Tool Cleaning, or SSPC - SP3, Power Tool Cleaning, depending on condition of existing paint and extent of corrosion. It is not necessary to remove tightly adhered mill scale, rust, and paint. Mill scale, rust and paint are considered tightly adherent when they cannot be removed with dull putty knife. In some severe cases where it is necessary to remove majority of existing paint, surface should be cleaned in accordance with SSPC -SP11, Power Tool Cleaning to Bare Metal.

2. When surface is cleaned to bare metal (SSPC - SP11), coat hydrant with three coat Alkyd/Silicone Alkyd system in accordance with Paragraph 2.03.B.2 as for new hydrants. When surface is cleaned to SSPC - SP2 or SSPC - SP3, coat hydrant with Silicone Alkyd Resin Enamel in general conformance with SSPC Paint Specification No. 21. Total dry film thickness of 3-6 mils.

3. Field coating should be conducted in accordance to the individual coatings manufacturer’s recommendations.

C. Exterior Below Traffic Flange (including lower barrel extensions).

1. Surface preparation in accordance with SSPC- SP10 (NACE 2) Near White Blast Cleaned Surface.

2. Primer: One or two coats of modified or equal polyamide epoxy primer, to be in general conformance with SSPC Paint Specification No. 42 or approved equal with a total dry film thickness (DFT) of 20 mils. Exterior below traffic flange should be the same color as the above traffic flange, i.e., blue. (Federal Standard Color #15187 (Blue) or equivalent.)

D. Interior Surfaces Above and Below Water Line Valve (including lower barrel extensions)

1. Material used for internal coating of hydrant interior ferrous surfaces must be NSF certified as suitable for contact with potable water as required by Chapter 290, Rules and Regulations for Public Water Systems, Texas Commission on Environmental Quality.

2. Coating shall be liquid or powder epoxy system in accordance with AWWA Standard C - 550 (latest revision). Coating may be applied in two or three coats, according to manufacturer's recommendations, for total dry film thickness not to exceed 20 mils.

PART 3 EXECUTION

3.01 INSTALLATION

A. Set fire hydrant plumb and brace at locations and grades as shown on Drawings. When barrel of hydrant passes through concrete slab, place 1-inch-thick piece of standard sidewalk expansion joint material around section of barrel passing through concrete.

B. Locate nozzle center line minimum 18 inches above finish grade.

C. Place 12-inch by 12-inch yellow indicators (plastic, sheet metal, plywood, or other material approved by Project Manager) on pumper nozzles of new or relocated fire hydrants installed on new water lines not in service. Remove indicators after new water line is tested and approved by Project Manager. Obtain Project Manager's approval in writing prior to installation of hydrants which require changes in bury depth due to obstructions not shown on Drawings. Unit price adjustments will not be allowed for changes in water line flow line or fire hydrant barrel length caused by obstructions.

D. Plug branch lines to valves and fire hydrants shown on Drawings to be removed. Deliver fire hydrants designated for salvage to nearest Utility Maintenance Quadrant Facility.

E. Install branches (leads) in accordance with Section 02511 - Water Lines. Provide fully restrained joints for branches (leads) and fittings.

F. Coating Requirements:

1. Apply coatings in strict accordance with manufacturer's recommendations. No requirements of this specification shall cancel or supersede written directions and recommendations of specific manufacturer so as to jeopardize integrity of applied system.

2. Furnish affidavit of compliance that coatings furnished complies with requirements of this specification and referenced standards, as applicable.

G. Use following color code for field coating of hydrant bonnet to indicate size of water line supplying hydrant:

Supply Water Line Diameter (inches)	Bonnet Color
6	Yellow
8	White
12-20	Green
24 and larger	Orange

H. Remove and dispose of unsuitable materials and debris in accordance with requirements of Section 01576 - Waste Material Disposal.

END OF SECTION

SECTION 02521

GATE VALVES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Gate valves.

1.02 REALTED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02514 – Disinfection of Water Lines

E. Section 02515 – Hydrostatic Testing of Pipelines

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for gate valves 20 inches in diameter and smaller under this Section. Include payment in unit price for water lines.

2. Payment for gate valves 24 inches to 36 inches in diameter is on a unit price basis. Unit price includes cost of required box for gate valves.

3. Payment for 2-inch blow-off valve with box is on a unit price basis for each installation.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM A 307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength.

B. ASTM B 62 - Standard Specification for Composition Bronze or Ounce Metal Casting.

C. ASTM D 429 - Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.

D. ASTM B 763 - Standard Specification for Copper Alloy Sand Castings for Valve Applications.

E. AWWA C 500 - Standard for Metal-Seated Gate Valves for Water Supply Service.

F. AWWA C 509 - Standard for Resilient-Seated Gate Valves for Water Supply Service.

G. AWWA C 515- Standard for Reduced Wall, Resilient- Seated Gate Valves for Water Supply Service.

H. AWWA C 550 - Standard for Protective Interior Coatings for Valves and Hydrants.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer's product data for proposed valves for approval.

C. Provide detailed drawings of gearing mechanism for 20-inch and larger gate valves.

1.06 QUALITY CONTROL

A. Submit manufacturer's affidavit that gate valves are manufactured in the United States and conform to stated requirements of AWWA C 500, AWWA C 509, AWWA C 515, and this Section, and that they have been satisfactorily tested in the United States in accordance with AWWA C 500, AWWA C 509, and AWWA C 515.

PART 2 PRODUCTS

2.01 MATERIALS

A. Gate Valves: AWWA C 500, AWWA C 509, AWWA C 515 and additional requirements of this Section. Direct bury valves and those in subsurface vaults open clockwise; aboveground and plant valves open counterclockwise.

B. If type of valve is not indicated on Drawings, use gate valves as line valves for sizes 20-inches and smaller. When type of valve is indicated, no substitute is allowed.

C. Gate Valves 1-1/2 inches in Diameter and Smaller: 125 psig; bronze; rising-stem; single- wedge; disc type; screwed ends

D. Coatings for Gate Valves 2 inches and larger: AWWA C 550 non-toxic, imparts no taste to water, functions as physical, chemical, and electrical barrier between base metal and surroundings, minimum 8-mil-thick, fusion-bonded epoxy. Prior to assembly of valve, apply protective coating to interior and exterior surfaces of body.

E. Gate Valves 2 inches in diameter: Iron body, double disc or resilient-seated, non-rising stem, 150-pound test, 2-inch square nut operating clockwise to open.

F. Gate Valves 3 inches to 12 inches in diameter: Non-directional, standard-wall resilient seated (AWWA C 509), parallel seat double disc (AWWA C 500), or reduced-wall resilient seated gate valves (AWWA C 515), 200 psig pressure rating, bronze mounting, push-on bell ends with rubber joint rings, and nut-operated unless otherwise specified. Provide approved standard-wall resilient seated valves. Provide approved reduced-wall resilient seated valves. Provide approved double disc valves. Comply with following requirements unless otherwise specified in Drawings:

1. Design: Fully encapsulated rubber wedge or rubber seat ring mechanically attached with minimum 304 stainless-steel fasteners or screws; threaded connection isolated from water by compressed rubber around opening.

2. Body: Cast or ductile iron, flange bonnet and stuffing box together with ASTM A 307 Grade B bolts. Manufacturer's initials, pressure rating, and year manufactured shall be cast in body.

3. Bronze: Valve components in waterway to contain not more than 15 percent zinc and not more than 2 percent aluminum.

4. Stems: ASTM B 763 bronze, alloy number-995 minimum yield strength of 40,000 psi; minimum elongation in 2-inches of 12 percent, non-rising.

5. O-rings: For AWWA C 500, Section 3.12.2. For AWWA C 509, Sections 2.2.6 and 4.8.2. For AWWA C 515, Section 4.2.2.5.

6. Stem Seals Consist of three O-rings, two above and one below thrust collar with anti- friction washer located above thrust collar for operating torque.

7. Stem Nut: Independent or integrally cast of ASTM B 62 bronze.

8. Resilient Wedge: Molded, synthetic rubber, vulcanized and bonded to cast or ductile iron wedge or attached with 304 stainless steel screws tested to meet or exceed ASTM D 429 Method B; seat against epoxy-coated surface in valve body.

9. Bolts: AWWA C 500 Section 3.4, AWWA C 509 Section 4.4 or AWWA C 515 Section 4.4.4; stainless steel; cadmium plated, or zinc coated.

G. Gate valves 14 inch and larger in Diameter: AWWA C 500; parallel seat double disc gate valves; push-on bell ends with rubber rings and nut-operated unless otherwise specified. Provide approved double disc valves with 150 psig pressure rating. Comply with following requirements unless otherwise specified on Drawings:

1. Body: Cast iron or ductile iron; flange together bonnet and stuffing box with ASTM A 307 Grade B bolts. Cast following into valve body manufacturer's initials, pressure rating, and year manufactured. When horizontally mounted, equip valves greater in diameter than 12 inches with rollers, tracks, and scrapers.

2. O rings: For AWWA C 500, Section 3.12.2. For AWWA C 515, Section 4.2.2.5.

3. Stems: ASTM B 763 bronze, alloy number-995 minimum yield strength of 40,000 psi; minimum elongation in 2-inches of 12 percent, non-rising.

4. Stem Nut: Machined from ASTM B 62 bronze rod with integral forged thrust collar machined to size; non-rising.

5. Stem Seals: Consist of three O-rings, two above and one below thrust collar with anti- friction washer located above thrust collar for operating torque.

6. Bolts: AWWA C 500 Section 3.4 or AWWA C 515 Section 4.4.4; stainless steel; cadmium plated, or zinc coated.

7. Discs: Cast iron with bronze disc rings securely penned into machined dovetailed grooves.

8. Wedging Device: Solid bronze or cast-iron, bronze-mounted wedges. Thin plates or shapes integrally cast into cast-iron surfaces are acceptable. Other moving surfaces integral to wedging action shall be bronze monel or nickel alloy-to-iron.

9. Provide bypass for double-disc valves (AWWA C500).

10. Bronze Mounting: Built as integral unit mounted over, or supported on, cast-iron base and of sufficient dimensions to be structurally sound and adequate for imposed forces.

11. Gear Cases: Cast iron; furnished on 18-inch and larger valves and of extended type with steel side plates, lubricated, gear case enclosed with oil seal or O-rings at shaft openings.

12. Stuffing Boxes: Located on top of bonnet and outside gear case.

H. Gate valves 14 inches to 48 inches: Provide AWWA C 515; reduced-wall, resilient seated gate valves with 250 psig pressure rating. Furnish with spur or bevel gearing.

1. Mount valves horizontally if proper ground clearance cannot be achieved by normal vertical installation. For horizontally mounted gate valves, provide bevel operation gear mounted vertically for above ground operation.

2. Use valve body, bonnet, wedge, and operator nut constructed of ductile iron. Fully encapsulate exterior of ductile iron wedge with rubber.

3. Ensure wedge is symmetrical and seals equally well with flow in either direction.

4. Provide ductile iron operator nut with four flats at stem connection to apply even input torque to the stem.

5. Bolts: AWWA C515, Section 4.4.4, Stainless Steel; cadmium plated or zinc coated.

6. Provide high strength bronze stem and nut.

7. O-rings: AWWA C515, Section 4.2.2.5, pressure O-rings as gaskets.

8. Provide stem sealed by three O-rings. Top two O-rings are to be replaceable with valve fully open at full rated working pressure.

9. Provide thrust washers to the thrust collar for easy valve operation.

I. Gate Valves Extension Stem: When shown on Drawings, provide non-rising, extension stem having coupling sufficient to attach securely to operating nut of valve. Upper end of extension stem shall terminate in square wrench nut no deeper than 4 feet from finished grade or as shown on Drawings. Support extension stem with an arm attached to wall of manhole or structure that loosely holds extension stem and allows rotation in the axial direction only.

J. Gate Valves in Factory Mutual (Fire Service) Type Meter Installations: Conform to provisions of this specification; outside screw and yoke valves; carry label of Underwriters' Laboratories, Inc.; flanged, Class 125; clockwise to close.

K. Gate Valves for Tapping Steel Pipe: Provide double disc gate valve. Resilient wedge gate valve shall only be installed in a vertical position.

L. Provide flanged joints when valve is connected to steel or PCCP.

M. Key valve stem into the operator nut.

N. Do not exceed 600 ft-lbs of torque on operator nut on gate valve.

PART 3 EXECUTION

3.01 INSTALLATION

A. Earthwork. Conform to applicable provisions of Section 02317 - Excavation and Backfill for Utilities.

B. Operation. Do not use valves for throttling without prior approval of manufacturer.

3.02 SETTING VALVES AND VALVE BOXES

A. Remove foreign matter from within valves prior to installation. Inspect valves in open and closed positions to verify that parts are in satisfactory working condition.

B. Install valves and valve boxes where shown on Drawings. Set valves plumb and as detailed. Center valve boxes on valves. Carefully tamp earth around each valve box for minimum radius of 4 feet, or to undisturbed trench face when less than 4 feet. Install valves completely closed when placed in water line.

C. For pipe section of each riser, use only 6-inch, ductile iron Class 51, or DR18 PVC pipe cut to proper length. Riser must be installed to allow complete access for operation of valve. Assemble and brace box in vertical position as indicated on Drawings.

3.03 DISINFECTION AND TESTING

A. Assist Project Manager with disinfection of valves and appurtenances as required by Section 02514 - Disinfection of Water Lines and test as required by Section 02515 - Hydrostatic Testing of Pipelines.

B. Double-Disc Gate Valves: Apply hydrostatic test pressure equal to twice rated working pressure of valve between discs. Valve shall show no leakage through metal, flanged joints, or stem seals. Test at rated working pressure, applied between discs. Valve shall show no leakage through metal, flanged joints, or stem seals. Do not exceed leakage rate of 1 oz per hr per inch of nominal valve size.

C. Solid-Wedge Gate Valves: Apply hydrostatic pressure equal to twice rated working pressure of valve with both ends bulkheaded and gate open. Valve shall show no leakage through metal, flanged joints, or stem seals. Test at rated working pressure, applied through bulkheads alternately to each side of closed gate with opposite side open for inspection. Valve shall show no leakage through metal, flanged joints, or stem-seals. Do not exceed leakage rate of 1 oz per hr per inch of nominal valve size.

D. Repair or replace valves which exceed leakage rate.

3.04 PAINTING OF VALVES

A. Paint valves in vaults, stations, and above ground with approved paint.

END OF SECTION

SECTION 02522

BUTTERFLY VALVES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Butterfly valves.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02082 – Precast Concrete Manholes

D. Section 02085 – Valve Boxes, Meter Boxes, and Meter Vaults

E. Section 02317 – Excavation and Backfill for Utilities

F. Section 02511 – Water Lines

G. Section 02514 – Disinfection of Water Lines

H. Section 02515 – Hydrostatic Testing of Pipelines

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for butterfly valves with operator manhole or valve box is on a unit price basis for each. Payment includes actuator, valve box or manhole (where shown), foundation and appurtenances necessary for complete installation of valve.

2. For butterfly valves with vault, valve and vault will be paid separately. Butterfly Valve will be paid on a unit price basis for each and includes hardware, actuator, testing and installation. Vault will be paid on a lump sum basis, and includes all materials, equipment, and appurtenances necessary for complete vault structure, foundation and supports as shown on Drawings.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASME B 16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. ASTM A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

C. ASTM A 193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.

D. ASTM A 194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

E. ASTM A 536 – Standard Specification for Ductile Iron Castings.

F. ASTM A 564 – Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.

G. AWWA C 504 - Standard for Rubber-Seated Butterfly Valves.

H. AWWA C 516 – Large-Diameter Rubber-Seated Butterfly Valves, Sizes 78 in. (2,000 mm) and Larger.

I. NSF/ANSI 61 – Drinking Water System Components – Health Effects.

J. AWWA C 550 - Standard for Protective Interior Coatings for Valves and Hydrants.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer’s product data for proposed valves and actuators for approval.

C. Submit Proof-of-Design and hydrostatic testing procedures in accordance with AWWA C504 or C516.

D. As part of initial review, submit manufacturer’s affidavits certifying the following:

1. Compliance with specifications for valves and actuators.

2. Butterfly valves were manufactured in the United States.

3. Butterfly valves conform to applicable requirements of AWWA C504 or C516.

E. Butterfly valves have been satisfactorily tested in the United States in accordance with AWWA C504 or AWWA C516 using test pressure of 150 psi in both directions.

F. At time of delivery, submit manufacturer’s affidavits certifying the following:

1. Coatings for interior surfaces of valves conform to applicable requirements of AWWA C550. Submit results of holiday test and thickness measurements of coatings.

2. Valves were manufactured in accordance with AWWA C504 or C516.

G. At time of delivery, furnish certified drawings and material test records by manufacturer. Furnish certified copies of test reports for review.

H. Submit data indicating maximum torque required to open valve, maximum torsional strength of shaft and torque output of actuator.

I. Provide submittal information on CD-ROM in Adobe portable document format (*.PDF).

J. Include number of turns to operate valves to fully open/closed.

K. For 30-inch and larger diameters, submit procedures for complete seat replacement in the field.

1.06 QUALITY CONTROL

A. Perform valve leakage tests in both directions at 150 psi in factory and field. Hydrostatic field tests of 150 psi shall be made against dished head plug or similar arrangement.

B. When proof of design tests are performed on valve delivered to job site, replace disc, bushing, shaft and seals with new unused items, and test and certify as described above.

C. Hydrostatic Testing by Manufacturer:

1. Hydrostatic testing to be witnessed by Project Manager prior to shipment of valves. Provide minimum 4 weeks notice to Project Manager to schedule witness testing. When possible, maximize number of valves to be tested during a plant visit; no more than two visits will be allowed per project to witness test valves, unless otherwise approved by Project Manager. City will pay expenses for each visit up to total of two visits incurred by Project Manager to witness testing of each grouping of valve(s) per project. Expenses for subsequent or extended visits by Project Manager for defective valves, improper scheduling or valve failures are to be paid by Contractor. Witness of hydrostatic testing by Project Manager will only be in regard to compliance with this specification and will not constitute approval by Project Manager nor relieve Contractor of obligations to comply with contract documents.

2. Document serial number on valve at time of testing and reflect in certified test records furnished to Project Manager. Identification plate must be permanently affixed to valve and actuator prior to hydrostatic testing.

3. Hydrostatic testing to conform to AWWA C504 or C516 except as modified below:

   a. Install actuator prior to hydrostatic testing. Test actuator to verify actual number of turns match manufacturer's published number of turns. Verify valve stops are in correct positions.

   b. Fully open and close valve prior to performing shell test and prior to each leakage test.

   c. Perform shell test first.

   d. When tested with water, adequately dry seat and disc.

   e. When tested with air, fill top of valve with water to aid in viewing possible leakage.

   f. Pressure Gauges: Calibrated within past 12 months; 0-500 psi range in increments of 5 psi; present calibration certificates prior to hydrostatic testing.

   g. If seat adjustment is required during hydrostatic testing, perform valve leakage test again in both directions. Once seat adjustment is made, fully open and fully close valve three (3) times, and repeat leakage test.

4. Field Testing:

   a. When valve arrives at the job site, Contractor is to operate valve fully open and closed twice in presence of Project Manager. Document number of turns to open and close each time.

   b. Install operator nut plum.

   c. After valve is installed, repeat the operation test and document number of turns in presence of Project Manager.

   d. Manufacturer's representative must be present to witness the operation test again at the substantial walk thru. Verify valve operate fully open/closed twice at the appropriate number of turns.

PART 2 PRODUCTS

2.01 VALVES AND ACTUATORS

A. Butterfly Valves and Actuators: Provide approved butterfly valves and actuators. Conform to AWWA C504 for 72-inch and smaller diameters. Conform to AWWA C516 for 78-inch and larger diameters. Compliance with NSF 61 is required for all parts in contact with finished water.

B. If type of valve is not indicated on Drawings, use butterfly valves for line valve sizes 24-inch and larger. When type of valve is specified on Drawings, no substitute will be allowed, unless otherwise approved by Project Manager.

C. Butterfly valves shall be short-body, flanged design and installed at locations as shown on Drawings.

D. Direct-bury valves and valves in subsurface vaults shall open clockwise. Above-ground and plant valves shall open counterclockwise.

E. Provide flanged joints when valve is connected to steel or PCCP. Provide ASTM A193 Grade B7 high strength steel stud bolts with ASTM A194 heavy hex nuts. Refer to flange bolting requirements in Section 02511 – Water Lines.

F. Butterfly Valves and Actuators (Additional Requirements for Large Diameter Water Lines):

1. Provide valves from approved manufacturer[(1)]. Provide all valves for single project, from same manufacturer.

   [(1)]as modified for seat replacement in field for City of Houston

2. Provide manual actuators for single project from same manufacturer.

3. Shaft connecting actuator to valve body must be fully enclosed. Bonnet and extension to be fully enclosed and watertight.

2.02 VALVE CONSTRUCTION

A. Valves:

1. 72-inches and smaller diameters: AWWA C504, Class 150B. Body: Cast Iron, ASTM A 126, Class B, or Ductile Iron. Flanges: ASME B16.1, Class 125.

2. 78-inches and larger diameters: AWWA C516, Class 150B. Body: ASTM A536 Grade 65-45-12. Flanges: ASME B16.1, Class 125 for up to 96-inch, AWWA C207, Class D with bolt holes ¼-inch larger than nominal bolt diameter for larger than 96-inch diameters.

B. Discs: ASTM A536 Grade 65-45-12 Ductile Iron.

C. Seats: Buna-N or neoprene, and may be applied to the disc or body. Mechanically secure seat to disc or body using stainless steel retainer ring and bolts. Do not rely solely on adhesive properties of epoxy or similar bonding agent to attach seat to body. When seat is on disc, retain seat in position by shoulders located on both disc and stainless steel retaining ring. Mating surfaces for seats: Type 304 or 316 stainless steel, and secured to disc by mechanical means. Sprayed-on or plated mating surfaces not allowed. Seat must be adjustable and replaceable in field with no special tools for valves greater than 30-inches in diameter.

D. Coat interior wetted ferrous surfaces of valve, including disc, with epoxy or fusion bonded epoxy suitable for potable water conditions. Epoxy, surface preparation, and epoxy application: In accordance with AWWA C550 and coating manufacturer's recommendations. Provide minimum dry film thickness of 8 mils for epoxy coating or minimum DFT of 16 mils for fusion bonded epoxy. Coatings shall be holiday tested and measured for thickness.

E. Valve shaft and keys: 24-inches in diameter and greater require a minimum of two (2) taper pins used for attaching valve shaft to valve disc. Use of torque plug for purposes of attaching valve shaft is not permitted. Shaft bearings: stainless steel, bronze, nylon or Teflon (supported by fiberglass mat or backing material with proven record of preventing Teflon flow under load) in accordance with AWWA C504 or AWWA C516. Sinter stainless steel bearing material. Design valve shaft to withstand 3 times the amount of torque necessary to open valve. Shaft Material:

1. 72-inches and smaller: Type 304 stainless steel for treated (potable) water applications. Type 316 stainless steel for raw water applications.

2. 78-inches and larger: ASTM A564, Type 630 (17-4 PH), Stainless Steel, Condition 1150.

3. Design valve shaft to withstand 3 times the amount of torque necessary to open valve.

F. Taper pins: Stainless Steel. Valves 24-inches in diameter and greater require a minimum of two (2) taper pins used for attaching valve shaft to valve disc, use of torque plug for purposes of attaching valve shaft is not permitted. Shaft Bearings: sintered stainless steel, sintered bronze, nylon or Teflon (supported by fiberglass mat or backing material with proven record of preventing Teflon flow under load) in accordance with AWWA C504 or C516.

G. Packing: Self adjusting and wear compensating, full or split ring V-type, and replaceable without removing actuator assembly.

H. Retaining Hardware for Seats: Type 304 or 316 stainless steel. Nuts and screws used with clamps and discs for rubber seats shall be held securely with locktight, or other approved method, to prevent loosening by vibration or cavitational effects.

I. Valve disc shall seat in position at 90 degrees to pipe axis and shall rotate 90 degrees between full-open and tight-closed position. Install valves with valve shafts horizontal and convex side of disc facing anticipated direction of flow, except where shown otherwise on Drawings.

J. For valves utilizing retaining rings, tighten bolts to a uniform torque. Measure torque prior to testing valve.

2.03 VALVE ACTUATOR CONSTRUCTION

A. Provide actuators for valves with size based on line velocity of 16 feet per second and uni-directional service, and unless otherwise shown on Drawings, equip with geared manual actuators. Provide fully enclosed and traveling-nut type, rack-and-pinion type, or worm-gear type for valves 24-inches and smaller. For 30-inches and larger, provide worm-gear or traveling-nut type.

B. Provide actuator designed for installation with valve shaft horizontal unless otherwise indicated on Drawings.

C. Provide bonnet extensions, as required, between valve body and actuator. Space between actuator housing and valve body shall be completely enclosed so that no moving parts are exposed to soil or elements.

D. Provide oil-tight and watertight actuator housings for valves, specifically designed for submerged service, and factory packed with suitable grease.

E. Install valve position indicator on each actuator housing located above ground or in valve vaults. Valves shall be equipped with 2-inch actuator nut only.

F. Indicate direction of opening of valve on exposed visible part of assembly and cast direction of open on 2-inch nut on top of valve operator extension. Paint 2-inch actuator nut and extension shaft black when counterclockwise open and red when clockwise to open.

G. Design worm-gear or traveling-nut actuators to be self-locking and designed to transmit twice the required actuator torque without damage to faces of gear teeth or contact faces of screw or nut.

H. Actuators shall be capable of withstanding minimum 450 foot-pounds of torque against the stops without damage to any parts of the actuator or valve.

2.04 VALVE BOXES

A. Provide Standard Type "A" valve boxes conforming to requirements of Section 02085 - Valve Boxes, Meter Boxes, and Meter Vaults.

2.05 VALVE SERVICE MANHOLES

A. For large diameter water lines, provide manholes to dimensions shown on Drawings conforming to requirements of Section 02082 - Precast Concrete Manholes.

PART 3 EXECUTION

3.01 EARTHWORK

A. Conform to applicable provisions of Section 02317 - Excavation and Backfill for Utilities.

3.02 SETTING VALVES AND VALVE BOXES

A. Prior to hydrostatic testing of water line and valve:

1. Test valve by opening and closing valve a minimum of two times to verify valve seats properly.

2. Verify number of turns from fully open to fully closed position is same as identified in manufacturer's submittal.

3. Adjust valve as required if number of turns do not match.

4. Remove foreign matter from within valves.

B. Install valves in accordance with manufacturer's recommendations. Install valves where shown on Drawings or as located by Project Manager.

C. Use valve boxes for 16-inch and 24-inch valves unless otherwise shown on Drawings. Set valves plumb and as detailed. Center valve boxes on valves. Carefully tamp earth around each valve box for minimum radius of 4 feet, or to undisturbed trench face when less than 4 feet.

D. Avoid disturbing or overstressing valve body when installing valves. Perform field adjustment of valves under pressure to ensure shutoff occurs in number of rotations as described in valves operation and maintenance manual.

E. Submit certification that large diameter valve was installed, adjusted, and exercised in accordance with manufacturer's instructions. Manufacturer's certification shall state that all performance characteristics of large diameter valves, as installed, have been met. Adjustments made to valve, for any reason, must be made by manufacturer's representative.

3.03 DISINFECTION AND TESTING

A. Assist City with disinfection of valves and appurtenances as required by Section 02514 - Disinfection of Water Lines and test as required by Section 02515 - Hydrostatic Testing of Pipelines. Do not use valves for throttling without prior approval of manufacturer.

3.04 COATING OF PIPING

A. Coat valves located in vaults, stations, and above ground using approved paint. Coating shall be 6-12 mils thick, but no more than 12 mils. Apply coating in accordance with manufacturer's recommendations.

END OF SECTION

SECTION 02523

PRESSURE REDUCING VALVES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pressure reducing valves (PRV).

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02085 – Valve Boxes, Meter Boxes, and Meter Vaults

D. Section 02317 – Excavation and Backfill for Utilities

E. Section 02514 – Disinfection of Water Lines

F. Section 02515 – Hydrostatic Testing of Pipelines

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for pressure reducing valves is on unit price basis for each valve installed.

2. Payment includes vault, piping, manhole, fittings, and appurtenances necessary for complete installation of valve.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is a Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASME B 16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. ASTM A 48 - Standard Specification for Gray Iron Castings.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer's product data for proposed valves for approval.

C. Submit design calculations and shop drawings for valve vaults and manholes, sealed by Engineer registered in the State of Texas.

1.06 QUALITY CONTROL

A. Submit manufacturer's affidavit that pressure reducing valves purchased for Work, were manufactured and tested in the United States, and conform to requirements of this Section.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide approved PRV with basket strainer in location and arrangement as shown on Drawings.

1. Valve body: Ductile iron with ASME B16.1, Class 125, flanges.

2. Valve cover: ASTM A 48 cast iron.

3. Valve internals:

a. Provide top and bottom single moving disc and diaphragm assembly.

b. Use flexible nylon fabric reinforced elastomer diaphragm integral with assembly.

c. Provide valve internal trim (seat ring, disc guide, and cover bearing) made of stainless steel.

d. Provide heat fusion bonded epoxy coating to internal and external surfaces of valve body including disc retainer and diaphragm washer. Holiday test coating applied to valve body.

e. Treat stem and seat with penetrative salt nitride process.

f. Use Xylan coated seat.

g. Do not use leather parts.

B. Control Tubing: Contain shutoff cocks with Y-strainer.

C. PRV: Equip with visual valve position indicator. Fit valve position indicator with air-bleed petcock. Initially set in field by authorized manufacturer's representative with 60 psi downstream pressure.

D. Provide basket strainer upstream of PRV as shown on Drawings.

1. Strainer body: Quick-opening type, fabricated-steel construction with ASME B 16.1, Class 150, flanges.

2. Basket: Type 304, stainless steel.

3. Model: Provide basket compatible with the manufacturer of the pressure reducing valve. Hayward Model 90, or approved equal, for PRV 4 inches through 24 inches. Provide Hayward Model 510, or approved equal, for PRV 14 inches or greater when space limitations dictate use of smaller strainer housing.

E. Provide pressure reducing pilot that has adjustable range of 20 - 175 psi. Provide and install pilot system components according to manufacturer's recommendations unless otherwise approved by Project Manager.

F. Valve Vaults: Provide as shown on Drawings and conforming to requirements of Section 02085 - Valve Boxes, Meter Boxes, and Meter Vaults.

PART 3 EXECUTION

3.01 EARTHWORK

A. Conform to applicable provisions of Section 02317 - Excavation and Backfill for Utilities.

3.02 SETTING VALVES

A. Provide services of technical representative of valve manufacturer on site during installation of valves and to serve as adviser on aspects of installation. Take necessary precautions to protect pilot system during PRV installation.

B. Prior to installing valves, remove foreign matter from within valves. Inspect valves in open and closed position to verify that parts are in satisfactory working condition.

3.03 DISINFECTION AND TESTING

A. Disinfect valves and appurtenances as required by Section 02514 - Disinfection of Water Lines and test as required by Section 02515 - Hydrostatic Testing of Pipelines.

3.04 PAINTING OF PIPING AND VALVES

A. Paint piping and valves located in vaults, stations, and above ground using ACRO Paint No. 2215, or approved equal.

END OF SECTION

SECTION 02524

AIR RELEASE AND VACUUM RELIEF VALVES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Air release and vacuum relief valves.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02082 – Precast Concrete Manholes

D. Section 02317 – Excavation and Backfill for Utilities

E. Section 02514 – Disinfection of Water Lines

F. Section 02515 – Hydrostatic Testing of Pipelines

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for air release and vacuum relief valves is on unit price basis for each valve installed.

2. Payment includes manhole or vault (when required), fittings, vent piping and bollard(s) and appurtenances necessary for complete installation of valve.

3. Payment for valve assembly on aerial crossing includes fittings, anti-vandalism protection, freeze protection, vent piping and appurtenances necessary for complete installation of valve.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM A 48 - Standard Specification for Gray Iron Castings.

B. ASTM A 126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

C. ASTM A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

D. ASTM A 276 - Standard Specification for Stainless Steel Bars and Shapes.

E. ASTM A 313 - Standard Specification for Stainless Steel Spring Wire.

F. ASTM B 584 - Standard Specification for Copper Alloy Sand Castings for General Applications.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer's product data for proposed valves for approval.

PART 2 PRODUCTS

2.01 DESCRIPTION

A. Provide combination air valves designed to fulfill functions of air release (permit escape of air accumulated in line at high point of elevation while line is under pressure) and vacuum relief.

B. Provide inlet and outlet connections, and orifice as shown on Drawings.

1. Valve exterior: Painted with shop-applied primer suitable for contact with potable water.

2.02 MATERIALS

A. Air Release Valves: Provide approved air release valves ASTM A 48, Class 30, cast iron; float and leverage mechanism with body and cover, ASTM A 240 or ASTM A 276 stainless steel; orifice and seat, stainless steel against Buna-N or Viton mechanically retained with hex head nut and bolt. Other valve internals shall be stainless steel or bronze.

B. Air Release and Vacuum Relief Valves: Provide single-body, standard combination valves or duplex-body custom combination valves as indicated on Drawings.

1. For 2-inch and 3 inch, single-body valves, provide inlet and outlet size as shown on Drawings and orifice sized for 100 psi working pressure.

a. Valve materials: body, cover, and baffle, ASTM A 48, Class 35, or ASTM A 126, Grade B cast iron; plug or poppet, ASTM A 276 stainless steel; float, ASTM A 240 stainless steel; seat, Buna-N; other valve internals, stainless steel.

2. For 3 inch and larger duplex body valves as shown on Drawings, provide approved air release valve.

    a. Air and vacuum valve materials: body and cover, ASTM A 126, Class B, cast iron; float, ASTM A 240 stainless steel; seat, Type 304, stainless steel and Buna-N, for sanitary sewer, Garlock #3000 (non-asbestos),for water lines; other valve internals, stainless steel or bronze (for sanitary sewer).

    b. Air release valve: Constructed as specified in paragraph above on Air Release Valves.

C. Vacuum Relief Valves: Provide approved air inlet vacuum relief valves with flanged inlet and outlet connections as shown on Drawings. Provide air release valves in combination with inlet and outlet, and orifice as shown on Drawings. Valve shall open under pressure differential not to exceed 0.25 psi.

1. Materials for vacuum relief valves: valve body, ASTM A 48, Class 35, cast iron; seat and plug, ASTM B 584 bronze, copper alloy 836; spring, ASTM A 313, Type 304, stainless steel; bushing, ASTM B 584 bronze, copper alloy 932; retaining screws, ASTM A 276, Type 304, stainless steel.

D. Additional Requirements for Wastewater Applications:

1. Air Release/Vacuum Relief Valves shall have a minimum seating pressure of at most 5 psi through a maximum operating pressure of 250 psi unless otherwise specified by the Engineer.

2. Valve bodies shall be constructed of 316 stainless steel.

3. Valves that require adjustment of a spring or nuts shall not be allowed.

4. Piping connections between dissimilar metals, e.g., ductile iron or cast iron and stainless steel, etc., shall be provided with dielectric insulating kits consisting of dielectric gaskets, bolt sleeves, and washers to prevent any galvanic action between the dissimilar metals.

5. The valves shall have an internal debris shield and debris screen or an alternative mechanism to prevent clogging of the orifice.

6. Rubber components used shall be suitable for wastewater application.

7. Float materials shall be ASTM A 240 stainless steel, polypropylene, polyurethane, or HDPE for wastewater applications.

E. Manholes: As shown on Drawings conforming to requirements of Section 02082 - Precast Concrete Manholes.

PART 3 EXECUTION

3.01 EARTHWORK

A. Conform to applicable provisions of Section 02317 - Excavation and Backfill for Utilities.

3.02 SETTING VALVES IN MANHOLES AND VAULTS

A. If required by Project Manager, provide services of technical representative of valve manufacturer available on site during installation of valves.

B. Prior to installing valves, remove foreign matter from within valves. Inspect valves in open and closed position to verify that parts are in satisfactory working condition.

C. Install valves and valve manholes and vaults where indicated on Drawings or as located by Project Manager. Set manholes and vaults plumb and as detailed. Center manholes on valves. Compact cement-stabilized sand around each manhole and vault for minimum radius of 4 feet, or to undisturbed trench face when less than 4 feet. Provide above-ground vents for manholes and vaults as indicated on Drawings.

3.03 DISINFECTION AND TESTING

A. Assist City with disinfection of valves and appurtenances as required by Section 02514 - Disinfection of Water Lines and test as required by Section 02515 - Hydrostatic Testing of Pipelines.

3.04 PAINTING OF PIPING AND VALVES

A. Paint piping and valves located in manholes, stations, and above ground using approved paint.

END OF SECTION

SECTION 02525

TAPPING SLEEVES AND VALVES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Tapping sleeves and valves for connections to existing water system.

1.02 REALTED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02085 – Valve Boxes, Meter Boxes, and Meter Vaults

D. Section 02221 – Removing Existing Pavements, Structures, Wood, and Demolition Debris

E. Section 02317 – Excavation and Backfill for Utilities

F. Section 02521 – Gate Valves

G. Section 02528 – Polyethylene Encasement/Wrap

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment is on unit price basis for each tap installed.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

3. For water lines 4-inches and greater, no payment will be made until coupon (cut out portion of pipe tapped) is delivered to City.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

B. ASTM A193 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Pressure Service and Other Special Purposed Applications.

C. ASTM A194 - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

D. AWWA C 110 - Standard for Ductile-Iron and Gray-Iron Fittings, 3 in. through 48 in., for Water and other Liquids.

E. AWWA C 200 - Standard for Steel Water Pipe - 6 in. and Larger.

F. AWWA C 207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 in. Through 144 in.

G. AWWA C 500 - Standard for Metal Seated Gate Valves, for Water Supply Service.

H. AWWA C 223 - Fabricated Steel and Stainless Steel Tapping Sleeves.

I. OSHA 29 CFR 1926.1101 – Asbestos.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit results of tapping sleeves NPT test opening.

C. Submit manufacturer's affidavit as required in Section 02521 - Gate Valves.

D. For tapping fiberglass reinforced pipe (FRP), submit tapping procedures in accordance with FRP manufacturer’s recommendations.

1.06 DELIVERY, STORAGE AND HANDLING

A. Ship steel sleeves in wooden crates that provide protection from damage to epoxy coating during transport and storage.

PART 2 PRODUCTS

2.01 MATERIALS

A. Tapping Sleeves:

1. Tapping Sleeve Bodies: AWWA C 110 cast or ductile iron or AWWA C 200 carbon steel in two sections to be bolted together with high-strength, corrosion-resistant, low-alloy steel bolts with mechanical joint ends.

2. Branch Outlet of Tapping Sleeve:

a. Flanged, machined recess, AWWA C 207, Class D, ANSI 150 pound drilling.

b. Gasket: Affixed around recess of tap opening to prevent rolling or binding during installation.

3. Use cast iron split sleeve where fire service from 6-inch water line is approved.

4. For tapping Fiberglass Reinforced Pipe (FRP), provide stainless steel tapping sleeves. Do not use cast iron or ductile iron tapping sleeves. Comply with FRP pipe manufacturer's recommendations for tapping procedures.

B. Welded-steel tapping-sleeve bodies may be used in lieu of cast or ductile iron bodies for following sizes and with following restrictions:

1. Flange: AWWA C 207, Class D, ANSI 150 pound drilling.

2. Gasket: Affixed around recess of tap opening to prevent rolling or binding during installation.

3. Steel sleeves are restricted to use on pipe sizes 6 inches and larger.

4. Body: Heavy, welded-steel construction; top half grooved to retain neoprene O-ring seal permanently against outside diameter of pipe.

5. Bolts: AWWA C 500 Section 3.5; coated with 100 percent vinyl resin or corrosive resistant material.

6. Steel Sleeves Finish: Fusion-bonded epoxy coated to minimum 12 mil thickness.

7. Finished Epoxy Coat: Free of laminations and blisters; and remain pliant and resistant to impact with non-peel finish.

8. Provide approved steel tapping sleeves

9. Tapping Sleeves: Provide with 3/4-inch NPT test opening for testing prior to tapping. Provide 3/4-inch bronze plug for opening.

10. Do not use steel sleeves for taps greater than 75 percent of pipe diameter.

11. Comply with AWWA C 223 - Fabricated Steel and Stainless Steel Tapping Sleeves.

C. Stainless Steel tapping-sleeve bodies and flange may be used in lieu of cast or ductile iron bodies for following sizes and with following restrictions:

1. Flange: ASTM A240 Stainless Steel, Type 304, ANSI 150 pound drilling.

2. Gasket: Full circumferential, affixed around recess of tap opening to prevent rolling or binding during installation, compounded for water and sewer service.

3. Stainless Steel sleeves are restricted to use on pipe sizes 4 inches and larger.

4. Body: ASTM A240 Stainless Steel, Type 304.

5. Bolts: ASTM A193 Stainless Steel, Type 304.

6. Nuts: ASTM A194 Stainless Steel, Type 304.

7. Branch Outlet: Heavy Stainless Steel Pipe.

8. Provide approved stainless steel tapping sleeves.

9. Do not use stainless steel sleeves for taps greater than 75 percent of pipe diameter.

10. Comply with AWWA C 223 - Fabricated Steel and Stainless Steel Tapping Sleeves.

D. Tapping Valves: Meet requirements of Section 02521 - Gate Valves with following exceptions:

1. Inlet Flanges:

a. AWWA C 110; Class 125.

b. AWWA C 110; Class 150 and higher: Minimum 8-hole flange.

2. Outlet: Standard mechanical or push-on joint to fit any standard tapping machine.

3. Valve Seat Opening: Accommodate full-size shell cutter for nominal size tap without contact with valve body; double disc.

E. Valve Boxes: Standard Type "A" valve boxes conforming to requirements of Section 02085 - Valve Boxes, Meter Boxes, and Meter Vaults.

PART 3 EXECUTION

3.01 APPLICATION

A. Install tapping sleeves and valves at locations and of sizes shown on Drawings, maintain 5 feet spacing from edge of tapping sleeve from any other tap or fitting. Install sleeve so valve is in horizontally level position unless otherwise indicated on Drawings.

B. Clean tapping sleeve, tapping valve, and pipe prior to installation and in accordance with manufacturer's instructions.

C. Hydrostatically test installed tapping sleeve to 150 psig for minimum of 15 minutes. Inspect sleeve for leaks, and remedy leaks prior to tapping operation.

D. When tapping concrete pressure pipe, size on size, use shell cutter one standard size smaller than water line being tapped.

E. Do not use Large End Bell (LEB) increasers with next size tap unless existing pipe is asbestos- cement.

3.02 INSTALLATION

A. Verify outside diameter of pipe to be tapped prior to ordering sleeve.

B. Verify clearance of 5 feet to maintain spacing.

C. Tighten bolts in proper sequence so that undue stress is not placed on pipe. For installation of tapping sleeves on FRP, comply with pipe manufacturer's recommendations for bolt torque values.

D. Align tapping valve properly and attach to tapping sleeve. Insert insulation sleeves into flange holes of tapping valve and pipe. Make insertions of sleeves on pipe side of tapping valve. Do not damage insulation sleeves during bolt tightening process.

E. Make tap with sharp, shell cutter:

1. For 12-inch and smaller tap, use minimum cutter diameter one-half inch less than nominal tap size.

2. For 16-inch and larger tap, use manufacturer's recommended cutter diameter.

3. For tapping FRP pipe, comply with pipe manufacturer's recommendations for forward feed rate.

F. Withdraw coupon and flush cuttings from newly-made tap.

G. Wrap:

1. For 12-inch and smaller tap, wrap completed tapping sleeve and valve in accordance with Section 02528 - Polyethylene Encasement/Wrap.

2. For 16-inch and larger tap, apply coal tar epoxy around completed tapping sleeve and valve. The coal tar epoxy shall be applied with minimum of two (2) coats. Each coat of coal tar epoxy shall have minimum dry film thickness of 16 mils.

H. Place concrete thrust block behind tapping sleeve (not over tapping sleeve and valve).

I. Request inspection of installation prior to backfilling.

J. Backfill in accordance with Section 02317 - Excavation and Backfill for Utilities.

3.03 ADDITIONAL REQUIREMENTS FOR TAPPING ASBESTOS-CEMENT (AC) PIPE

A. Notify Project Manager when AC pipe is encountered.

B. Refer to Section 02221 – Removing Existing Pavements, Structures, Wood, and Demolition Debris for crew training, safety precautions, and AC pipe removal requirements.

C. Protocol:

1. Mechanically excavate to no more than 6 in. of AC pipe. Carefully uncover the remainder of pipe by hand or with shovel.

2. Keep pipe adequately wet before and during work.

3. Locate tap a minimum of 5 ft. away from existing AC collar.

4. Use of power tools is prohibited.

5. Remove waste AC pipe coupon.

END OF SECTION

SECTION 02526

WATER METERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Water meters, submeters, and fire service meters.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02085 – Valve Boxes, Meter Boxes, and Meter Vaults

D. Section 02501 – Ductile Iron Pipe and Fittings

E. Section 02502 – Steel Pipe and Fittings

F. Section 02506 – Polyvinyl Chloride Pipe

G. Section 02512 – Water Tap and Service Line Installation

H. Section 02525 – Tapping Sleeves and Valves

I. Section 02527 – Polyurethane Coatings on Steel or Ductile Iron Pipe

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement for water meters is on unit price basis for installation of each meter type and size.

2. Payment includes vault, piping and appurtenances necessary for complete installation of meter.

3. Measurement for relocating and reinstalling meter with new box is on unit price basis for each meter relocated and reinstalled.

4. No separate payment for adjustment of meter or meter box unless otherwise shown in Drawings.

5. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work is in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASME B 16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. AWWA C 510 - Standard for Double Check Valve Backflow - Prevention Assembly.

C. AWWA C 700 - Standard for Cold-Water Meters - Displacement Type, Bronze Main Case.

D. AWWA C 701 - Standard for Cold-Water Meters - Turbine Type for Customer Service.

E. AWWA C 702 - Standard for Cold-Water Meters - Compound Type.

F. AWWA C 703 - Standard for Cold-Water Meters - Fire Service Type.

G. AWWA Manual M6 - Water Meters - Selection, Installation, Testing, and Maintenance.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit written certification of calibration and test results.

C. Submit manufacturer's certification that meters meet applicable requirements of this Specification Section.

D. Submit accuracy registration test certification from manufacturer for each 3-inch through 10- inch diameter meter.

1.06 QUALITY ASSURANCE

A. Submit manufacturer's warranty against defects in materials and workmanship for one year from date of Substantial Completion.

B. Provide vendor's unconditional guarantee that performance of each meter meets applicable AWWA standards and AWWA Manual M6 as follows:

1. Displacement type: 10 years from installation or register registration shown below, whichever comes first.

Size (inch)	Registration (million gallons)
5/8, 3/4	1.5
1	2.5
1-1/2	5.0
2	10.5

2. Turbine type: 1 year from date of installation.

3. Compound type: 1 year from date of installation.

4. Fire service type: 1 year from date of installation.

C. Operations of hermetically sealed register, 5/8-inch to 2-inch diameter, shall be unconditionally guaranteed for 15 years.

D. Provide manufacturer's unconditional guarantee for each sealed register against leakage, fogging, discoloration, and stoppage for 15 years from date of installation.

E. Vendor may replace meters that become defective within guarantee period with meters that comply with this Specification. City will return defective meters to vendor at their expense. Meters repaired or replaced under this guarantee must meet accuracy limits for new meters upon receipt and accuracy limits for remaining period of initial guarantee.

1.07 EASEMENT REQUIREMENTS

A. Install 2-inch and smaller water meters and shut-off valves (stop boxes) in right-of-way when possible. Otherwise, install in a minimum 5-foot by 5-foot separate water meter easement contiguous with public right-of-way.

B. Install 3-inch to 6-inch water meters in a minimum of 10-foot by 20-foot separate water meter easement contiguous with public right-of-way.

C. Install 8-inch and larger water meters in a minimum of 15-foot by 25-foot separate water meter easement contiguous with public right-of-way.

D. Locate water meter easements contiguous with public right-of-way unless approved by Project Manager. Provide minimum fifteen foot wide access easement when not contiguous with public right-of-way.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide meters of type and size as indicated on Drawings, unless otherwise indicated.

B. Provide bolted split casings. Main casings of meters and external fasteners: Copper alloy with minimum 75 percent copper for 5/8 inch to 2 inches, bronze or cast iron, hot-dipped galvanized or epoxy coating for 3 inches and larger.

C. Straightening Vanes: Non-corrosive material compatible with case material.

D. Intermediate gear train shall not come into contact with water and shall operate in suitable lubricant.

E. Registers: Automatic Meter Reading (AMR) type that provides pulse, contact closure, piezo switch or encoder generated output signal, compatible with City's radio and telephone AMR systems. Provide minimum 12-foot wire when permanently connected to register. Lens: impact resistant. Register box: tamper resistant by means of tamper screw or plug: Register: permanently sealed, straight-reading, center-sweep test hand, magnetic driven, U.S. gallons. Digits: 6, black in color, with lowest registering 3 digits (below 1,000-gallon registration) having contrasting digit and background color. Register capacity of meters: 9.99 million gallons for 5/8 inch to 2 inches and 999.999 million gallons for 3 inches and larger.

F. Connections: 5/8 inch to 1 inch: threads at each end; 1-1/2 to 2 inches: 2-bolt oval flanges each end; 3 inches and larger: flange at each end.

G. Stamp manufacturer's meter serial number on outer case. Stamp manufacturer's meter serial number on outside of register lid when provided. Manufacturer's serial numbers shall be individual and not duplicated.

H. Meters: Provide approved meters equip with AMR type register to connect to City of Houston's AMR system.

I. Manufacturing Quality Control shall permit successful interchangeability from one meter to another of same size including registers, measuring chambers and units, discs or pistons as units, change gears, bolts, nuts, and washers without affecting accuracy of new meter.

J. For water meter vaults provide:

1. 1/4-inch steel or aluminum with stainless steel hinge pins. Door shall open to 90 degrees and automatically lock in that position.

2. Provide approved meter vault covers.

2.02 METER APPLICATIONS

A. Meter type requirements to usage application

1. All meters must be compatible with the City of Houston automated meter reading (AMR) System and /or automated metering infrastructure (AMI) system

2. Sizes 5/8-inch to 2-inch Meters: Displacement type excluding application exceptions notes in paragraph 2.02 A.3

3. Exceptions

   a. Meter types for sizes 1-inch to 2-inch NFPA 13-D, 13-R applications require prior approval by the City of Houston. (Displacement meters are not allowed for these applications).

   b. Applications where constant flow is required a 2-inch turbine type meter may be substituted.

B. Sizes 3-inch and above Meters:

1. Turbines:

   Processing plants
   Manufacturing facilities
   Lawn sprinkler systems
   Effluent water in treatment plants
   Booster (pump)stations
   Level controlled tank filling operations
   Fire hydrants (transients)
   Inter-systems sale or transfer
   Sewer credit/sub-meter

2. Compounds:

   Multi-family dwellings
   Motels and hotels
   Hospitals
   Schools
   Restaurants
   Office buildings
   Dormitories, nursing homes, department stores, shopping malls, and other commercial establishments

3. Fire Rated Turbines:

   Open systems feeding directly from a tank

4. Fire Rated Compounds:

   Combination domestic and fire services
   Open system not feeding directly from a tank

5. Electromagnetic Meters:

   Inter-system sale or transfer

Raw water
Basement or inside structure installations
Contract water
Above ground applications in potential hazardous chemical environs Meters larger than 10-inch.

C. Meter size requirements to flow considerations

1. Meter flow range is dependent on amount of pressure and slightly varies with manufacture.

Flow Range	Max. Continuous Flow	Meter Size
¼ - 25 GPM	15 GPM	5/8" Positive Displacement
¾ - 70 GPM	50 GPM	1" Positive Displacement
1 ¼ - 120 GPM	80 GPM	1 ½" Positive Displacement
1 ½ - 170 GPM	100 GPM	2" Positive Displacement

Flow Range	Max. Continuous Flow	Meter Size
5 – 550 GPM	450 GPM	3" Turbine
15 – 1250 GPM	1000 GPM	4" Turbine
20 – 2500 GPM	2000 GPM	6" Turbine
30 – 4500 GPM	3500 GPM	8" Turbine
50 – 7000 GPM	5500 GPM	10" Turbine

Flow Range	Max. Continuous Flow	Meter Size
½ - 450 GPM	350 GPM	3" Domestic Compound
¾ - 1250 GPM	1000 GPM	4" Domestic Compound
1 – 2000 GPM	1400 GPM	6" Domestic Compound
3/4 - 1200 GPM	1200 GPM	4" Fire Compound
1 ½ - 2500 GPM	2500 GPM	6" Fire Compound
2 – 4000 GPM	4000 GPM	8" Fire Compound
2 – 6500 GPM	6500 GPM	10" Fire Compound

D. Meter location preference hierarchy for 3" and larger applications

1. Outline by order of preference for Meter Easement location. Any installation other than "D1." requires approval from the Office of the City Engineer (OCE).

   a. Adjacent to Public ROW

   b. Not adjacent to Public ROW with water line easement.

   c. Parking garage

   d. Mechanical room area of basement

e. Public ROW

f. Above ground meter installations are required on potential hazardous chemical environs, and meters larger than 10".

2. Per chapter 7 of the City of Houston Design Manual, install separate tap and service lead for each domestic meter. Irrigation meters are to be branched off the domestic service.

Eligibility Requirements for Meter Easement Locations

Meter Location	Meter Easement	Water line Easement	P.A.E.	A.D.A. Requirements	Electric and Phone Service	Encroachment Permit	Min. Utility Spacing	Special Meter Vault, or Meter Setup Requirements
Grade Level Easement Adjacent to ROW	YES	NO	NO	NO	NO	NO	NO	NO
Grade Level Easement Not Adjacent to ROW	YES	YES	NO	NO	NO	NO	NO	NO
Parking Garage	YES	**NO	YES	NO	YES	NO*	NO	YES
Mechanical Room in Basement	YES	**NO	NO	NO	YES	NO*	NO	YES
Public ROW	NO	NO	NO	YES	NO	YES	YES	YES
Above Ground Installations	YES	**NO	YES	NO	YES	NO	NO	YES

* Provided structure does not encroach ROW
** Provided meter is set adjacent to ROW

Acronym Definition:
P.A.E.- Permanent Access Easement.
A.D.A.- Americans with Disabilities Act.
ROW- Right of Way.

2.03 MATERIALS

A. Cold-Water Meters:

1. Displacement Type: AWWA C 700; sizes 5/8 inch up to and including 2 inches; oscillating disc or piston of magnetic drive type; bolted split-case design, with either being removable.

2. Turbine Type: AWWA C 701; Class II; sizes 1-1/2 inches through 10 inches; flanged; straight-through measuring chamber; rotor construction: polypropylene or similar non-rubber material with specific gravity of approximately 1.0, equipped with near frictionless replaceable bearings in turbine working against rotor shaft positioned thrust bearing. Transient/Fire Hydrant Meter Inlet: Female fitting for attachment to hose nozzle with National Standard Fire hose thread. Outlet: 2-inch nipple with National Pipe Thread. Include restriction plate to limit flow through meter to 400 gpm at 65 psi. 1-1/2 inches through 8 inches are to be furnished with test plugs in the outlet port of the meter for field testing.

3. Compound Type: AWWA C 702; sizes 2 inches through 6 inches. Measuring chambers: For use in continuous operation; separate units of copper alloy (minimum 84 percent copper) or approved polymer material, inert in corrosive potable water; with centering device for proper positioning. Measuring pistons: Non-pilot type with division plates of rubber covering vulcanized to stainless steel or other approved material of sufficient thickness to provide minimum piston oscillation noise. Measuring discs: Flat or conical type, one piece, mounted on monel or 316 stainless steel spindle. Measuring chamber strainer screen area: Twice area of main case inlet.

4. Fire-Service Type: sizes 4 inches through 10 inches; turbine-type, compound type, proportional type; AWWA C 703, with separate check valve conforming to AWWA C 510. Determine size of fire meter by adding fire flow and domestic flow.

2.04 STRAINERS

A. Displacement Potable Water Meters 5/8 inch through 2 inches: Self-straining by means of annular space between measuring chamber and external case or with strainer screens installed in meter. Provide rigid screens which fit snugly, are easy to remove, with effective straining area at least double that of main case inlet.

B. Potable Water Meters 2-inch diameter and larger: Equip with separate external strainer with bronze body for diameters less than 8 inches. 8-inch diameter and larger may be cast iron, hot- dipped galvanized or epoxy coating. Strainers: Bolted to inlet side of meter, detachable from meter, easily removable lid. Strainer screen: Made of rounded cast bronze, stainless steel wire, having nominal screen size of 3-1/2 mesh-per-inch (U.S. Series) not less than 45 percent clear area.

C. Provide separate approved external strainers (when required by meter manufacturer) approved for use in fire service metered connections by Underwriters Laboratories. Bodies: Cast iron or copper alloy. Ends: Flanged in accordance with ASME B 16.1, Class 125. Provide stainless steel basket. Strainers shall be detachable from meter.

2.05 CONNECTIONS AND FITTINGS

A. Provide pipe for connections in accordance with Section 02501 - Ductile Iron Pipe and Fittings and Section 02506 - Polyvinyl Chloride Pipe. Use restrained joints and flanged joints only.

B. Fittings:

1. For meters 2 inches and smaller: Same type of fittings as Outlet End fittings for Curb Stop in accordance with Section 02512 - Water Tap and Service Line Installation.

2. For meters 3 inches and larger: Restrained ductile iron; push-on bell joints or mechanical joint fittings between water line and meter vault; Class 125 flanged inside meter vaults; cement mortar lined and sealed.

2.06 LAYING LENGTHS

A. Minimum laying lengths for meter and standard strainer shall be as shown on Drawings.

PART 3 EXECUTION

3.01 TAPPING AND METER SERVICE INSTALLATION

A. Refer to Section 02525 - Tapping Sleeves and Valves for tapping requirements.

B. Meter Service Line:

1. Use pipe and fittings conforming to requirements of Section 02501 - Ductile Iron Pipe and Fittings, or Section 02506 - Polyvinyl Chloride Pipe.

2. Limit pulling and deflecting of joints to limits recommended by manufacturer.

3. Make vertical adjustments with offset bends where room will permit. Minimize number of bends as shown on detail drawings.

4. Provide minimum of ten pipe diameters of straight pipe length upstream and downstream of meter vault.

3.02 METER FITTING HOOKUP

A. Support meter piping and meter, level and plumb, during installation. Support meters 3 inches and larger with concrete at minimum of two locations.

B. Use round flanged fittings inside meter box or vault except for mechanical joint to flange adapter. Provide full-face 1/8-inch black neoprene or red rubber gasket material on flanged joints. Provide bolts and nuts made from approved corrosion-resistant material.

C. Tighten bolts in proper sequence and to correct torque.

D. Visually check for leaks under normal operating pressure following installation. Repair or replace leaking components.

3.03 METER BOX AND VAULT INSTALLATION

A. Conform to requirements of Section 02085 - Valve Boxes, Meter Boxes, and Meter Vaults.

B. Perform adjustment to existing meter in accordance with Section 02085 - Valve Boxes, Meter Boxes, and Meter Vaults.

3.04 BASEMENT INSTALLATIONS FOR METERS

A. All piping within meter easement inside the building in basement must be welded steel to conform to Section 02502 - Steel pipe and Fittings or restrained Ductile Iron to conform to Section 02501 - Ductile Iron pipe and Fittings. All transitions from PVC to Steel or Ductile iron must be made on the exterior side of the basement wall. All materials must be on the City approved list of materials.

1. The meter piping must conform to the City of Houston detail drawings for typical meter piping arrangement.

2. All pipes must be installed straight into the building.

B. 3” and larger meter installations for basements must be the Utility Customer Service approved for billing electromagnetic meter from the City of Houston approved products list.

C. The customer must provide a NEMA type 4 enclosure 20”H x 16”W x 10”D for the mounting and containment of the meter electronics. The 120AC receptacle and phone jack must be installed in the enclosure.

D. The customer must provide and maintain 120AC power and phone line within five feet of the meter location.

1. The 120AC power must terminate with a GFI protected receptacle and be connected to the structure’s emergency back up power.

E. The customer must provide a phone line which can be a shared phone line.

1. Phone line must terminate with a phone jack inside the service rack enclosure.

F. The customer will be required to give the City of Houston the appropriate size meter easement to conform to the City of Houston Design Manual, with a minimum 8 feet clearance between floor and ceiling.

1. Meters installed in an interior room must be fitted with double doors for easy equipment access. A floor drain must be installed within the meter easement for water drainage.

2. The meter must be placed on the same floor level that the service line enters the structure. The service line must enter through the wall of the building. Use link seal method for pipe penetration thru wall as shown in City of Houston Detail Drawing.

3. The customer or property owner shall keep the space occupied by the meter free from rubbish or obstruction of any kind, and provide access in accordance to City of Houston Ordinance Chapter 47.

G. No signal from the meter will be shared, duplicated, or split for the customers use. Once the meter is installed and accepted by the City of Houston the meter, instruments, and all attachments becomes the sole property of the City of Houston.

3.05 CONTRACT METER INSTALLATIONS

A. All contract potable water and raw water accounts are required to install the Utility Customer Service approved for billing electromagnetic meter from the City of Houston approved product list.

1. With exception of Emergency Backup System meters EBS which will be the approved mechanical type meter for the application.

B. All meter vaults must be designed to the City of Houston standard detail drawings.

1. Meter installations larger than 10” that cannot be installed within the standard City vault, or meter installations in potential hazardous chemical environs must be installed above ground.

2. The City of Houston Engineer’s office and the Meter Shop must approve an above ground meter installation.

3. All above ground meter installations must be painted to City of Houston specifications Section 02527 - Polyurethane Coatings on Steel or Ductile Iron Pipe and have freeze protection.

4. Above ground meter installations must have an 8’tall perimeter fence with a gate when it is not inside a water plant facility.

C. All meter installations require meter easements and require a water line easement when meter easement is not adjacent to the City of Houston Right of Way.

1. All meters that are not located adjacent to the Public Right of Way must have an all weather hard surface road to the meter location.

D. All contract account customers must supply 120 AC voltage with a GFI receptacle and phone service with phone jack to be terminated in a NEMA type 4 enclosure 20”H x 16”W x 10”D at the meter location.

1. Electrical service to the City of Houston meter station must be connected to the back up generator when installed within the districts plant facility.

2. 1” PVC electrical conduit must be installed from the enclosure to the meter for the meter electronics.

E. No customer will be allowed to share, spilt, duplicate, or disrupt any signal generated from the City of Houston meter.

3.06 TESTING

A. Accuracy registration tests will be conducted in accordance with latest revision of AWWA standard for type and size of meter.

1. Tests will be run by City of Houston on meters prior to installation at City's meter repair shop. Meters 2-inches and smaller will be tested at random at City's discretion. All 3 inches and larger meters will be tested.

2. Accuracy of displacement meters during guarantee period shall be as follows:

a. Initial period: of 18 months from date of shipment or 12 months from date of installation: 98.5% to 101.5% at standard and minimum flow rates; 98% to 101% at low flow rates.

b. Second period: AWWA new meter accuracy as tested below.

	GUARANTEE PERIOD			TEST FLOW RATE
Meter Size (inches)	Age of Meter Years	or	Million* Gallons	Minimum Rate (gpm)
5/8	>1 to <5		0.5	1/4
1	>1 to <5		1.0	3/4
1-1/2	>1 to <5		2.5	1-1/2
2	>1 to <5		5.5	2

* Total registration.

c. Third period: AWWA new meter accuracy for standard flow rates and AWWA repair meter accuracy for minimum flow rate as tested below.

	GUARANTEE PERIOD			TEST FLOW RATE		
Meter Size (inches)	Age of Meter Years	or	Million* Gallons	Standard Flow Rate (gpm)	and	Minimum Rate (gpm)
5/8	>5 to <10		1.5	2-15		1/4
1	>5 to <10		2.5	4-40		3/4
1-1/2	>5 to <10		5.0	8-50		1-1/2
2	>5 to <10		10.0	15-100		2

* Total registration.

3. Minimal acceptable accuracy in percent of low flow registration for turbine meters:

Meter Size (inches)	Minimum Flow (gpm)	% Accuracy Required
2	3	95
3	5	95
4	15	95
6	20	95
8	20	95
10	30	95

END OF SECTION

SECTION 02527

POLYURETHANE COATINGS ON STEEL OR DUCTILE IRON PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Polyurethane coating system for use as steel pipe internal lining and external coatings, and external coating for ductile iron pipe.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02518 – Steel Pipe and Fittings for Large Diameter Water Lines

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. No separate payment will be made for work performed under this Section. Include cost of polyurethane coatings in contract unit prices for steel pipe or ductile iron pipe.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum): If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AWWA C 222 - Polyurethane Coatings for the Interior and Exterior of Steel Water Pipe and Fittings.

B. ASTM D 16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications.

C. ASTM D 522 - Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings.

D. ASTM D 570 - Standard Test Method for Water Absorption of Plastics

E. ASTM D 4060 - Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser

F. ASTM D 4541 - Standard Test Method for Pull Off Strength of Coatings Using Portable Adhesion Testers

G. ASTM E 96 - Standard Test Methods for Water Vapor Transmission of Materials

H. ASTM G 14 - Standard Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)

I. ASTM G 95 - Standard Test Method for Cathodic Disbondment Test of Pipeline Coatings (Attached Cell Method)

J. NACE SP-0188 - Discontinuity (Holiday) Testing of New Protective Coatings

K. NAPF 500-03 - Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings

L. SSPC-PA 2 - Procedure for Determining Conformance to Dry Coating Thickness Requirements.

M. SSPC-PA Guide 10 - Guide to Safety and Health for Industrial Painting Projects .

N. SSPC-SP 1 – Solvent Cleaning

O. SSPC-SP10 - Near-White Metal Blast Cleaning

P. SSPC-SP11 – Power-Tool Cleaning to Bare Metal

1.05 SAFETY

A. Secure, from manufacturer, Material Safety Data Sheet (MSDS) for polyurethane coatings and repair materials listed in this Section.

B. Safety requirements stated in this specification and in related sections apply in addition to applicable federal, state and local rules and regulations. Comply with instructions of coating manufacturer and requirements of insurance underwriters.

C. Follow handling and application practices of SSPC-PA Guide 10, and Coating Manufacturer's Material Safety Data Sheet.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit coating manufacturer's catalog sheets, product data sheets, material data sheets and other manufacturer’s information for all material provided. Include manufacturer’s recommendation and instructions for surface preparation, application and curing.

C. Quality Control Submittals. Furnish the following:

1. Shop and field applicator's experience with list of references substantiating compliance. Submit references of 5 successful projects completed within the last 3 years for each applicator. Each project listed should be at least 500 linear feet in length, unless otherwise approved by Project Manager.

2. Monitoring records for shop coated pipe, including coating "affidavit of compliance" to requirements of this Section stating that coatings were applied in factory, in accordance with manufacturer's requirements, and AWWA C222.

3. Factory applied coatings: Coating manufacturer's certification stating that the individual coating applicators have met the qualification certification requirements as specified in this Section.

4. Upon request by Project Manager, provide:

   a. Manufacturer's coating application Quality Control Manual

   b. Coating Performance Test report with statement that no reformulations have been made subsequent to the coating tests performed for the report.

   c. Current test equipment calibration certificates

5. Provide administrative documents showing that QA/QC personnel in both shop and field are certified as NACE International Coating Inspector (Level III).

6. Field applied coatings: Environmental monitoring records.

1.07 QUALITY ASSURANCE

A. Shop and Field Coating Applicator's Experience and Certification:

1. Minimum 5 years' practical experience in application of the specified products required for Coating Applicator and the coating application supervisor (Certified Applicator).

2. Minimum 2 years' practical experience in application of the specified coating system required for Coating application personnel whom have direct coating application responsibility.

3. Certification by coating manufacturer as an approved coating applicator required for Coating Applicator.

B. Shop: Unless otherwise approved by Project Manager, coating manufacturer's technical representative to be present for a minimum of three calendar days for technical assistance and instruction at the start of coating operations within the shop. During this visit, technical representative to observe surface preparation and coating application, and conduct or observe tests of coating to ensure conformance with application instructions, recommended methods, and conditions.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Use standard closed containers to prevent gelling, thickening deleteriously or forming of gas within period of one year from date of manufacture.

B. Label each container of separately packaged component clearly and durably to indicate date of manufacture, manufacturer's batch number, quantity, color, component identification and designated name or formula specification, number of coatings together with special instructions. Do not use coating components older than one year.

C. Deliver coating materials to pipe manufacturer in sealed containers showing designated name, batch number, color, date of manufacture and name of coating manufacturer.

D. Store material onsite in enclosures, out of direct sunlight in warm, ventilated and dry area. Protect from freezing.

E. Prevent puncture, inappropriate opening or other action which may lead to product contamination.

1.09 OBSERVATION OF WORK

A. Provide minimum 14 days advance notice to Project Manager before start of coating or lining work to allow for scheduling of shop or field observation.

B. Provide full access to Project Manager for all facilities and documentation regarding surface preparation, environmental conditions and coating applications.

C. Observation by Project Manager or waiver of observation does not relieve Contractor of Contractor's responsibility to perform work in accordance with Specifications.

D. Materials are subject to testing for conformance with this specification.

E. Project Manager may retain services of independent, third-party NACE CIP Level III-Certified Inspector for partial or full-time inspection of the work.

PART 2 PRODUCTS

2.01 GENERAL

A. Supply coating material in new, undamaged, labeled, unopened containers clearly and durably displaying date of manufacture, manufacturer's batch number, component identification, component color, manufacturer's name and product name. Store and handle in accordance with manufacturer's written instructions. Discard coating material that exceeds manufacturer's recommended shelf life, or is stored improperly, prior to usage, and replace with new material.

B. Clean, prime, and coat surfaces of pipe and fittings in accordance with referenced standards, written instructions by coating manufacturer, and these specifications.

C. Provide coating materials from single manufacturer. Product substitutions during project are not permitted without approval from Project Manager.

2.02 COATING MATERIAL

A. Coating System: ASTM D16 Type V thermoset, aromatic polyurethane plastic polymer in accordance with AWWA C222 (referred to as a polyurethane system).

B. Acceptable Materials:

1. DuraShield 110, 210, 310 (External), DuraShield 110-61 NSF, 210-61 NSF, 310-61 NSF (Internal), by LifeLast Inc., Pflugerville, TX,

2. CorroPipe 3000 (External), CorroPipe II PW (Internal) by Sherwin-Williams, Minneapolis, MN,

3. Protec II (External), Protec II PW (Internal) by ITW PolySpec/Futura Coatings, Houston, TX,

4. Polyclad 777PL (External), Polyclad 767 (Internal) by Carboline, St. Louis, MO,

5. or approved equal.

C. Cured Coating Properties. In accordance with AWWA C222 except as follows:

1. ASTM E 96 Permeance using Water Procedure BW (App. X1): no more than 0.16 inch-lb.

2.03 SURFACE PREPARATION

A. The requirements listed below are for surface preparation procedures in the factory. For surface preparation in the field, refer to PART 3 – Execution.

B. Steel Pipe. In accordance with coating manufacturer's requirements.

C. Ductile Iron Pipe. Prepare surface in accordance with manufacturer's recommendations and NAPF 500-03.

1. Provide uncoated ductile iron pipe when polyurethane coatings are used. Do not apply asphaltic coating to ductile iron pipe and then attempt to remove prior to polyurethane coating application.

2. Do not apply surface preparation that is designed for steel pipe to ductile iron pipe. Unlike steel surfaces, it is possible to over blast the external surface of ductile iron pipe. Consult ductile iron pipe and polyurethane coating manufacturer regarding method of application and surface preparation to be used.

2.04 FACTORY APPLICATION OF POLYURETHANE

A. Equipment: As required by manufacturer.

B. Temperature: Minimum 5 degrees F above dew point temperature. Temperature of surface shall not be less than 50 degrees F during application or as per manufacturers recommendation.

C. Humidity: Heating of pipe surfaces may be required when relative humidity exceeds 80 percent.

D. Do not thin or mix resins; use as received. Store resins at temperature above 55 degrees F at all times or as manufacturers recommendation.

E. Application: Conform to coating manufacturer's recommendations. Apply directly to substrate to achieve specified thickness. Multiple-pass, one-coat application process is permitted provided maximum allowable recoat time specified by coating manufacturer is not exceeded.

F. Recoat only when coating has cured less than maximum time specified by coating manufacturer. When coating has cured for more than recoat time, follow coating manufacturers recommendations for recoating.

G. Cure and perform cure test in accordance with manufacturer’s recommendations prior to handling, inspection, testing, and placement in service.

2.05 FACTORY INSPECTION

A. Project Manager may inspect coatings at coating applicator's facilities.

B. Inspection procedures to be in accordance with AWWA C222. Conduct inspection any time after coating has reached initial cure. Repair in accordance with manufacturer’s requirements and these specifications. Remove rejected coating from the full length of pipe to bare metal and reapply using proper application methods.

2.06 HOLDBACK COATING SYSTEM

A. Provide holding primer for corrosion protection of cutbacks or holdbacks compatible with specified joint coating system and weld after backfill requirements, where applicable.

B. Holdback coating to prevent corrosion of prepared pipe ends for duration of storage and construction, and recommended for buried exposures.

C. Primer should not result in running or melting of coating and causing toxic fumes when heated during welding on weld after backfill joints.

D. Apply holding primer in accordance with primer manufacturer's recommendations, but maintain clearances required for proper joint installation as recommended by pipe manufacturer.

E. Ductile Iron Joints: Apply coating to unlined pipe surfaces including inside of bell socket and outside of spigot. Coating thickness on sealing areas of spigot end of pipe exterior: minimum 8 mils (0.008 inch), maximum of 10 mils (0.010 inch). Maximum 10 mils may be exceeded in spigot end provided maximum spigot diameter as specified by pipe manufacturer is not exceeded and approved by pipe manufacturer.

F. Welded joints:

1. Field welded on the inside: Provide four-inch coating holdback on spigot end and six-inch coating holdback on bell end.

2. Field welded on the outside: Provide six-inch coating holdback on the spigot end, and four-inch coating holdback on the bell end.

2.07 THICKNESS

A. External Coatings: Minimum DFT of 25 mils (0.025 inch).

B. Internal Coatings (Linings): Minimum DFT of 25 mils.

C. Thickness Determinations: Use Type 1 magnetic thickness gauge as described in SSPC-PA2. No single gauge reading may be less than specified thickness.

D. Do not accept pipe with deficient coating thickness. If pipe in field is found to have a coating thickness as measured by SSPC PA-2 that is less than the specified thickness, the pipe segment shall be rejected.

2.08 FACTORY REPAIR OF INTERNAL AND EXTERNAL COATINGS

A. The procedures listed below are for repairs made to internal and external coatings in the factory. For field repairs, see Part 3 – Execution.

B. Defect size is defined as follows: Minor – less than 6 inches by greatest dimension. Major – exceeds 6 inches by greatest dimension.

C. General

1. Repair areas where holidays are detected or coating is visually damaged, such as blisters, bubbles, cuts, or other defects.

2. Provide coating repair materials that are compatible with the shop-applied coating system and approved by coating manufacturer.

3. Provide repair materials as required for the coating system and repair classification.

D. Repair Materials:

1. Provide polyurethane, single use kits that are supplied by parent coating manufacturer.

2. For major repairs in the shop, reapply using plural component spray equipment by a manufacturer certified coating applicator.

E. For internal coatings, five repairs maximum allowed per 100 square feet of pipe for internal linings. If this number is exceeded, pipe must be stripped of lining, re-blasted, and recoated in factory.

PART 3 EXECUTION

3.01 FIELD ENVIRONMENTAL CONTROLS

A. General

1. Do not apply coatings when:

a. Surface or ambient temperatures exceed the maximum or minimum temperatures recommended by the coating manufacturer.

b. In dust or smoke-laden atmosphere, blowing dust or debris, or under conditions that can cause icing on metal surface.

c. When it is expected surface temperatures may drop below 5 degrees above dew point within 4 hours after application of coating.

d. Whenever relative humidity exceeds 85 percent or the maximum recommended by the coating manufacturer.

2. When weather conditions dictate, provide and operate heaters and dehumidification equipment to allow pipe surfaces to be prepared and coated as specified and in accordance with the manufacturers coating application recommendations.

3. Do not proceed with surface preparation and coating application activities until adequate temperature and humidity controls are in place and functioning within environmental limits specified.

4. Monitor ambient temperature, relative humidity, dew point, temperature, and pipe surface temperature (work area only) in strict conformance with manufacturer's requirements, but not greater than 5 hours between measurements. Document and submit environmental monitoring records to Project Manager upon completion, if requested.

3.02 PIPE INSTALLATION

A. When required by Project Manager, provide services of pipe manufacturer's representative for period of not less than 2 weeks at beginning of actual pipe laying operations to advise Contractor regarding installation including but not limited to handling and storing, cleaning and inspecting, coatings repairs, and general construction methods as to how they may affect pipe coatings.

B. When required by Project Manager, coating manufacturer's technical representative to provide a written report to the Project Manager for each visit. Include copies of test data collected, description of observations, and all recommended corrective actions. Submit within five working calendar days after the visit. After corrective actions are complete, representative to certify application complies with manufacturer's coating application recommendations.

C. Use nylon straps, padded lifts and padded storage skids. Field cuts should be kept to minimum. Repair damage to coating due to handling or construction practices.

D. Just before each section of pipe is to be placed into trench, conduct visual and holiday inspection in accordance with AWWA C222. Repair defects in coating system before pipe is installed.

E. For field-welded joints, drape minimum 18-inch wide strip of heat-resistant material over top half of pipe on each side of the coating holdback to protect from weld spatter.

F. Provide transition from cement mortar lining to polyurethane lining in accordance with coating manufacturer's recommendations and as approved by Project Manager.

3.03 FIELD REPAIR AND TOUCHUP

A. Apply repair and touchup materials in conformance with manufacturer's recommendations.

B. Repair Procedure – Joints:

1. External Joints. Provide heat shrink sleeve in accordance with Section 02518 – Steel Pipe for Large Diameter Water Lines. Metal surface must be free of all dirt, dust, and surface corrosion prior to sleeve application. Where corrosion in the holdback area is visible, prepare surface in accordance with SSPC-SP11, Power Tool Cleaning to Bare Metal for steel pipe, or NAPF 500-03-03 Power Tool Cleaning for ductile iron pipe

2. Internal Joints. Prepare surface and provide environmental controls in accordance with manufacturer's recommendations.

    a. Remove oil or grease by solvent wiping pipe and adjacent coating in accordance with SSPC-SP1, Solvent Cleaning.

    b. Clean pipe surface in accordance with SSPC-SP11, Power-Tool Cleaning to Bare Metal or abrasively blast in the field in accordance with SSPC-SP10, Near-White Metal Blast Cleaning. Clean the full circumference of the pipe and feather the edges of the existing polyurethane coating a minimum of two inches.

    c. Remove loose or damaged pipe lining at joint and repair as specified herein, or extend joint lining.

    d. Apply lining material by hand or spray equipment. Provide material that is compatible with shop lining and approved by manufacturer.

    e. Provide a NACE Level II or III inspector experienced with the applied coating system to inspect surface preparation of the joint lining and document application conditions. Submit documentation to Project Manager.

C. Repair Procedure – Field Defects:

1. Repair Materials (subject to Project Manager's approval):

    a. Heat-applied repair patches

    b. Single use polyurethane coating kits that control mix ratios

    c. Coating manufacturer's polyurethane coating repair products

2. Repair Procedures:

    a. Solvent clean in accordance with SSPC-SP1 for steel pipe or NAPF 500-03-01 for ductile iron pipe.

    b. Power tool clean in accordance with SSPC-SP11 for steel pipe and NAPF 500-03-03 for ductile iron pipe. Feather the coating and provide overlap in accordance with a manufacturer's recommendations.

c. Apply repair material as described above in accordance with manufacturer's recommendations.

d. If a heat-applied repair patch is used, do not overlap patches or use more than one patch for a single repair. If repair area exceeds the size of a single patch, use alternate repair method as listed above.

D. Repair Procedure - Thermite Brazed Connection Bonds:

1. Remove polyurethane coating with power wire brush from area on metal surface which is to receive thermite brazed connection.

2. Grind metal surface to shiny metal with power grinder and coarse grit grinding wheel.

3. Apply thermite-brazed connection using equipment, charge and procedure recommended by manufacturer of thermite equipment.

4. Drape minimum 18-inch wide strip of heat-resistant material over top half of pipe on all sides during welding to protect from weld spatter.

5. After welded surface has cooled to temperature below 130 degrees F, apply protective coating repair material to weld, exposed pipe surface and damaged areas of polyurethane coating. A heat-applied repair patch may be used as approved by Project Manager.

6. Do not cover or backfill freshly repaired areas of coating at thermite-brazed connection until repair material has completely cured. Allow material to cure in conformance with manufacturer's recommendations.

END OF SECTION

SECTION 02528

POLYETHYLENE ENCASEMENT/WRAP

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Polyethylene encasement that may be part of the corrosion protection system for pipe, valves, fittings, and other appurtenances in ductile or cast iron systems.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for polyethylene wrap. Include cost of polyethylene wrap in unit price for pipes and fittings to be wrapped.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 REFERENCES

A. ASTM D 149 – Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.

B. ASTM D 882 – Standard Test Method for Tensile Properties of Thin Plastic Sheeting.

C. ASTM D 1709 – Standard Test Methods for Impact Resistance of Plastic Film by the Free- Falling Dart Method.

D. ASTM D 1922 – Standard Test Method for Propagation Tear Resistance of Plastic Film and Thin Sheeting by Pendulum Method.

E. ASTM D 4976 – Standard Specification for Polyethylene Plastics Molding and Extrusion Materials.

F. AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems.

G. AWWA C600 – Standard for Installation of Ductile-Iron Mains and Their Appurtenances.

1.05 SUBMITTALS

A. Submittal Procedures: Submit product data in accordance with Section 01330 - Submittal Procedures.

B. Product Data: Submit product data for proposed film, and tape or plastic tie straps for approval. All film to be used in accordance with this standard specification will be manufactured from virgin polyethylene, will not be recycled and shall be purchased new for the project, clean, sound and without defects.

C. Samples: Submit samples of polyethylene tube and/or sheet for approval. Provide one sample of tube for each pipe diameter and one sample of each sheet material to be used. Samples will be a minimum of 40 square feet of standard production material.

D. Quality Assurance Plan: Submit quality assurance plans for film manufacturing and field application.

1. Film Manufacturing: The manufacturer of polyethylene film for corrosion protection encasement of ductile iron pipe will have a verifiable quality control system to assure that film is produced from only virgin polyethylene and that it complies with all requirements of this specification. Documentation of Quality Control procedures and test results will be submitted and will be made available for inspection for at least one year subsequent to delivery to job site.

2. Field Application: The contractor will develop, and submit for approval, a comprehensive Quality Assurance Plan for installation of polyethylene encasement. Address all aspects of material and pipe handling, bedding, preparation of pipe surface, film installation and anchoring, service taps and backfill. Include written procedures to be used by installers.

E. Manufacturer’s Certification: Submit polyethylene film manufacturer's certification of compliance with this Section. The polyethylene film manufacturer will provide a notarized statement from an officer of the company that the film meets the inspection and all applicable material specifications of this specification. The manufacturer’s statement of compliance must be verifiable. Statements from distributors or contractors will not be accepted in lieu of a statement from the original manufacturer of the polyethylene film.

F. Installer Qualifications: Polyethylene encasement will only be installed by qualified persons who have been trained in the proper procedures described in Part 3 of these specifications.

1. Qualified Persons: Qualified persons shall be those that have had training and experience in the installation of polyethylene encasement for corrosion protection of ductile iron pipe. Such persons may be qualified by the Ductile Iron Pipe Research Association, ductile iron pipe manufacturers or engineering/inspection firms who offer training courses in the proper method(s) of installation. Proof of qualifications shall be submitted with the shop drawings and shall be provided to project inspectors upon request.

PART 2 PRODUCTS

2.01 MATERIALS

A. Polyethylene Film: Tubular or sheet form without tears, breaks or defects, conforming to the following requirements.

1. High-Density, Cross-Laminated, Polyethylene: High–density, cross-laminated polyethylene film manufactured from virgin polyethylene material conforming to the following:

a. Raw Material. Raw materials to meet the requirements of ASTM D 4976:

(1) Group: 2 (Linear)

(2) High-density: 0.940 to 0.960 g/cm3

(3) Volume resistivity: 1015 ohm-cm, minimum

b. Physical Properties. Physical properties of finished film to be as follows:

(1) Tensile Strength: 6,300 psi, minimum in machine and transverse direction (ASTM D 882).

(2) Elongation: 100 percent, minimum in machine and transverse direction (ASTM D 882) as measured using rubber lined grips.

(3) Dielectric Strength: 800 volts/mil thickness, minimum (ASTM D 149)

(4) Impact Resistance: 800 grams, minimum (ASTM D 1709 Method B)

(5) Propagation Tear Resistance: 250 grams force, minimum in machine and transverse direction (ASTM D1922)

c. Thickness: High-density, cross-laminated polyethylene film shall have a nominal thickness of 0.004 in. (4 mils) with a minus 10% tolerance. Nowhere shall the film be less than 0.0036 (3.6 mils).

d. Color: Supply white or black polyethylene film with a minimum 2 percent hindered-amine ultraviolet inhibitor.

e. Polyethylene Tube and Sheet Size: For push-on joint pipe, polyethylene tube and sheet sizes to conform to the following:

Nominal Pipe Diameter (Inches)	Minimum Polyethylene Width (Inches)	
	Flat Tube	Sheet
3	14	28
4	14	28
6	16	32
8	20	40
10	24	48
12	27	54
14	30	60
16	34	68
18	37	74
20	41	82
24	54	108
30	67	134
36	81	162
42	81	162
48	95	190
54	108	216
60	108	216
64	121	242

2. Large Bell Circumferences: Where bell ends of the pipe are larger than the sheet sizes listed above, use sufficiently large tubes or sheets to cover the joints.

3. Marking: The polyethylene film will be clearly marked every two feet with the following information. Letters and numerals used for marking items "a" through "e" shall not be less than 1 inch in height and item "f" shall not be less than 1 1/2 inches in height.

a. Manufacturer's name or trademark

b. Year of manufacture

c. AWWA C105/A21.5

d. Minimum film thickness and material type (HDCLPE)

e. Applicable range of nominal pipe diameter size(s)

f. Warning – Corrosion Protection – Repair Any Damage

B. Plastic Tape: Provide 1 ½-inch wide, 6 mil thick, PVC tape with 5 mils of PVC backing and 1 mil of rubber adhesive for fitting, anchoring and repairing the encasement.

PART 3 EXECUTION

3.01 PREPARATION

A. Remove lumps of clay, mud, and cinders from pipe surface prior to installation of polyethylene encasement. Prevent soil or embedment material from becoming trapped between pipe and polyethylene.

B. Fit polyethylene film to contour of pipe to effect a snug, but not tight fit; encase with minimum space between polyethylene and pipe. Allow sufficient slack in contouring to prevent stretching polyethylene where it bridges irregular surfaces, such as bell-spigot interfaces, bolted joints, or fittings, and to prevent damage to polyethylene due to backfilling operations. Secure overlaps and ends with adhesive tape to hold polyethylene encasement in place until backfilling operations are complete.

C. For installations below water table or in areas subject to tidal actions, seal both ends of polyethylene tube with adhesive tape at joint overlap. Circumferentially wrap with tape, every two feet along the barrel.

3.02 INSTALLATION

A. Tubular Type (Method A):

1. Cut polyethylene tube to a length approximately 2 feet longer than pipe section. Slip tube around pipe, centering tube to provide 1-foot overlap on each adjacent pipe section. Bunch accordion-fashion lengthwise until it clears pipe ends.

2. Make shallow bell hole at joints to facilitate installation of polyethylene tube completely around pipe. Lower pipe into trench and make up pipe joint with preceding section of pipe. Methods other than bell holes shall be allowed, provided the polyethylene tube completely encases the pipe joints, including a minimum overlap of 1-foot.

3. After assembling pipe joint, make overlap of polyethylene tube. Pull bunched polyethylene from preceding length of pipe, slip it over end of adjoining length of pipe, and secure in place. Then slip end of polyethylene from adjoining pipe section over end of first wrap until it overlaps joint at end of preceding length of pipe. Secure overlap in place.

4. For each pipe length, take up slack width at top of pipe to make a snug, but not tight, fit along barrel of pipe, securing fold with tape at quarter points. Avoid a tight fit to prevent stretching the polyethylene where it bridges irregular surfaces, such as bell and spigot joints, restrained and bolted joints, and fittings; and to prevent damage to film during backfilling. The length of tape to secure wrap shall be no less than 1-foot.

5. Repair cuts, tears, punctures, or other damage to polyethylene. Proceed with installation of next section of pipe in same manner.

B. Tubular Type (Method B):

1. Cut polyethylene tube to a length approximately 1 foot shorter than pipe section. Slip tube around pipe, centering it to provide 6 inches of bare pipe at each end.

2. Make shallow bell hole at joints to facilitate installation of polyethylene tube completely around pipe. Lower pipe into trench and make up pipe joint with preceding section of pipe. Methods other than bell holes shall be allowed, provided the polyethylene tube completely encases the pipe joints, including a minimum overlap of 1-foot.

3. Take up slack width at top of pipe to make a snug, but not tight, fit along barrel of pipe, securing fold with tape at quarter points. Avoid a tight fit to prevent stretching the polyethylene where it bridges irregular surfaces, such as bell and spigot joints, restrained and bolted joints, and fittings; and to prevent damage to film during backfilling. The length of tape to secure wrap shall be no less than 1-foot.

4. Before making up joint, slip 4-foot length of polyethylene tube over end of preceding pipe section, bunching in accordion-fashion lengthwise. After completing joint, pull 4- foot length of polyethylene over joint, overlapping polyethylene previously placed on each adjacent section of pipe by at least 1 foot; make each end snug and secure.

5. Repair cuts, tears, punctures, or other damage to polyethylene. Proceed with installation of next section of pipe in same manner.

C. Sheet Type (Method C) – Applicable to Valves, Tees, Elbows and Other Fittings Only:

1. Cut polyethylene sheet to a length approximately 2 feet longer than pipe section. Center length to provide 1-foot overlap on each adjacent pipe section, bunching sheet until it clears pipe ends. Wrap polyethylene around pipe so that sheet circumferentially overlaps top quadrant of pipe. Secure cut edge of polyethylene sheet at intervals of approximately 3 feet.

2. Lower wrapped pipe into trench and make up pipe joint with preceding section of pipe. Make shallow bell hole at joints to facilitate installation of polyethylene. After completing joint, make overlap and secure ends.

3. Repair cuts, tears, punctures, or other damage to polyethylene. Proceed with installation of next section of pipe in same manner.

D. Installation in Augured Hole or Directional Drilled Bore:

E. Install as described in 3.02A. Tubular Type (Method A) with the exception that the polyethylene encasement overlap must face away from the pull direction to avoid the under film accumulation of drilling mud and other foreign matter.

F. Attach pulling head to spigot end of the leading pipe length.

G. Securely anchor the polyethylene tube to the end of the barrel of the leading pipe length by continuously taping the leading two feet of the barrel with overlapping tape wrap. Anchor the first wraps of tape directly on to the barrel of the pipe and extend the continuous taping on to the polyethylene encasement. For the remainder of the leading pipe length, overlap circumferential wraps of tape every one foot.

H. The drilling fluid and cuttings shall not enter under the polyethylene tube during the pull back or other operations. At assembled joints, the polyethylene overlap shall always have the forward pipe's polyethylene tube overlap the next following pipe's tube. The polyethylene on both sides of the joint shall be secured with circumferential wraps of tape or plastic tie straps.

I. Continue process by wrapping tape on each side of successive joints and every two feet along barrel.

J. Pipe-shaped Appurtenances: Cover bends, reducers, offsets, and other pipe-shaped appurtenances with polyethylene in same manner as pipe.

K. Odd-shaped Appurtenances: When it is not practical to wrap valves, tees, crosses, and other odd- shaped pieces in tube, wrap with flat sheet or split length of polyethylene tube by passing sheet around appurtenance and encasing it. Make seams by bringing edges together, folding over twice, and taping down. At valve stems and other penetrations, secure polyethylene film with tape.

L. Openings in Encasement: Create openings for branches, saddles, service taps, blowoffs, air valves, and similar appurtenances by making an X-shaped cut in polyethylene and temporarily folding back film. After appurtenance is installed, tape slack securely to appurtenance and repair cut, as well as other damaged area in polyethylene, with tape.

M. Hydrant Drain Relief: For hydrant relief holes and similar orifices, apply 3 wraps of tape completely around the polyethylene encased pipe, then, with a utility knife, cut a hole in the tape and polyethylene that is 1-inch larger in diameter than the orifice/opening.

N. Direct Service Taps: For direct service taps, apply 3 wraps of tape completely around the polyethylene encased pipe to cover the area where the tapping machine and chain will be mounted. After the tapping machine is mounted, install the corporation stop directly through the tape and polyethylene. After the direct tap is completed, the entire circumferential area shall be closely inspected and repaired as needed.

O. Service Connections: Wrap service lines of copper and other dissimilar metals with polyethylene or suitable dielectric tape for a minimum clear distance of 3 feet away from the cast or ductile iron pipe. Surface preparation and method of application shall follow tape manufacturer's written instructions.

P. Junctions between Wrapped and Unwrapped Pipe: Where polyethylene-wrapped pipe joins an adjacent pipe that is not wrapped, extend polyethylene wrap to cover adjacent pipe for at least 3 feet. Secure end with circumferential turns of tape.

Q. Installation of Pipe through Casings: Polyethylene encasement shall be used for pipe through casings. Use a single layer of polyethylene film. Casing spacers (insulated type) and casing end seals shall be installed. Do not damage the polyethylene film where these devices are attached to the pipe, over the encasement.

3.03 REPAIRS

A. Repair any cuts, tears, punctures, or damage to polyethylene with adhesive tape or with short length of polyethylene sheet or cut open tube, wrapped around pipe to cover damaged area, and secured in place.

3.04 BACKFILL

A. Use the same backfill material as that specified for pipe without polyethylene wrap. Prevent damage to the polyethylene wrap when placing backfill. Assure backfill material is free from cinders, refuse, boulders, rocks, stones, or other material that could damage the polyethylene. Follow AWWA C600 for backfilling.

3.05 QUALITY ASSURANCE

A. Freedom from Defects: All polyethylene film shall be clean, sound and free from defects.

B. Inspection: All parts of this Section are subject to inspection by the City of Houston or its designated representative.

C. Non-Compliance: The Contractor will correct any deficiencies in materials or installation at Contractor's expense, including excavating the pipe subsequent to backfilling and re-installing the polyethylene wrap.

END OF SECTION

SECTION 02529

TAPE COATINGS ON STEEL PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Preparing surfaces, providing adequate conditions for proper workmanship, furnishing, and applying tape coatings on external surfaces of steel pipe.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for tape coatings. Include payment in unit prices for items to which coatings are applied.

2. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AWWA C 209 - Tape Coatings for Steel Water Pipe and Fittings

B. AWWA C 214 – Tape Coatings for Steel Water Pipe

C. AWWA C 216 – Heat-Shrinkable Cross-Linked Polyolefin Coatings for Steel Water Pipe and Fittings

D. NACE Standard RP 02 74 - High Voltage Electrical inspection of Pipeline Coatings Prior to Installation

E. SSPC SP 1 – Solvent Cleaning

F. SSPC SP 6 – Commercial Blast Cleaning

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 – Submittal Procedures.

B. Submit tape manufacturer's catalog sheets, product data sheets, material data sheets and other information for all material provided. Include manufacturer's recommendation and instructions for surface preparation.

C. Quality Control Submittals. Furnish the following:

1. Shop and field applicator's experience with list of references substantiating compliance. Submit references of 5 successful projects completed within the last 3 years for each applicator. Each project listed should be at least 500 linear feet in length, unless otherwise approved by Project Manager.

2. Shop applied coatings:

a. Coating manufacturer's certification stating that the individual coating applicators have met the qualification certification requirements as specified in this Section.

b. Monitoring records, including coating "affidavit of compliance" to requirements of this Section stating that coatings were applied in factory, in accordance with manufacturer's requirements, and AWWA C214.

3. Upon request by Project Manager, provide:

a. Manufacturer's coating application Quality Control Manual

b. Coating Performance Test report with statement that no reformulations have been made subsequent to the coating tests performed for the report.

c. Current test equipment calibration certificates

4. Provide administrative documents showing that QA/QC personnel in both shop and field are certified as NACE International Coating Inspector (Level III).

1.06 QUALITY ASSURANCE

A. Shop and Field Coating Applicator's Experience and Certification:

1. Minimum 5 years' practical experience in application of tape coating.

2. Certification by tape coating manufacturer as an approved applicator.

B. Shop: Unless otherwise approved by Project Manager, coating manufacturer's technical representative to be present for a minimum of three calendar days for technical assistance and instruction at the start of tape coating application within the shop. During this visit, technical representative to observe surface preparation and coating application, and conduct or observe tests of coating to ensure conformance with application instructions, recommended methods, and conditions.

C. Project Manager may retain services of independent, third-party NACE CIP Level III-Certified Inspector for partial or full-time inspection of the work.

1.07 OBSERVATION OF WORK

A. Provide full access to Project Manager for all facilities and documentation regarding surface preparation, environmental conditions and coating applications.

B. Require the protective coating manufacturer to furnish a qualified technical representative to visit the project site for technical support as may be necessary to resolve field problems attributable to or associated with manufacturer's products.

C. Materials are subject to testing for conformance with this specification.

D. Project Manager may retain services of independent, third-party NACE Level III-Certified Inspector for partial or full-time inspection of the work.

PART 2 PRODUCTS

2.01 SHOP-APPLIED TAPE COATING

A. Prefabricated polyolefin tape applied as a four layer system consisting of liquid adhesive, corrosion-preventive tape (inner layer), mechanical protective tape (intermediate layer), and mechanical-protective tape (outer layer) in accordance with AWWA C214.

1. For steel pipe fittings, provide hand-applied tape wrap in accordance with AWWA C209 or heat shrink sleeves in accordance with AWWA C216.

B. Acceptable Materials:

1. Polyken® YGIII by Berry Plastics,

2. or approved equal.

C. Provide one 20 mil inner layer for corrosion protection and two 30 mil layers of intermediate and outer tape for mechanical protection. Total nominal thickness: 80 mil.

D. At outlets, prior to applying tape, provide approved filler putty to fill in gap for smooth, sloped transition between top of reinforcing plate and pipe.

E. Liquid Adhesive: Compatible with tape coating, supplied by coating system manufacturer.

F. Coating holdback: 4 to 4 ½ inches from joint end to facilitate joining and welding of pipe. Taper successive layers by 1 inch staggers to facilitate field wrapping and welding of joints.

G. Width: 12 or 18 inches.

H. Do not expose tape coating to direct sunlight longer than recommended by the tape coating manufacturer.

2.02 SURFACE PREPARATION

A. Expel moisture from pipe surface prior to application using pre-heating.

B. Clean bare pipe from mud, mill lacquer, wax, oil, grease, rust, mill scale or other contaminants. Inspect and clean surfaces according to SSPC SP 1. Allow cleaning solvent to dry prior to coating application.

C. Blast clean in accordance with SSPC SP-6. Provide anchor profile of at least 1.5 mils, but no greater than 3.0 mils.

D. Remove surface imperfections such as slivers, scabs, burrs, weld spatter, and gouges by hand filling or grinding. Presence of metallic defects may be cause for rejection of pipe.

E. Before applying inner-layer tape, grind weld seams flush for a distance of 18 in. along the length of pipe on both ends.

F. Cover weld seams with stripping tape when weld reinforcement is greater than 3/32 in. or if profile and position of weld seam prevents conformability of tape coating to the steel surface.

2.03 SHOP APPLICATION

A. Follow procedures as recommended by tape coating manufacturer.

B. Separate tape dispensing equipment far enough apart to visually inspect continuous steps.

C. Make cutbacks straight and for total thickness of coating.

D. State of dryness of liquid adhesive prior to application of weld strip and inner layer of tape to be in accordance with written recommendation of manufacturer.

E. Apply weld strip tape over liquid adhesive and extend minimum of one inch on each side of weld seam. Weld strip tape may contact rollers as long as release liner is in place and adhesion requirements are met.

F. Remove release liner of weld strip tape before applying inner layer of tape.

G. Spirally apply inner layer of tape in direction of pipe helix weld. Overlap each spiral of tape 1 inch or greater with next successive spiral of tape applied.

H. Perform electrical inspection of inner layer of tape before intermediate layer of tape is applied. If holiday is detected, repair immediately using manufacturer-approved tape patch, prior to applying intermediate layer of tape. Patch to extend minimum 3-inches in all directions. Perform electrical retest at repaired area, and if no holidays are found, proceed with outer layer application.

I. Repair holidays visually or electrically discovered in completed tape coating by peeling back and removing outer intermediate and inner layers from damaged area. Repair exposed area by applying liquid adhesive and a layer of inner tape or inner tape patch. Provide lap of 4-inches minimum in all directions. Re-test repaired area with holiday detector. If no holidays are found, cover with intermediate and outer-layer tape patches with minimum lap of 4 inches in all directions beyond inner-tape patch.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Inspect pipe coating for holidays and damage to coating.

B. Until final acceptance of the coatings, furnish inspection devices in good working condition for the detection of holidays. Provide the services of a Level II or III NACE certified coating inspector for all holiday detection work until the final acceptance of such coatings. Operate holiday inspection devices in the presence of the Project Manager.

C. Perform test procedure in accordance with NACE Standard RP 02 74. Perform electrical holiday test with 60 cycle current audio detector. Use test voltage below:

Total Nominal Coating Thickness (mils)	Test Voltage (Volts)
70	11,500
80	12,000

3.02 FIELD REPAIRS

A. If test indicates no holidays and outer or intermediate wrap is torn, remove damaged layers of tape by carefully cutting with sharp razor-type knife. Apply holiday detector to exposed area to confirm that no damage has been made to inner tape layer. Wash with Xylol area to be patched and at least 4 inches of undamaged tape where hand applied tape wrap will overlap. Replace each layer of tape with a tape patch with minimum 4-inches overlap in all directions as specified by manufacturer.

B. If test indicates holiday, remove outer and intermediate layers and expose inner wrap. Prime exposed area and overlaps with light coat of liquid adhesive. Firmly press into place patch of two 35 mil inner wrap tape extending 4 inches from affected area in all directions. Second patch to overlap first patch by 4 inches. Perform holiday test of patch to verify satisfactory installation. Wash exposed outer wrap tape with Xylol and prime with liquid adhesive. Place outer layer patch with an overlap of 4-inches in all directions.

C. For severe outer or intermediate wrap tape tears or damage, and holiday is not detected, remove outer wrap to boundaries of damaged area, taking care not to damage inner wrap coating. Before replacing outer and intermediate wraps, apply holiday detector to exposed area to determine that no damage has been made to the primary coating. After verification that no holidays exist in underlying tape, clean damaged area and use repair patch. Apply as specified herein for repair of areas where bare pipe is exposed.

D. Do not allow bubbles in tape coating regardless of holiday test results. Cut out bubbles and patch as described above.

E. Perform surface preparation and coating applications in the presence of the Project Manager, or Project Manager's appointed NACE certified coating inspector, unless Project Manager has granted prior approval to perform the work in their absence.

F. Inspection by the Project Manager or the NACE certified inspector, or the waiver of inspection of any particular portion of the work, does not relieve the Contractor of the Contractor's responsibility to perform the Work in accordance with these Specifications.

END OF SECTION

SECTION 02531

GRAVITY SANITARY SEWERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Gravity sanitary sewers and appurtenances, including stacks and service connections.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01555 – Traffic Control and Regulation

D. Section 01578 – Control of Ground and Surface Water

E. Section 02081 – Cast-In-Place Concrete Manholes

F. Section 02082 – Precast Concrete Manholes

G. Section 02083 – Fiberglass Manholes

H. Section 02090 – Frames, Grates, Rings, and Covers

I. Section 02221 – Removing Existing Pavements, Structures, Wood, and Demolition Debris

J. Section 02260 – Trench Safety System

K. Section 02317 – Excavation and Backfill for Utilities

L. Section 02320 – Utility Backfill Materials

M. Section 02321 – Cement Stabilized Sand

N. Section 02427 – Plastic Liner for Large-Diameter Concrete Sewers and Structures

O. Section 02501 – Ductile Iron Pipe and Fittings

P. Section 02504 – Fiberglass Reinforced Pipe

Q. Section 02505 – High Density Polyethylene (HDPE) Solid and Profile Wall Pipe

R. Section 02506 – Polyvinyl Chloride Pipe

S. Section 02508 – Extra Strength Clay Pipe

T. Section 02532 – Sanitary Sewer Force Mains

U. Section 02533 – Acceptance Testing for Sanitary Sewers

V. Section 02534 – Sanitary Sewer Service Stubs or Reconnections

W. Section 02550 – Sliplining Sanitary Sewers

X. Section 02556 – Cured-In-Place Pipe

Y. Section 02558 – Cleaning and Television Inspection

Z. Section 02571 – Pipe Bursting/Crushing Sanitary Sewers

AA. Section 02611 – Reinforced Concrete Pipe

BB. Section 02911 – Topsoil

CC. Section 02921 – Hydro Mulch Seeding

DD. Section 02922 – Sodding

EE. Section 02951 – Pavement Repair and Restoration

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for gravity sanitary sewers by open-cut or within Potentially Petroleum Contaminated Area (PPCA) is on linear foot basis, complete in place, including sewer pipe, connections to existing manholes, post installation television inspection and testing. Measurement will be taken along centerline of pipe from centerline to centerline of manholes.

2. Payment for television inspection of existing gravity sanitary sewer will be on a linear foot basis. Measurement will be taken along centerline of pipe from centerline to centerline of manholes. See Section 02558 - Cleaning and Television Inspection.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit proposed methods, equipment, materials and sequence of operations for sewer construction. Plan operations so as to minimize disruption of utilities to occupied facilities or adjacent property.

C. Test Reports: Submit test reports and inspection videos as specified in Part 3 of this Section. Videos become property of City.

1.05 QUALITY ASSURANCE

A. Qualifications. Install sanitary sewer that is watertight both in pipe-to-pipe joints and in pipe-to- manhole connections. Perform testing in accordance with Section 02533 - Acceptance Testing for Sanitary Sewers.

B. Regulatory Requirements.

1. Install sewer lines to meet minimum separation distance from potable water line, as scheduled below. Separation distance is defined as distance between outside of water pipe and outside of sewer pipe. When possible, install new sanitary sewers no closer to water lines than 9 feet in all directions. Where this separation distance cannot be achieved, new sanitary sewers shall be installed as specified in this section.

2. Make notification to Project Manager when water lines are uncovered during sanitary sewer installation where minimum separation distance cannot be maintained.

3. Lay gravity sewer lines in straight alignment and grade.

1.06 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Inspect pipe and fittings upon arrival of materials at job site.

B. Handle and store pipe materials and fittings to protect them from damage due to impact, shock, shear or free fall. Do not drag pipe and fittings along ground. Do not roll pipe unrestrained from delivery trucks.

C. Use mechanical means to move or handle pipe. Employ acceptable clamps, rope or slings around outside barrel of pipe and fittings. Do not use hooks, bars, or other devices in contact with interior surface of pipe to lift or move lined pipe.

PART 2 PRODUCTS

2.01 PIPE

A. Provide piping materials for gravity sanitary sewers of sizes and types indicated on Drawings or as specified.

B. Unlined reinforced concrete pipe is not acceptable.

C. Pipe shall be color coded green.

2.02 PIPE MATERIAL SCHEDULE

A. Unless otherwise shown on Drawings, use pipe materials that conform to requirements specified in one or more of following Sections:

1. Section 02427 - Plastic Liner for Large-Diameter Concrete Sewers and Structures.

2. Section 02501 - Ductile Iron Pipe and Fittings.

3. Section 02504 - Fiberglass Reinforced Pipe.

4. Section 02505 - High Density Polyethylene (HDPE) Solid and Profile Wall Pipe.

5. Section 02506 - Polyvinyl Chloride Pipe.

6. Section 02508 - Extra Strength Clay Pipe.

7. Section 02611 - Reinforced Concrete Pipe.

8. Section 02532 – Sanitary Sewer Force Mains.

B. Where shown on Drawings, provide pipe meeting minimum class, dimension ratio, or other criteria indicated.

C. Pipe materials other than those listed above shall not be used for gravity sanitary sewers.

2.03 APPURTENANCES

A. Stacks. Conform to requirements of Section 02534 - Sanitary Sewer Service Stubs or Reconnections.

B. Service Connections. Conform to requirements of Section 02534 - Sanitary Sewer Service Stubs or Reconnections.

C. Roof, street or other type of surface water drains shall not be connected or reconnected into sanitary sewer lines.

2.04 BEDDING, BACKFILL, AND TOPSOIL MATERIAL

A. Bedding and Backfill: Conform to requirements of Section 02317 - Excavation and Backfill for Utilities, Section 02320 - Utility Backfill Materials, and Section 02321 - Cement Stabilized Sand.

B. Topsoil: Conform to requirements of Section 02911 - Topsoil.

PART 3 EXECUTION

3.01 PREPARATION

A. Prepare traffic control plans and set up street detours and barricades in preparation for excavation when construction will affect traffic. Conform to requirements of Section 01555 - Traffic Control and Regulation.

B. Provide barricades, flashing warning lights, and warning signs for excavations. Conform to requirements of Section 01555 - Traffic Control and Regulation. Maintain barricades and warning lights where work is in progress or where traffic is affected by work.

C. Perform work in accordance with OSHA standards. Employ trench safety system as specified in Section 02260 - Trench Safety System for excavations over 5 feet deep.

D. Immediately notify agency or company owning utility line which is damaged, broken or disturbed. Obtain approval from Project Manager and agency or utility company for repairs or relocations, either temporary or permanent.

E. Remove old pavements and structures including sidewalks and driveways in accordance with requirements of Section 02221 - Removing Existing Pavements, Structures, Wood, and Demolition Debris.

F. Install and operate dewatering and surface water control measures in accordance with Section 01578 - Control of Ground and Surface Water.

G. Do not allow sand, debris or runoff to enter sewer system.

3.02 DIVERSION PUMPING

A. Install and operate required bulkheads, plugs, piping, and diversion pumping equipment to maintain sewage flow and to prevent backup or overflow. Obtain approval for diversion pumping equipment and procedures from Project Manager.

B. Design piping, joints and accessories to withstand twice maximum system pressure or 50 psi, whichever is greater.

C. No sewage shall be diverted into area outside of sanitary sewer.

D. In event of accidental spill or overflow, immediately stop overflow and take action to clean up and disinfect spillage. Promptly notify Project Manager so that required reporting can be made to Texas Natural Resources Conservation Commission and Environmental Protection Agency by Project Manager.

3.03 EXCAVATION

A. Earthwork. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities. Use bedding as indicated on Drawings.

B. Line and Grade. Establish required uniform line and grade in trench from benchmarks identified by Project Manager. Maintain this control for minimum of 100 feet behind and ahead of pipe-laying operation. Use laser beam equipment to establish and maintain proper line and grade of work. Use of appropriately sized grade boards which are substantially supported is also acceptable. Protect boards and location stakes from damage or dislocation.

C. Trench Excavation. Excavate pipe trenches to depths shown on Drawings and as specified in Section 02317 - Excavation and Backfill for Utilities.

3.04 PIPE INSTALLATION BY OPEN CUT

A. Install pipe in accordance with pipe manufacturer's recommendations and as specified in following paragraphs.

B. Install pipe only after excavation is completed, bottom of trench fine graded, bedding material is installed, and trench has been approved by Project Manager.

C. Install pipe to line and grade indicated. Place pipe so that it has continuous bearing of barrel on bedding material and is laid in trench so interior surfaces of pipe follow grades and alignment indicated. Provide bell holes where necessary.

D. Install pipe with spigot ends toward downstream end of flow such that water flows into bell and out the spigot.

E. Form concentric joint with each section of adjoining pipe so as to prevent offsets.

F. Keep interior of pipe clean as installation progresses. Remove foreign material and debris from pipe

G. Provide lubricant, place and drive home newly laid sections with come-a-long winches so as to eliminate damage to sections. Install pipe to "home" mark where provided. Use of back hoes or similar powered equipment will not be allowed unless protective measures are provided and approved in advance by Project Manager.

H. Keep excavations free of water during construction and until final inspection.

I. When work is not in progress, cover exposed ends of pipes with approved plug to prevent foreign material from entering pipe.

J. Where gravity sanitary sewer is to be installed under existing water line with separation distance of at least 2 feet and less than 9 feet, install new sewer pipe so that one full18 foot long pipe is centered on water line crossing. Embed sewer pipe in cement stabilized sand for minimum distance of 9 feet on each side of crossing.

K. Where gravity sanitary sewer is to be installed under existing water line with separation distance of less than 2 feet, install new sewer using pressure-rated pipe as shown on Drawings. Maintain minimum 1 foot separation distance.

L. Where the length of the stub is not indicated, install the stub to the right-of-way line and seal the free end with an approved plug.

3.05 PIPE INSTALLATION OTHER THAN OPEN CUT

A. For installation of pipe by augering, jacking, or tunneling, conform to requirements of specification sections on tunneling augering, jacking and microtunneling work as appropriate.

B. For rehabilitation of existing sewer lines, conform to requirements of specification Section 02550- Sliplining Sanitary Sewers, Section 02556 - Cured-In-Place Pipe or Section 02571- Pipe Bursting/Crushing Sanitary Sewers.

3.06 INSTALLATION OF APPURTENANCES

A. Service Connections. Install service connections to conform to requirements of Section 2534 - Sanitary Sewer Service Stubs or Reconnections.

B. Stacks. Construct stacks to conform to requirements of Section 02534 - Sanitary Sewer Service Stubs or Reconnections.

C. Construct manholes to conform to requirements of Section 02081 - Cast-in-Place Concrete Manholes, Section 02082 - Precast Concrete Manholes, and Section 02083 - Fiberglass Manholes, as applicable. Install frames, rings, and covers to conform to requirements of Section 02090 - Frames, Grates, Rings, and Covers.

3.07 INSPECTION AND TESTING

A. Visual Inspection: Check pipe alignment in accordance with Section 02533 - Acceptance Testing for Sanitary Sewers.

B. Mandrel Testing. Use Mandrel Test to test flexible pipe for deflection. Refer to Section 02533 - Acceptance Testing for Sanitary Sewers.

C. Pipe Leakage Test. After backfilling line segment and prior to tie-in of service connections, visually inspect gravity sanitary sewers where feasible, and test for leakage in accordance with Section 02533 - Acceptance Testing for Sanitary Sewers. Maintain piezometer installed to conform with Section 01578 - Control of Ground and Surface Water, until acceptance testing is completed.

3.08 BACKFILL AND SITE CLEANUP

A. Backfill and compact soil in accordance with Section 02317 - Excavation and Backfill for Utilities.

B. Backfill trench in specified lifts only after pipe installation is approved by Project Manager.

C. Repair and replace removed or damaged pavement, curbs, gutters, and sidewalks as specified in Section 02951 - Pavement Repair and Restoration.

D. Provide hydro mulch seeding in areas of commercial, industrial or undeveloped land use over surface of ground disturbed during construction and not paved or not designated to be paved. Grade surface at uniform slope to natural grade as indicated on Drawings. Provide minimum of 4 inches of topsoil as specified in Section 02911 - Topsoil and apply hydro mulch according to requirements of Section 02921 – Hydro Mulch Seeding.

E. Provide sodding in areas of residential land use over surface of ground disturbed during construction and not paved or not designated to be paved. Grade surface at uniform slope to natural grade as indicated on Drawings. Provide minimum of 4 inches of topsoil per Section 02911 - Topsoil. Sod disturbed areas in accordance with Section 02922 - Sodding.

3.09 POST-INSTALLATION TELEVISION INSPECTION

A. Prior to final acceptance of newly constructed gravity sanitary sewers, perform cleaning and closed circuit television inspection. Post installation television inspection shall be performed in accordance with Section 02558 – Cleaning and Television Inspection.

B. Provide TV inspection reports and video submittals in accordance with Section 02558 – Cleaning and Television Inspection for each line segment submitted.

C. Upon completion of video review, Contractor will be notified regarding final acceptance of sewer segment.

END OF SECTION

SECTION 02532

SANITARY SEWER FORCE MAINS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Sanitary sewer force mains.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02501 – Ductile Iron Pipe and Fittings

E. Section 02504 – Fiberglass Reinforced Pipe

F. Section 02505 – High Density Polyethylene (HDPE) Solid and Profile Wall Pipe

G. Section 02506 – Polyvinyl Chloride Pipe

H. Section 02509 – Fiberglass Reinforced Pipe for Pressure Mains

I. Section 02528 – Polyethylene Encasement/Wrap

J. Section 03315 – Concrete for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for installation of force main pipe by open-cut, augered with or without casing, or within limits of Potentially Petroleum Contaminated Area (PPCA) is on linear foot basis. Measurement will be taken along center line of pipe from end to end. Payment will be made for each foot of force main installed, complete in place including pipe, excavation, bedding, backfill and special backfill, shoring, earthwork, connections to existing manholes, acceptance testing, and pipe and accessories.

2. Payment for installation of force main pipe at a bayou crossing is on a lump sum basis.

3. The Unit Price item identifies line segments between stations as shown on Drawings.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCE STANDARDS

A. ACI 318 - Building Code Requirements for Structural Concrete and Commentary.

B. ASTM D 696 - Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30 C and 30 C with a Vitreous Silica Dilatometer.

C. ASTM D 2992 - Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for “Fiberglass” (Glass-Fiber Reinforced Thermosetting-Resin) Pipe and Fittings.

D. ASTM D 2996 - Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber- Reinforced Thermosetting-Resin) Pipe.

E. Uni-Bell UNI-B-3 Polyvinyl Chloride (PVC) Pressure Pipe (complying with AWWA C 900).

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit proposed methods, equipment, materials, and sequence of operations for force main construction. Plan operations to minimize disruption of utilities to occupied facilities or adjacent property.

C. Force mains 24 inches in diameter and larger: Submit shop drawings and design calculations for joint restraint systems using reinforced concrete encasement of pressure pipe and fittings.

D. Submit qualifications, proposed methods, equipment, materials, and sequence for acceptance testing of pipeline. Submit evidence of experience with pipeline proving by pigging for at least three projects of equal or greater scope; project list shall include dates, size and length of pipe, location, owner name, contact person, and telephone number. Provide certificate of training by manufacturer of pigging equipment being used.

E. Submit test reports as specified in Part 3 of this Section.

PART 2 PRODUCTS

2.01 PIPE FITTING MATERIAL SCHEDULE

A. Unless otherwise shown on Drawings, use pipe materials that conform to requirements specified in one or more of the following Sections:

1. Section 02501 - Ductile-Iron Pipe and Fittings.

2. Section 02504 - Fiberglass Reinforced Pipe.

3. Section 02505 - High Density Polyethylene (HDPE) Solid and Profile Wall Pipe.

4. Section 02506 - Polyvinyl Chloride Pipe. Provide Lined Ductile-Iron Fittings in Accordance with Section 02501 - Ductile-Iron Pipe and Fittings.

5. Section 02509 – Fiberglass Reinforced Pipe for Pressure Mains.

B. Pipe shall be color coded green.

2.02 THRUST RESTRAINT

A. Unless otherwise shown on Drawings, provide concrete thrust blocking for force mains up to 12-inches in diameter, to prevent movement of buried lines under pressure at bends, tees, caps, valves and hydrants. Blocking shall be Portland cement concrete, as specified in Section 03315 - Concrete for Utility Construction. Place concrete in accordance with details on Drawings. Place thrust blocks between undisturbed ground and fittings. Anchor fittings to thrust blocks so that pipe and fitting joints are accessible for repairs. Concrete shall extend from 6 inches below pipe or fitting to 12 inches above.

B. For force mains larger than 12 inches in diameter, and where indicated on Drawings, provide restrained joints conforming to requirements of force main pipe material specifications. Install restrained joints for length of pipe on both sides of each bend or fitting for full length shown on Drawings.

C. Horizontal and vertical bends between zero and 10 degrees deflection angle will not require thrust blocks or harnessed or restrained joints.

D. Horizontal and vertical bends between 10 degrees and 90 degrees deflection angle shall have thrust restraint as shown on Drawings.

E. Provide thrust restraint at tees, plugs, blowoff drains, valves, and caps, as indicated.

F. Reinforced concrete encasement of force main pipe and fittings may be used in lieu of manufactured joint restraint systems. Alternate joint restraint systems using reinforced concrete encasement shall conform to following design requirements.

1. Design calculations shall be performed and sealed by Professional Engineer licensed in State of Texas.

2. Base design calculations upon soil parameters quantified in geotechnical report for site where alternative thrust restraint system is to be installed. When data is not available for site, use parameters recommended by geotechnical engineer.

3. The design system pressure shall be specified test pressure.

4. The following safety factors shall be used in sizing restraint system:

   a. Apply factor of safety equal to 1.5 for passive soil resistance.

   b. Apply factor of safety equal to 2.0 for soil friction.

5. Contain encasement entirely within standard trench width and terminate on both ends at pipe bell or coupling.

6. Concrete encasement reinforcement steel shall be designed for all loads, including internal pressure and longitudinal forces. Concrete design shall be in accordance with ACI 318.

PART 3 EXECUTION

3.01 PIPE INSTALLATION BY OPEN-CUT

A. Perform excavation, bedding, and backfill in accordance with Section 02317 - Excavation and Backfill for Utilities.

B. Wrap ductile-iron pipe and fittings with polyethylene wrap in accordance with requirements of Section 02528 – Polyethylene Encasement/Wrap. Do not install polyethylene wrap on ductile iron pipe protected by cathodic protection system or fusion bonded or polyurethane coated fittings.

C. Install pipe in accordance with pipe manufacturer's recommendations and as specified in following paragraphs.

D. Install pipe only after excavation is completed, bottom of trench is fine graded, bedding material is installed, and trench has been approved by Project Manager.

E. Install pipe to line and grade indicated. Place pipe so that it has continuous bearing of barrel on bedding material and is laid in trench so interior surfaces of pipe follow grades and alignment indicated. Provide bell holes where necessary.

F. Install pipe with spigot ends toward direction of flow. Form concentric joint with each section of adjoining pipe so as to prevent offsets.

G. Keep interior of pipe clean as installation progresses. Where cleaning after laying pipe is difficult because of small pipe size, use suitable swab or drag in pipe and pull it forward past each joint immediately after joint has been completed. Remove foreign material and debris from pipe.

H. Provide lubricant, place and drive home newly-laid sections with come-a-long winches so as to eliminate damage to sections. Install pipe to "home" mark where provided. Use of back hoes or similar powered equipment will not be allowed unless protective measures are provided and approved in advance by Project Manager.

I. Keep excavations free of water during construction and until final inspection.

J. When work is not in progress, cover exposed ends of pipes with approved plug to prevent foreign material from entering pipe.

K. Where sanitary sewer force main is to be installed under existing water line with separation distance of less than 2 feet, install one full joint length of pipe, minimum 18 foot length, centered on water line and maintain minimum 6-inch separation distance.

3.02 PIPE INSTALLATION OTHER THAN OPEN-CUT

A. For installation of pipe by augering, jacking, or tunneling, conform to requirements of specification section of augering or tunneling work.

3.03 HYDROSTATIC TESTING

A. After pipe and appurtenance have been installed, test line and drain. Prevent damage to Work or adjacent areas. Use clean water to perform tests.

B. Project Manager may direct tests of relatively short sections of completed lines to minimize traffic problems or potential public hazards.

C. Test pipe in presence of Project Manager.

D. Test pipe at 150 psig or 1.5 times design pressure of pipe, whichever is greater. Design pressure of force main shall be rated total dynamic head of lift station pump.

E. Test pipe at required pressure for minimum of 4 hours.

F. Maximum allowable leakage shall be as calculated by following formula:

$$L = (S)\ (D)\ (P^{0.5}) / 155{,}400$$

Where: L = Leakage in gallons per hour per 1,000 feet of pipe.
S = Length of pipe in feet.
D = Inside diameter of pipe in inches.
P = Test pressure in pounds per square inch.

G. Correct defects, cracks, or leakage by replacement of defective items or by repairs as approved by Project Manager.

H. Plug openings in force main after testing and flushing. Use cast iron plugs or blind flanges to prevent debris from entering tested pipeline.

3.04 PIGGING TEST

A. After completion of hydrostatic testing and prior to final acceptance, test force mains longer than 200 feet by pigging to ensure piping is free of obstructions.

B. Pigs: Provide proving pigs manufactured of open-cell polyurethane foam body, without coating or abrasives which would scratch or otherwise damage interior pipe wall surface or lining. Pigs shall be able to pass through reductions of up to 65 percent of nominal cross- sectional area of pipe. Pigs shall be able to pass through standard fittings such as 45-degree and 90-degree elbows, crosses, tees, wyes, gate valves, or plug valves, as applicable to force main being tested.

C. Test Execution: Conduct pigging test in presence of Project Manager. Provide at least 48- hours notice of scheduled pigging of force main prior to commencing test.

END OF SECTION

SECTION 02533

ACCEPTANCE TESTING FOR SANITARY SEWERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Acceptance testing for sanitary sewers including:

1. Visual inspection of sewer pipes.
2. Mandrel testing for flexible sewer pipes.
3. Leakage testing of sewer pipes.
4. Leakage testing of manholes.
5. Smoke testing of point repairs.
6. Television and Video Inspection.

B. All tests listed in this Section are not necessarily required on this Project. Required tests are named in other Sections which refer to this Section for testing criteria and procedures.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01578 – Control of Ground and Surface Water

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for acceptance testing under this Section. Include payment in unit price for work requiring acceptance testing.
2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 828 - Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines.

B. ASTM D 3034 - Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

C. ASTM F 794 - Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.

D. ASTM F 1417 - Standard Practice for Installation Acceptance of Plastic Non-Pressure Sewer Lines Using Low-Pressure Air.

E. ASTM C 1244 - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.

1.05 PERFORMANCE REQUIREMENTS

A. Gravity flow sanitary sewers are required to have straight alignment and uniform grade between manholes.

B. Flexible pipe, including "semi-rigid" pipe, is required to show no more than 5 percent deflection. Test pipe no sooner than 30 days after backfilling of line segment but prior to final acceptance using standard mandrel to verify that installed pipe is within specified deflection tolerances.

C. Must meet Texas Commission on Environmental Quality (TCEQ) Testing Requirements Chapter-217-57.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Test Plan: Before testing begins and in adequate time to obtain approval through submittal process, prepare and submit test plan for approval by Project Manager. Include testing procedures, methods, equipment, and tentative schedule. Obtain advance written approval for deviations from Drawings and Specifications.

C. Test Reports: Submit test reports for each test on each segment of sanitary sewer.

1.07 GRAVITY SANITARY SEWER QUALITY ASSURANCE

A. Repair, correct, and retest manholes or sections of pipe which fail to meet specified requirements when tested.

B. Provide testing reports and video tape of television inspection as directed by Project Manager.

C. Upon completion of tape reviews by Project Manager, Contractor will be notified regarding final acceptance of sewer segment.

1.08 SEQUENCING AND SCHEDULING

A. Perform testing as work progresses. Schedule testing so that no more than 1000 linear feet of installed sewer remains untested at one time.

B. Coordinate testing schedules with Project Manager. Perform testing under observation of Project Manager.

PART 2 PRODUCTS

2.01 DEFLECTION MANDREL

A. Mandrel Sizing. Rigid mandrel shall have outside diameter (O.D.) equal to 95 percent of inside diameter (I.D.) of pipe. Inside diameter of pipe, for purpose of determining outside diameter of mandrel, shall be average outside diameter minus two minimum wall thicknesses for O.D. controlled pipe and average inside diameter for I.D. controlled pipe, dimensions shall be per appropriate standard. Statistical or other "tolerance packages" shall not be considered in mandrel sizing.

B. Mandrel Design. Rigid mandrel shall be constructed of metal or rigid plastic material that can withstand 200 psi without being deformed. Mandrel shall have nine or more "runners" or "legs" as long as total number of legs is odd number. Barrel section of mandrel shall have length of at least 75 percent of inside diameter of pipe. Rigid mandrel shall not have adjustable or collapsible legs which would allow reduction in mandrel diameter during testing. Provide and use proving ring for modifying each size mandrel.

C. Proving Ring. Furnish "proving ring" with each mandrel. Fabricate ring of 1/2-inch-thick, 3-inch-wide bar steel to diameter 0.02 inches larger than approved mandrel diameter.

D. Mandrel Dimensions (5 percent allowance). Average inside diameter and minimum mandrel diameter are specified in Table 02533-5, Pipe vs. Mandrel Diameter, at end of this Section. Mandrels for higher strength, thicker wall pipe or other pipe not listed in table may be used when approved by Project Manager.

2.02 EXFILTRATION TEST

A. Water Meter: Obtain transient water meter from City for use when water for testing will be taken from City system. Conform to City requirements for water meter use.

B. Test Equipment:

1. Pipe plugs.

2. Pipe risers where manhole cone is less than 2 feet above highest point in pipe or service lead.

2.03 INFILTRATION TEST

A. Test Equipment:

1. Calibrated 90-degree V-notch weir.

2. Pipe plugs.

2.04 LOW PRESSURE AIR TEST

A. Minimum Requirement for Equipment:

1. Control panel

2. Low-pressure air supply connected to control panel.

3. Pneumatic plugs: Acceptable size for diameter of pipe to be tested; capable of withstanding internal test pressure without leaking or requiring external bracing.

4. Air hoses from control panel to:

a. Air supply.

b. Pneumatic plugs.

c. Sealed line for pressuring.

d. Sealed line for monitoring internal pressure.

B. Testing Pneumatic Plugs: Place pneumatic plug in each end of length of pipe on ground. Pressurize plugs to 25 psig; then pressurize sealed pipe to 5 psig. Plugs are acceptable when they remain in place against test pressure without external aids.

2.05 GROUND WATER DETERMINATION

A. Equipment: Pipe probe or small diameter casing for ground water elevation determination.

2.06 SMOKE TESTING

A. Equipment:

1. Pneumatic plugs.

2. Smoke generator as supplied by Superior Signal Company, or approved equal.

3. Blowers producing 2500 scfm minimum.

PART 3 EXECUTION

3.01 PREPARATION

A. Provide labor, equipment, tools, test plugs, risers, air compressor, air hose, pressure meters, pipe probe, calibrated weirs, or any other device necessary for proper testing and inspection.

B. Determine selection of test methods and pressures for gravity sanitary sewers based on ground water elevation. Determine ground water elevation using equipment and procedures conforming to Section 01578 - Control of Ground and Surface Water.

3.02 VISUAL INSPECTION OF GRAVITY SANITARY SEWERS

A. Check pipe alignment visually by flashing light between structures. Verify if alignment is true and no pipes are misplaced. In case of misalignment or damaged pipe, remove and re-lay or replace pipe segment.

3.03 MANDREL TESTING FOR GRAVITY SANITARY SEWERS

A. Perform deflection testing on flexible and semi-rigid pipe to confirm pipe has no more than 5 percent deflection. Mandrel testing shall conform to ASTM D 3034. Perform testing no sooner than 30 days after backfilling of line segment, but prior to final acceptance testing of line segment.

B. Pull approved mandrel by hand through sewer sections. Replace any section of sewer not passing mandrel. Mandrel testing is not required for stubs.

C. Retest repaired or replaced sewer sections.

3.04 LEAKAGE TESTING FOR GRAVITY COLLECTION SYSTEM PIPES

A. For a collection system pipe that will transport wastewater by gravity flow, test gravity sanitary sewer pipes for leakage by either exfiltration or infiltration methods, as appropriate, or with low pressure air testing.

B. Compensating for Ground Water Pressure:

1. Where ground water exists, install pipe nipple at same time sewer line is placed. Use 1/2-inch capped pipe nipple approximately 10 inches long. Make installation through manhole wall on top of sewer line where line enters manhole.

2. Immediately before performing line acceptance test, remove cap, clear pipe nipple with air pressure, and connect clear plastic tube to nipple. Support tube vertically and allow water to rise in tube. After water stops rising, measure height in feet of water over invert of pipe. Divide this height by 2.3 feet/psi to determine ground water pressure to be used in line testing.

C. Exfiltration test:

1. Determine ground water elevation.

2. Plug sewer in downstream manhole.

3. Plug incoming pipes in upstream manhole.

4. Install riser pipe in outgoing pipe of upstream manhole when highest point in service lead (house service) is less than 2 feet below bottom of manhole cone.

5. Fill sewer pipe and manhole or pipe riser, when used, with water to point 2-1/2 feet above highest point in sewer pipe, house lead, or ground water table, whichever is highest.

6. Allow water to stabilize for one to two hours. Take water level reading to determine drop of water surface, in inches, over one-hour period, and calculate water loss (1 inch of water in 4 feet diameter manhole equals 8.22 gallons) or measure quantity of water required to keep water at same level. Loss shall not exceed that calculated from allowable leakage according to Table 02533-1 at end of this Section.

D. Infiltration test: Ground water elevation must be not less than 2.0 feet above highest point of sewer pipe or service lead (house service).

1. Determine ground water elevation.

2. Plug incoming pipes in upstream manhole.

3. Insert calibrated 90-degree V-notch weir in pipe on downstream manhole.

4. Allow water to rise and flow over weir until it stabilizes.

E. Low Air Pressure Test: When using this test conform to ASTM C 828, or ASTM F 1417, as applicable, with holding time not less than that listed in Table 02533-2.

1. Low Pressure Air testing for sections of pipe shall be limited to lines less than 36-inch average inside diameter. Refer to charts 02533-2 and 02533-3.

2. Lines 36-inch average inside diameter and larger shall be tested at each joint. Minimum time allowable for pressure to drop from 3.5 pounds per square inch gauge to 2.5 pounds per square inch during joint test shall be 10 seconds, regardless of pipe size.

F. Retest: Repair and retest any section of pipe which fails to meet requirements.

3.05 TEST CRITERIA TABLES

A. Exfiltration and Infiltration Water Tests: Refer to Table 02533-1, Water Test Allowable Leakage, at end of this Section.

B. Low Pressure Air Test:

1. Times in Table 02533-2, Time Allowed for Pressure Loss from 3.5 psig to 2.5 psig, at end of this Section, are based on equation from Texas Commission on Environmental Quality (TCEQ) Design Criteria 217.57

$$T = 0.0850(D)(K)/(Q)$$

Where: T = time for pressure to drop 1.0 pounds per square inch gauge in seconds

K = 0.000419 DL, but not less than 1.0

D = average inside diameter in inches

L = length of line of same pipe size in feet

Q = rate of loss, 0.0015 ft3/min./sq. ft. internal surface

2. Since K value of less than 1.0 shall not be used, there are minimum testing times for each pipe diameter as given in Table 02533-3, Minimum Testing Times for Low Pressure Air Test.

Notes:
1. When two sizes of pipe are involved, compute time by ratio of lengths involved.
2. Lines with 27-inch average inside diameter and larger may be air tested at each joint.
3. Lines with average inside diameter greater than 36 inches must be air tested for leakage at each joint.
4. If joint test is used, perform visual inspection of joint immediately after testing.
5. For joint test, pipe is to be pressurized to 3.5 psi greater than pressure exerted by groundwater above pipe. Once pressure has stabilized, minimum times allowable for pressure to drop from 3.5 pounds per square inch gauge to 2.5 pounds per square inch gauge shall be 10 seconds.

3.06 LEAKAGE TESTING FOR MANHOLES

A. After completion of manhole construction, wall sealing, or rehabilitation, but prior to backfilling, test manholes for water tightness using hydrostatic or vacuum testing procedures.

B. Plug influent and effluent lines, including service lines, with suitably-sized pneumatic or mechanical plugs. Ensure plugs are properly rated for pressures required for test; follow manufacturer's safety and installation recommendations. Place plugs minimum of 6 inches outside of manhole walls. Brace inverts to prevent lines from being dislodged when lines entering manhole have not been backfilled.

C. Vacuum testing:

1. Install vacuum tester head assembly at top access point of manhole and adjust for proper seal on straight top section of manhole structure. Following manufacturer's instructions and safety precautions, inflate sealing element to recommended maximum inflation pressure; do not over-inflate.

2. Evacuate manhole with vacuum pump to 10 inches mercury (Hg), disconnect pump, and monitor vacuum for time period specified in Table 02533-4, Vacuum Test Time Table.

3. A manhole passes the test if after 2.0 minutes and with all valves closed, the vacuum is at least 9.0 inches of mercury (Hg).

D. Perform hydrostatic exfiltration testing as follows:

1. Seal wastewater lines coming into manhole with internal pipe plug. Then fill manhole with water and maintain it full for at least 1 hour.

2. The maximum leakage for hydrostatic testing shall be 0.025 gallons per foot diameter per foot of manhole depth per hour.

3. If water loss exceeds amount tabulated above, locate leaks, complete repairs necessary to seal manhole and repeat test procedure until satisfactory results are obtained.

3.07 SMOKE TEST PROCEDURES FOR POINT REPAIRS

A. Application: Perform smoke test to:

1. Locate points of line failure for point repair.

2. Determine when point repairs are properly made.

3. Determine when service connections have been reconnected to rehabilitated sewer.

4. Check integrity of connections to newly replaced service taps to liners and to existing private service connections.

B. Limitations: Do not backfill service taps until completion of this test. Test only those taps in single manhole section at one time. Keep number of open excavations to minimum.

C. Preparation: Prior to smoke testing, give written notices to area residents no fewer than 2 days, nor more than 7 days, prior to proposed testing. Also give notice to City of Houston Police and Fire Departments 24 hours prior to actual smoke testing.

D. Isolate Section: Isolate manhole section to be tested from adjacent manhole sections to keep smoke localized. Temporarily seal annular space at manhole for sliplined sections.

E. Smoke Introduction:

1. Operate equipment according to manufacturer's recommendation and as approved by Project Manager.

2. Conduct test by forcing smoke from smoke generators through sanitary sewer main and service connections. Operate smoke generators for minimum of 5 minutes.

3. Introduce smoke into upstream and downstream manhole as appropriate. Monitor tap/connection for smoke leaks. Note sources of leaks.

F. Repair and Retest: Repair and replace taps or connections noted as leaking and then retest. Taps and connections may be left exposed in only one manhole section at time. When repair or replacement, testing or retesting, and backfilling of excavation is not completed within 1 work day, properly barricade and cover each excavation as approved by Project Manager.

G. Service Connections: On houses where smoke does not issue from plumbing vent stacks to confirm reconnection of sewer service to newly installed liner pipe, perform dye test to confirm reconnection. Introduce dye into service line through plumbing fixture inside structure or sewer cleanout immediately outside structure and flush with water. Observe flow at service reconnection or downstream manhole. Detection of dye confirms reconnection.

3.08 TELEVISION AND VIDEO INSPECTION PROCEDURE

A. Refer to Document 02588- Cleaning and Television Inspection

Table 02533-1
WATER TEST ALLOWABLE LEAKAGE

DIAMETER OF RISER OR STACK IN INCHES	VOLUME PER INCH OF DEPTH		ALLOWANCE LEAKAGE*	
	INCH	GALLONS	PIPE SIZE IN INCHES	GALLONS/MINUTE PER 100 FT.
1	0.7854	.0034	6	0.0039
2	3.1416	.0136	8	0.0053
2.5	4.9087	.0212	13	0.0066
3	7.0686	.0306	12	0.0079
4	12.5664	.0306	15	0.0099
5	19.6350	.0544	18	0.0118
6	28.2743	.1224	21	0.0138
8	50.2655	.2176	24	0.0158
			27	0.0177
			30	0.0197
			36	0.0237
			42	0.0276
For other diameters, multiply square of diameters by value for 1" diameter.			Equivalent to 50 gallons per inch of inside diameter per mile per 24 hours.	

* Allowable leakage rate must not exceed 10 gallons per inch of inside diameter per mile per 24 hours, when sewer is identified as located within 25-year flood plain.

Table 02533-2
ACCEPTANCE TESTING FOR SANITARY SEWERS

TIME ALLOWED FOR PRESSURE LOSS FROM 3.5 PSIG TO 2.5 PSIG														
Pipe Diam. (in)	Min. Time (min: sec)	Length for Min. Time (ft)	Time for Longer Length (sec)	Specification Time for Length (L) Shown (min:sec)										
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft	500 ft	550 ft	600 ft
6	5:40	398	0.8548	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:25	7:07	7:50	8:33
8	7:33	298	1.5196	7:33	7:33	7:33	7:33	7:36	8:52	10:08	11:24	12:40	13:56	15:12
10	9:27	239	2.3743	9:27	9:27	9:27	9:54	11:52	13:51	15:50	17:48	19:47	21:46	23:45
12	11:20	199	3.4190	11:20	11:20	11:20	14:15	17:06	19:57	22:48	25:39	28:30	31:20	34:11
15	14:10	159	5.3423	14:10	14:10	17:48	22:16	26:43	31:10	35:37	40:04	44:31	48:58	53:25
18	17:00	133	7.6928	17:00	19:14	25:39	32:03	38:28	44:52	51:17	57:42	64:06	70:31	76:56
21	19:50	114	10.4708	19:50	26:11	34:54	43:38	52:21	61:05	69:48	78:32	87:15	95:59	104:42
24	22:40	99	13.6762	22:48	34:11	45:35	56:59	68:23	79:47	91;10	102:34	113:58	125:22	136:46
27	25:30	88	17.3089	28:51	43:16	57:42	72:07	86:33	100:58	115:24	129:49	144:14	158:40	173:05
30	28:20	80	21.3690	35:37	53:25	71:14	89:02	106:51	124:39	142:28	160:16	178:05	195:53	213:41
33	31:10	72	25.8565	43:06	64:38	86:11	107:44	129:17	150:50	172:23	193:55	215:28	237:01	258:34

Table 02533-3
MINIMUM TESTING TIMES FOR LOW PRESSURE AIR TEST

PIPE DIAMETER (INCHES)	MINIMUM TIME (SECONDS)	LENGTH FOR MINIMUM TIME (FEET)	TIME FOR LONGER LENGTH (SECONDS/FT
6	340	398	0.855
8	454	298	1.520
10	567	239	2.374
12	680	199	3.419
15	850	159	5.342
18	1020	133	7.693
21	1190	114	10.471
24	1360	100	13.676
27	1530	88	17.309
30	1700	80	21.369
33	1870	72	25.856

Table 02533-4 VACUUM TEST TIME TABLE

DEPTH IN FEET	TIME IN SECONDS BY PIPE DIAMETER		
	48"	60”	72”
4	10	13	16
8	20	26	32
12	30	39	48
16	40	52	64
20	50	65	80
24	60	78	96
*	5.0	6.5	8.0
*Add T times for each additional 2-foot depth. (The values listed above have been extrapolated from ASTM C 1244			

Table 02533-5
PIPE VS. MANDREL DIAMETER

Material and Wall Construction	Nominal Size (Inches)	Average I.D. (Inches)	Minimum Mandrel Diameter (Inches)
PVC-Solid (SDR 26) 5.476	6	6	5.764
	8	7.715	7.329
	10	9.646	9.162
PVC-Solid (SDR 35) 11.150	12	12	11.737
	15	14.374	13.655
	18	17.629	16.748
	21	20.783	19.744
	24	23.381	22.120
	27	26.351	25.033
PVC-Truss	8	7.750	7.363
	10	9.750	9.263
	12	11.790	11.201
	15	14.770	14.032
PVC-Profile (ASTM F 794)	12	11.740	11.153
	15	14.370	13.652
	18	17.650	16.768
	21	20.750	19.713
	24	23.500	22.325
	27	26.500	25.175
	30	29.500	28.025

	36	35.500	33.725
	42	41.500	39.425
	48	47.500	45.125
HDPE-Profile	18	18.000	17.100
	21	21.000	19.950
	24	24.000	22.800
	27	27.000	25.650
	30	30.000	28.500
	36	36.000	34.200
	42	42.000	39.900
	48	48.000	45.600
	54	54.000	51.300
	60	60.000	57.000
Fiberglass (Class SN 46)	12	12.85	11.822
	18	18.66	17.727
	20	20.68	19.646
	24	24.72	23.484
	30	30.68	29.146
	36	36.74	34.903
	42	42.70	40.565
	48	48.76	46.322
	54	54.82	50.079
	60	60.38	57.361
Polypropylene	12	11.82	11.229
	15	14.78	14.041
	18	17.73	16.844
	24	23.64	22.458
	30	29.55	28.073
	36	35.46	33.687
	42	41.37	39.302
	48	47.28	44.916

END OF SECTION

SECTION 02534

SANITARY SEWER SERVICE STUBS OR RECONNECTIONS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Installation of service stubs in sanitary sewers serving areas where sanitary sewer service did not previously exist.

B. Reconnection of existing service connections along parallel, replacement, or rehabilitated sanitary sewers.

C. Installation of sanitary sewer service stubs, within street right-of-way, terminating with a clean-out and a plug at the right-of-way to allow for future connection of a single service, on at a double-wye fitting plugged at both to allow for future connection to two services.

1.02 RELATED SECTIONS

A. Document 00410 – Bid Form

B. Section 01270 – Measurement and Payment

C. Section 01330 – Submittal Procedures

D. Section 01504 – Temporary Facilities and Controls

E. Section 01578 – Control of Ground and Surface Water

F. Section 02260 – Trench Safety System

G. Section 02317 – Excavation and Backfill for Utilities

H. Section 02448 – Pipe and Casing Augering for Sewers

I. Section 02533 – Acceptance Testing for Sanitary Sewers

J. Section 02534 – Sanitary Sewer Service Stubs or Reconnections

K. Section 02558 – Cleaning and Television Inspection

L. Section 02921 – Hydro Mulch Seeding

M. Section 02951 – Pavement Repair and Restoration

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for sanitary sewer service stubs or service reconnections with stacks located within 5 feet of sanitary sewer main centerline is on unit price basis for each stub or reconnection. Payment will be made for each service stub or reconnection installed complete in place, including service connections, couplings, and adapters disconnecting existing services, reconnecting new service, fittings, excavation, and backfill.

2. Payment for sanitary sewer service stubs or service reconnections without stacks located within 5 feet of sanitary sewer main is on unit price basis for each stub or reconnection. Payment will be made for each service stub or reconnection installed complete in place, including service connections, couplings, and adapters disconnecting existing services, reconnecting new service, fittings, excavation, backfill and testing.

3. Payment for sanitary sewer service leads beyond 5 feet from the right-of-way and clean-outs shall be paid as follows:

   a. Payment for sanitary sewer service leads beyond 5 feet from the right-of-way clean-out, connection or reconnection shall be paid for on a linear foot basis. Measurement shall be taken along the centerline of the pipe from the centerline of the lead connection or stack at the sanitary sewer main and shall end 5 foot from the right-of-way. Payment will be made for each linear foot of pipe installed, complete in place, including sewer pipe, excavation, shoring, bedding, backfill, and accessories. Auger pipe for service stubs will be paid as provided in Section 02448 - Pipe and Casing Augering for Sewers.

   b. Payment for standard 6-inch clean-out on service lead assembly for a single or double future service connection installed at end of lead is on a unit price basis for each assembly and shall include all portions of the lead and service connection with clean-out within 5 feet of the right-of-way. Payment will be made for each assembly installed and complete in place, including excavation, fittings, offsets, plugs, pipe sections, valve boxes, bedding, backfill, and testing.

4. Pay estimates for progress payments will be made as measured above according to following schedule:

   a. An estimate for 95 percent payment will be authorized when reconnection is completely installed and backfilled.

   b. An estimate for 100 percent payment will be authorized when reconnection has been tested as specified in Section 02533-Acceptance Testing for Sanitary Sewers.

5. One or more connections discharging into common point are considered one service connection. Contractor shall not add service reconnections without approval of Project Manager. Project Manager may require connections to be relocated to avoid having more than two service connections per reconnection.

6. Protruding service connections which must be removed to allow liner insertion are paid as service reconnection when connected. If abandoned, they will be paid as abandoned connection.

7. Payment for abandonment of service connection is on unit price basis for each abandoned connection. No separate payment will be made for abandonment of service connection unless excavation is required. No separate payment will be made for excavation of sanitary sewer services within new or replacement sewer trench.

8. No separate payment will be made for removal of existing sanitary sewer service stubs. Include payment in unit price for Section 02534 - Sanitary Sewer Service Stubs or Reconnections.

9. No separate payment will be made for abandoned service connection when service to be abandoned is within 4 feet of active connection. Payment for only one abandoned service connection will be allowed when second abandoned connection is within 4 feet of first.

10. If faulty remote cut is later corrected using procedures specified for reconnection by excavation, only one reconnection will be allowed for payment.

11. Sanitary Sewer Cleanout on Service Lateral shall be provided in accordance with detail provided. Payment is on per each basis as indicated in Document 00410B.

12. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM A 240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

B. ASTM C 923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.

C. ASTM C 1173 - Standard Specification for Flexible Transition Couplings for Underground Piping Systems.

D. ASTM D 395 - Standard Test Methods for Rubber Property-Compression Set.

E. ASTM D 412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.

F. ASTM D 543 - Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents.

G. ASTM D 570 - Standard Test Method for Water Absorption of Plastics.

H. ASTM D 572 - Standard Test Method for Rubber-Deterioration by Heat and Oxygen.

I. ASTM D 638 - Standard Test Method for Tensile Properties of Plastics.

J. ASTM D 1149 - Standard Test Methods for Rubber Deterioration-Cracking in an Ozone Controlled Environment

K. ASTM D 1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

L. ASTM D 2240 - Standard Test Method for Rubber Property-Durometer Hardness

M. ASTM D 3034 - Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

N. ASTM D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.

O. ASTM F 477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

1.05 PERFORMANCE REQUIREMENTS

A. Accurately locate in field all proposed service stubs along new sanitary sewer main.

B. Accurately locate in field existing service connections and proposed service stubs along alignment of new parallel or replacement sewer main.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit product data for each pipe product, fitting, coupling and adapter.

C. Show reconnected services on record drawings. Give exact distance from each service connection to nearest downstream manhole.

D. Submit Post-installation television inspection videos in accordance with Document 02558 – Cleaning and Television Inspection.

PART 2 PRODUCTS

2.01 PVC SERVICE CONNECTION

A. As stub outs, use PVC sewer pipe of 4-inch through 10-inch diameter, conforming to ASTM D 1784 and ASTM D 3034, with cell classification of 12454. SDR (ratio of diameter to wall thickness) shall be 26 for pipe 10 inches in diameter or less.

B. PVC pipe shall be gasket jointed with gasket conforming to ASTM D 3212.

C. Provide service connection pipe in sizes shown on Drawings. For reconnection of existing services, select service connection pipe diameter to match existing service diameter. Reconnections to rehabilitated sanitary sewer mains shall be limited to following maximum service connection diameter:

Sewer Diameter	Maximum Service Connection Diameter
8" or less	4"
10" or greater	6"

D. Subject to above limits, provide 6-inch service connection when more than one service discharges into single pipe.

E. Connect service pipes to parallel or replacement sewer mains with prefabricated, full-bodied tee or wye fittings conforming to specifications for sewer main pipe material as specified in other Sections for sewers up to 18 inches in diameter.

F. Where sewers are installed using pipe augering or tunneling, or where sewer is greater than 18 inches in diameter, use three-piece service connection or pipe saddle conforming to ASTM C-923to connect service to sewer main.

2.02 PIPE SADDLES

A. Use pipe saddles only on rehabilitated sanitary sewer mains. Comply with Paragraph 2.01E for new parallel and replacement sanitary sewer mains.

B. Supply one-piece prefabricated saddle, either polyethylene or PVC, with neoprene gasket to accomplish complete seal. Use saddle fabricated to fit outside diameter of connecting pipe. Protruding lip of saddle must be at least 5/8-inch long with grooves or ridges to retain stainless steel band clamps.

C. Use 1/2-inch stainless steel band clamps for securing saddles to liner pipe.

2.03 COUPLINGS AND ADAPTERS

A. For connections between new PVC pipe stubouts and existing service, 4-, 6-, or 8-inch diameter, use flexible adapter coupling consisting of neoprene gasket, stainless steel shear rings with 1/2-inch stainless steel band clamps, and two nut and bolt clamps. For connections that are 10- inches or over, use neoprene gasket, with stainless steel shear band, and two stainless steel nut and bolt or T-Bolt clamps. Thermalized plastics are not allowed. Refer to approved couplings and adaptors.

1. Product characteristics, meet ASTM C1173 and requirements for neoprene rubber and metallic components.

2. Shear Band: ½ inch 300 series stainless steel shear band with two molded on worm gear clamps (ASTM A240)

3. Clamps: 300 Series nut and bolt clamp band fabricated from AISI Type 316 stainless steel (ASTM A240)

B. For connections between new PVC pipe stubout and new service, use approved rubber- gasket adapter coupling conforming to requirements of 2.03A.

C. Couplings and Adaptors components will be in accordance with following Requirements:

1. Neoprene Rubber. 100% rubber. Thermalized plastics are not allowed.

a. Compressive Strength/ Tensile Strength, psi min (ASTM D412 Die C, ASTM D638). Initial value: 1000 min. Value after 112 days: 1000 min

b. Elongation at break, % (ASTM D412, ASTM D638). Initial value: 200 Value after 112 days: 200

c. Shore Durometer, Type A, point change max (ASTM D2240). Initial value (1 sec. reading, min): 60. Value point change max: 15

d. Compression Set -- Chemical exposures, % max (ASTM D395 Method B). Initial Value: 20 max. Value after exposure: 20 max

e. Compression Set -- Bacteriological, unconditioned surface dry, % max (ASTM D395 Method B): Initial value 20. Value after 112 day: 20

f. Water Absorption, % max (ASTM D570). Initial value: 4. Value after 112 days: % max 2'4

g. Aged Tensile (psi) -- Tensile strength (after exposure to 300 psi (2100 kPa) oxygen at 158° ± 1.8°F [70° ± 1°C] for 96 hours), % of initial, min (ASTM D572). Initial: 70 min. After accelerated aging: 70 min.

h. Aged Elongation -- Elongation at break (after exposure to 300 psi (2100 kPa) oxygen at 158° ± 1.8°F [70° ± 1°C] for 96 hours), % of initial, min. (ASTM D572). Initial value: 70 min. Test after accelerated aging: 70 min.

i. Ozone resistance (after exposure to 100 pphm ozone for 50 hours at 104° ± 2°F [40° ± 1°C]), (ASTM D1149). Initial value: No cracking. After exposure: No cracking

j. Weight Change, % max. (approx. specimen size 1.0 x 3.0 x 0.1 inch) (25 x 75 x 2.5mm), (ASTM D543): value before and after exposure ±1.5 max

2. Stainless Steel components 300 series. (ASTM A240).

3. Components can be factory fabricated or mechanically molded

2.04 STACKS

A. Provide stacks for service connections wherever crown of sewer is 8 feet or more below finished grade.

B. Construct stacks of same material as sanitary sewer and as shown on Drawings.

C. Provide stacks of same nominal diameter at sanitary service line.

2.05 PLUGS AND CAPS

A. Seal upstream end of unconnected sewer service stubs with rubber gasket plugs or caps of same pipe type and size.

2.06 THREE PIECE SERVICE CONNECTION (TEE)

A. The connection is comprised of three parts; PVC hub, stainless steel band and rubber boot.

B. PVC hub and rubber boot shall be engineered to accept the wall thickness and internal radius of the pipe. The PVC hub and rubber boot shall protrude no more than ½" into the sewer pipe.

C. The PVC hub shall be in accordance with ASTM D-3034.

D. The rubber boot shall be in accordance with ASTM F 477.

E. The Tee shall be sized to accept 4" or 6" service lines, as required.

F. The Tee shall only be used when approved by the Project Manager.

G. Service Connection (Tee) shall be in accordance with Section 2.03.

2.07 SANITARY SEWER STANDARD CLEANOUT ON SERVICE LATERAL:

A. Where directed, the contractor shall remove (if existing) and install new sanitary sewer cleanout. This shall include: frame and cover, molded polyethylene, four-way cleanout, 12” Ultra-Rib PVC or SDR35 PVC riser pipe, 2-foot square concrete pad, cement stabilized sand backfill, and all labor, equipment, and site restoration.

B. The standard frame and cover shall be cast iron, embossed with “Sewer Cleanout” “City of Houston”.

C. The molded polyethylene, four-way cleanout shall be the "wastewater access chamber" as manufactured by Uponor ETI Co. or approved equal.

D. Riser pipe shall be 12" Ultra-Rib PVC or SDR35 PVC.

E. Provide sealing material between pipe riser and cleanout cover frame that is a hydrophilic elastic sealant, or approved equal.

2.08 SANITARY SEWER 4" OR 6" CLEANOUT ON SERVICE LATERAL

A. Where directed, the contractor shall remove (if existing) and install new sanitary sewer cleanout. This shall include: 4" or 6" removable threaded countersunk plug, 4" or 6" SDR 35 PVC riser pipe with 45 degree bend and wye, 3-RT Valve Box MFG by Old Castle Precast Inc or approved equal, and all labor, equipment, and site restoration. Payment made will be made at the unit price set in Document 00410B. Where service lateral to an abandoned house is encountered, install 4" or 6" plug for future house connection. All work shall be performed as per 4-Inch Cleanout Detail on Service Lead or Drawing No. 02534-05. Cleanout box may be installed in accordance with Drawing No. 02085-01.

PART 3 EXECUTION

3.01 PERFORMANCE REQUIREMENTS

A. Provide minimum of 72 hours notice to customers whose sanitary sewer service will potentially be interrupted.

B. Accurately field locate service connections, whether in service or not, along rehabilitated sanitary sewer main. For parallel and replacement sewers, service connections may be located as pipe laying progresses from downstream to upstream.

C. Properly disconnect existing connections from sewer and reconnect to rehabilitated liner, as described in this Section.

D. Reconnect service connections, including those that go to unoccupied or abandoned buildings or to vacant lots, unless directed otherwise by Project Manager. Install a stack and cap the reconnection where the service is to a vacant lot or location where a structure has been demolished, unless directed otherwise by Project Manager.

E. Complete reconnection of service lines within 24 hours after cured-in-place liner installation and within 72 hours after disconnection for sliplining, parallel, or replacement sanitary sewer mains.

F. Reconnect services on cured-in-place liner at 10 feet depth or less by excavation method. Project Manager reserves the right to require service connections by excavation when remote cut service connection damages lines.

G. Reconnection by excavation method shall include stack and fittings and required pipe length to reconnect service line.

H. Connect services 8 inches in diameter and larger to sewer by construction of manhole. Refer to appropriate Section on manholes for construction and payment.

I. All couplings and adapters used to either connect existing or new services to new PVC pipe stubouts shall be eccentric reducers when the coupling or adapter is used as a reducer and when used in the horizontal or on a horizontal slope less than 1:1 or less than a 45□ angle (such that the flowline across the pipe size transition shall remain straight; no upset). The Contractor shall properly cut the ends of the two PVC pipes joined by a flexible coupling or adapter such that they do not extend into the transition area of the reducer. Pipe size transitions on existing or new services to new PVC pipe stubouts shall not be made in the vertical (in a stack or riser). Flexible couplings or adapters shall not be allowed for use in the vertical or on a slope greater than 1:1 or greater than a 45º angle.

3.02 PROTECTION

A. Provide barricades, warning lights, and signs for excavations created for service connections. Conform to requirements of Section 01504 - Temporary Facilities and Controls.

B. Do not allow sand, debris, or runoff to enter sewer system.

3.03 PREPARATION

A. Determine existing sewer locations and number of existing service connections from closed- circuit television (CCTV) inspection tapes or from field survey. Accurately field locate existing service connections, whether in service or not. Use existing service locations to connect or reconnect service lines or liner.

B. For rehabilitated sanitary sewer mains, allow liner to normalize to ambient temperature and recover from imposed stretch. For cured-in-place liners, verify that liner is completely cured.

C. For new parallel and replacement sanitary sewer mains, complete testing and acceptance of downstream sewers as applicable. Provide for compliance with requirements of Paragraph 3.01E.

3.04 EXCAVATION AND BACKFILL

A. Excavate in accordance with Section 02317 - Excavation and Backfill for Utilities.

B. Perform work in accordance with OSHA standards. Employ Trench Safety System as specified in Section 02260 - Trench Safety System for excavations requiring trench safety.

C. Install and operate necessary ground water and surface water control measures in accordance with requirements of Section 01578 - Control of Ground and Surface Water.

D. Determine locations where limited access, buildings or structure preclude use of mechanical excavation equipment. Obtain approval from Project Manager for hand excavation.

E. When the excavation shows that a service line is not connected, abandon the service reconnection and backfill the excavation.

3.05 RECONNECTION BY EXCAVATION METHOD

A. Saddle Method

1. Remove a portion of the existing sanitary sewer main or carrier pipe to expose the liner pipe. Provide sufficient working space for installing a pre-fabricated pipe saddle.

2. Carefully cut a hole in the liner pipe to accept the protrusion on the underside of the saddle. Length of protrusion shall be equal to the wall thickness of the liner pipe.

3. Apply an approximately 1/2" diameter bead of uncured, 100% pure silicone caulk (siliconized caulk will not be allowed), GE or approved equal, to the surface of the gasket that contacts the bottom of the saddle. A 1/2" bead of silicone caulk shall also be placed around the tapped hole in the polyethylene, PVC, or cured-in-place pipe. The beads of caulk should be placed approximately in the center of the gasket and, on the pipe, in the center of the area covered by the gasket. The saddle shall be installed and secured while the silicone caulk is uniformly fluid and pliable, not hardened or rubbery and with no hardened, rubbery areas or nodules. Adequate quantities of silicone caulk should be applied to allow it to flow or be extruded into any corrugations in the gasket surface and into any irregularities (scratches or gouges) in the surface of the polyethylene, PVC, or cured-in-place pipe.

4. Install the saddle with gasket using stainless steel bands on each side of the saddle. Tighten the bands to produce a watertight seal between the saddle and the liner pipe.

B. Three Piece Service Connection Method

1. Remove a portion of the existing sanitary sewer main or carrier pipe to expose the liner pipe. Provide sufficient working space to install three piece service connection.

2. Precisely cut a circular hole, per the manufactures recommendations, in the liner pipe that will form a tight fit between the liner pipe PVC stub and rubber boot.

3. Install the rubber boot into the cored hole, making sure the boot is properly oriented to the mainline. Lubricate the rubber boot with a special solution provided by the three piece service connection manufacturer. Make sure the upper and lower ribs of the rubber boot are correctly seated against the inside and outside diameter of the liner pipe.

4. Insert the PVC hub into the rubber boot, per manufacturer's recommended instructions. Place stainless steel band around the top of the rubber boot and tighten to form a watertight seal.

C. Service Line Connections to Saddles or Three Piece Service Connections

1. Remove and replace cracked, offset or leaking service line up to 8 feet (measured horizontally) from the center line of the new liner.

2. Make connections between liner and existing service line using PVC sewer pipe and approved couplings/fittings using stainless steel bands to construct new stacks and/or service lines.

3. Test all service connections by smoke testing the sewer main and connections before backfilling.

4. Encase the entire service connection is cement stabilized sand or crushed stone. Place a minimum of 6 inches below and 12 inches above and on each side of the service line and pipe connection.

3.06 RECONNECTION BY REMOTE METHOD

A. Make service reconnections using remote-operated cutting tools on cured-in-place liners at depth greater than 10 feet.

B. Employ method and equipment that restore service connection capacity to not less than 90 percent of original capacity.

C. Immediately open missed connections and repair holes drilled in error using method approved by Project Manager.

3.07 RECONNECTION ON PARALLEL OR REPLACEMENT SEGMENTS

A. Install a full-bodied tee or wye fitting on the new sanitary sewer main for each service connection.

B. Remove and replace cracked, offset or leaking service line for up to 5 feet, measured horizontally, from centerline of sanitary sewer main.

C. Make up connection between main and existing service line using PVC sewer pipe and approved couplings, as shown on Drawings.

D. Test service connections before backfilling.

E. Embed service connection and service line as specified for sanitary sewer main as shown on Drawings. Place and compact trench zone backfill in compliance with Section 02317 - Excavation and Backfill for Utilities.

3.08 INSTALLATION OF NEW SERVICE STUBS

A. Install service connections on sanitary sewer main for each service connection. Provide length of pipe required to allow sufficient room for standard 6-inch clean-out service lead assembly in accordance with detail 02534-05. Install plug(s) or cap on the upstream end(s) of service stub(s) as needed.

B. Test service connections before backfilling.

C. Embed service connection and service line as specified for sanitary sewer main, and as shown on Drawings. Place and compact trench zone backfill in compliance with Section 02317 - Excavation and Backfill for Utilities. Install minimum 2-foot length of magnetic locating tape along axis of service stub and 9 inches to 12 inches above crown of pipe, at end of stub.

3.09 TESTING

A. Test service reconnections and service stubs. Follow applicable procedures given in Section 02533 - Acceptance Testing for Sanitary Sewers to perform smoke testing to confirm reconnection.

B. Perform post installation CCTV inspection as specified in Section 02558 - Cleaning and Television Inspection to show locations of service connection.

3.10 CLEANUP

A. Backfill excavation as specified in Section 02317 - Excavation and Backfill for Utilities.

B. Replace pavement or sidewalks removed or damaged by excavation in accordance with Section 02951 - Pavement Repair and Restoration. In unpaved areas, bring surface to grade and slope surrounding excavation. Replace minimum of 4 inches of topsoil and seed according to requirements of Section 02921 - Hydro Mulch Seeding.

END OF SECTION

SECTION 02550

SLIPLINING SANITARY SEWERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Sliplining existing sanitary sewers.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01340 – Shop Drawings, Product Data, and Samples

D. Section 01504 – Temporary Facilities and Controls

E. Section 01506 – Diversion Pumping

F. Section 01576 – Waste Material Disposal

G. Section 01578 – Control of Ground and Surface Water

H. Section 01740 – Site Restoration

I. Section 02260 – Trench Safety System

J. Section 02317 – Excavation and Backfill for Utilities

K. Section 02320 – Utility Backfill Materials

L. Section 02321 – Cement Stabilized Sand

M. Section 02505 – High Density Polyethylene (HDPE) Solid and Profile Wall Pipe

N. Section 02506 – Polyvinyl Chloride Pipe

O. Section 02533 – Acceptance Testing for Sanitary Sewers

P. Section 02553 – Point Repairs and Obstruction Removals

Q. Section 02555 – Manhole Rehabilitation

R. Section 02558 – Cleaning and Television Inspection

1.03 UNIT PRICES

A. Measurement for sliplining is on a linear foot basis for installed liner pipe, measured from center line of upstream manhole to center line of downstream manhole.

B. Insertion pits, access pits, clamp installation, embedment (bedding, haunching and initial backfill), field quality control (testing), sealing liner at manholes, grouting annular space, building up, shaping and reworking manhole inverts and benches, and pre-installation and post-installation cleaning and television inspection of completed work are included in sliplining unit price and not paid for separately.

C. Excavations initially begun as obstruction removals or point repairs which the Contractor later decides to use as insertion pits are considered as insertion pits and not paid for separately.

D. Trench safety systems, well pointing and other applicable bid items associated with insertion pits will be paid for at their respective contract unit prices.

E. Refer to Section 01270 - Measurement and Payment, for unit price procedures.

F. Payment for Item, 'Mobilization for short segment (<100')' will be paid when the contractor is issued a work order containing a line segment that is less than 100 feet in length and is not adjacent to another line segment, or when the total of all adjacent line segments is less than 100 feet.

1.04 REFERENCES

A. ASTM D 1784 - Standard Classification System and Basis for Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

B. ASTM D 1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

C. ASTM D 2122 - Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings.

D. ASTM D 2412 - Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.

E. ASTM D 2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.

F. ASTM D 2992 - Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings.

G. ASTM D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.

H. ASTM D 3262 - "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe.

I. ASTM D 3350 - Polyethylene Plastics Pipe and Fittings Materials.

J. ASTM D 3681 - Chemical Resistance of "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe in a Deflected Condition.

K. ASTM D 4161 - "Fiberglass" (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals.

L. ASTM F 585 - Standard Guide for Insertion of Flexible Polyethylene Pipe Into Existing Sewers.

M. ASTM F 714 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter.

N. ASTM F 794 - Specification for Poly (Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.

O. ASTM F 894 - Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe.

P. AWWA C 151 - Ductile-Iron Pipe, Centrifugally Cast.

1.05 DEFINITIONS

A. Sliplining: Reconstruction of sanitary sewers by insertion of liner pipe into existing sewers.

1.06 SYSTEM DESCRIPTION

A. Sliplining is accomplished by pulling or pushing liner pipe into existing sewers by use of mechanical or hydraulic equipment. Once in place, liner pipe is allowed time to normalize and is then cut to fit between manholes. Annular spaces between liners and existing sewers are sealed at each manhole. Manhole inverts and benches are reworked and reshaped. Existing sewers remain in operation during sliplining process, with sewage flow diverted around operations in progress.

1.07 QUALITY ASSURANCE

A. Liner Acceptance: Provide liner material manufactured, without defects, to standards and dimensions specified. Causes for rejection include physical defects of liner pipe, such as concentrated ridges, chain marks, discoloration, excessive spot roughness, pitting, visible cracks, foreign inclusions and varying wall thickness.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Prevent injury to or abrasion of pipe during loading, transportation and unloading. Do not drop pipe from vehicles nor allow pipe to roll down skids or slopes without proper restraining ropes. Use suitable pads, strips, skids or blocks for each pipe during transportation and while awaiting installation.

B. Do not use, and remove from construction site, pipe with physical damage such as cuts, gashes, nicks or abrasions, whether from manufacturing, shipping, storage or handling, and which is deeper than 10 percent of wall thickness.

C. Use wide belly band slings for lifting and moving pipe. Do not use bare chains in contact with pipe.

1.09 PERFORMANCE REQUIREMENTS

A. Maintain sewage flow by diversion pumping or other method approved by the Engineer.

B. Clear existing sewers of debris, obstructions and other foreign material and make point repairs to existing sewers as specified in Section 02553 - Point Repairs and Obstruction Removals.

C. Install sliplining according to this Section.

D. Grout annular space(s).

E. Shape, refurbish or construct manhole inverts as specified in Section 02555 -Manhole Rehabilitation.

F. Test lines as specified in Section 02533 - Acceptance Testing of Sanitary Sewers.

G. Video inspect completed lines as specified in Section 02558 - Cleaning and Television Inspection.

1.10 SUBMITTALS

A. Comply with Section 01330 - Submittal Procedures, and 01340 - Shop Drawings, Product Data and Samples.

B. Submit manufacturer's product data with complete information on pipeline materials, including physical properties and dimensions pertinent to this job. Furnish certificate(s) of compliance with specifications for materials to be supplied.

C. Submit independent laboratory test reports certifying that polyethylene pipe meets ASTM D 1248 and ASTM D 3350, that fiberglass reinforced plastic (FRP) pipe meets ASTM D 3681, or that PVC pipe meets ASTM F 794 and ASTM D 1784, as applicable.

D. Submit grouting plan showing where grout is to be injected, materials and chemicals to be used in grout, anchoring methods, and planned grouting pressure.

E. Submit video inspection as specified in Section 02558 - Cleaning and Television Inspection.

1.11 TESTING

A. The City may have tests performed on field samples by an independent laboratory following applicable ASTM specifications to verify physical properties and characteristics of supplied materials. Provide product samples as requested by the Engineer.

B. The City will pay for tests on materials which meet specification requirements. Contractor shall pay for failed tests and consequent retesting.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Liner pipe systems shall be polyethylene, fiberglass reinforced plastic (FRP) PVC profile wall or polyethylene profile wall pipe, as approved by the City.

B. Refer to City of Houston Approved Products List for acceptable product manufacturers.

2.02 POLYETHYLENE LINER PIPE AND FITTINGS

A. Provide polyethylene liner pipe, manufactured of solid-wall, high-density, high-molecular-weight polyethylene meeting ASTM D 1248, Type III, Class C, Grade P-34, Category 5, with a PPI rating of PE 3408. Use polyethylene material with a minimum cell classification of 3454 34D or E (inner wall of light color) under ASTM D 3350. Higher-numbered cell classification limits giving desirable higher primary properties, according to ASTM D 3350, are also acceptable. Provide pipe with hydrostatic design value not less than 1600 psi when tested according to ASTM D 2837. Dimensions and workmanship shall be in accordance with ASTM F 714 and ASTM D 2122.

B. Provide pipe with maximum Standard Dimension Ratio (SDR) and ratio of outside pipe diameter to wall thickness as specified below. Select SDR for the deeper of two manholes in each pipeline segment.

Maximum Liner SDR	Maximum Depth (feet)
26	10
21	15
19	20
17	Greater than 20

C. Minimum Outside Diameter of liner:

Existing Sewer Nominal Diameter (Inches)	Minimum O.D. of Liner (Inches)
8	7.125
10	8.625
12	10.75
15	14.00
18	16.00
21	18.00
24	22.00
27	26.00
30	28.00

2.03 FRP LINER PIPE AND FITTINGS

A. Pipe, joints and fittings: ASTM D 3262, Type 1, Liner 2, Grade 3.

B. FRP Liner Pipe: Reinforced plastic mortar pipe manufactured to produce a dense, nonporous, corrosion-resistant, consistent, composite structure. Minimum stiffness: 46 psi, measured in accordance with ASTM D 2412. Use with a stiffness of 72 psi where specified or shown on the Drawings.

C. Resin Systems: Thermosetting polyester resin, with or without filler, meeting ASTM D 3262.

D. Reinforcing Glass Fibers: Commercial grade E-type glass filaments, with binder and sizing compatible with impregnating resins.

E. Filler: Sand with at least 98 percent silica content, and maximum moisture content of 0.2 percent.

F. Joints: Low-profile, fiberglass bell-spigot joints or flush fiberglass bell spigot joints. Either joint shall utilize elastomeric sealing gaskets for watertight joints meeting ASTM D 4161.

G. Dimensions and Tolerances:

1. Pipe outside diameters and tolerances (18” to 48”): Comply with ASTM D 3262, Cast Iron Pipe Equivalent Outside Diameters, and table below.

2. When possible, supply pipe in nominal lengths of 20 feet. Where radius curves in existing pipe or limitations in entry pit dimensions restrict pipe length, shorter lengths may be used.

3. FRP pipe minimum outside diameters and minimum wall thicknesses for low profile, fiberglass bell-spigot joints:

Minimum Existing Sewer Nominal Diameter (Inches)	Minimum Wall Liner O.D. (Inches)	Minimum Wall Thickness 46 psi Stiffness (Inches)	Thickness 72 psi Stiffness (Inches)
21	19.50	0.39	0.44
24	21.60	0.43	0.49
30	25.80	0.50	0.57
36	32.00	0.61	0.70
42	38.30	0.72	0.83
48	44.50	0.83	0.95
54	50.80	0.94	1.08
60	57.10	1.05	1.21
66	62.90	1.15	1.33
72	69.20	1.27	1.46
78	75.40	1.38	1.59

4. FRP pipe minimum outside diameters and minimum wall thickness for flush fiberglass bell spigot joints:

Existing Sewer Nominal Diameter (Inches)	Minimum Liner O.D. (Inches)	Nom. Pipe Stiffness (PSI)	Minimum Wall Thickness (Inches)
21	19.50	426	0.75
24	21.60	310	0.75
30	25.80	187	0.76
36	32.00	143	0.86
42	38.30	95	0.90
48	44.50	82	0.99
54	50.80	74	1.09
60	57.10	65	1.17
66	62.90	62	1.27
72	69.20	71	1.45
78	75.40	59	1.49

5. Fabricate pipe ends square to pipe axis with a maximum tolerance of 1/8”.

H. Fittings:

1. Flanges, elbows, reducers, tees, wyes and other fittings: Capable of withstanding operating conditions.

2. Fabrication: Contact-molded or manufactured from mitered sections of pipe joined by glass-fiber-reinforced overlays.

2.04 PROFILE WALL PIPE

A. Profile wall pipe may be considered as liner pipe if appropriate submittals, including data, specifications and sizes were made and accepted during bid phase.

B. PVC Profile Wall Pipe: Comply with Section 02506 – Polyvinyl Chloride Pipe and ASTM F 794.

1. Minimum pipe stiffness: 46 psi.

2. Pipe joints: Flush gasketed joint system meeting ASTM D 3212. Flush joints shall not increase outside diameter or reduce inside diameter of the pipe.

3. Minimum outside diameter for liners:

Existing Sewer Nominal Diameter (Inches)	Minimum O.D. of PVC Profile Wall Liner (Inches)
24	22.110
30	28.232
36	31.415
42	37.800
48	44.220

4. Supply pipe in nominal lengths of 15 feet.

C. Polyethylene Profile Wall Pipe:

1. Comply with ASTM F 894 and Section 02505 - High Density Polyethylene (HDPE) Solid and Profile Wall Pipe.

2. Minimum pipe stiffness: 46 psi.

2.05 LINER PIPE SEALS AT MANHOLES

A. Sealer for annular spaces between liner pipes and host sewers at manholes: Refer to Specification 02555 – Manhole Rehabilitation when using wall sealing material or the Approved Product List for mechanical seals.

B. All manhole bench/invert work and annular seals shall be completed at the time of the post-TV inspection with Post-TV inspection being verification of completion. Failure to do so may be cause for rejection of the Post-TV inspection and require re-inspection.

2.06 CLAMPS AND GASKETS

A. Clamps: Stainless steel, including bolts and lugs, as manufactured by JCM Industries, Type 108, or equal. Furnish full circle, universal clamp couplings with at least 3/16-inch thick neoprene grid-type gaskets. Select clamps to fit outside diameter of liner pipe as follows:

Liner Pipe O.D. (Inches)	Minimum Clamp Length (Inches)
7.125	15
8.625	18
10.750 or greater	30

2.07 BEDDING MATERIAL

A. Bedding: Comply with Section 02320 - Utility Backfill Materials and Section 02321 - Cement Stabilized Sand.

PART 3 EXECUTION

3.01 OBSTRUCTION REMOVAL AND POINT REPAIR

A. Make point repairs and remove obstructions, such as roots, rocks and other debris, prior to installing liner pipe. Remove and dispose of in accordance with Section 01504 - Temporary Facilities and Controls, or Section 01576 - Waste Material Disposal.

B. Refer to Section 02553 - Point Repairs and Obstruction Removals, for requirements and procedures for point repairs and obstruction removals.

3.02 DIVERSION PUMPING

A. Refer to Section 01506 - Diversion Pumping.

3.03 INSERTION OR ACCESS PITS

A. Locate pits so that the total number is minimized and footage of liner pipe installed in a single pull is maximized. Where possible, use excavations at point repair locations for insertion pits.

B. Before excavating, locate all utilities, costs of utility repairs, temporary service and other cost arising out of damage to or interruption of utilities, resulting from operations under this Contract, shall be borne by Contractor at no additional cost to City.

C. Perform excavation and backfill in accordance with Section 02317 - Excavation and Backfill for Utilities.

D. Perform work in accordance with OSHA standards. Comply with Section 02260 - Trench Safety System, for excavations requiring trench safety.

E. Install and operate necessary dewatering and surface water control measures in accordance with Section 01578 - Control of Ground and Surface Water.

3.04 POLYETHYLENE LINER PIPE INSTALLATION

A. Joints:

1. Assemble and join sections of polyethylene liner pipe on site, above ground. Make joints by heating and butt-fusion method in strict conformance to manufacturer's instructions.

2. Use operators who are experienced with butt-fusion field-jointing of pipe. Operators shall be trained in fusing polyethylene pipe with similar equipment using proper jigs and tools in accordance with pipe manufacturer’s standard procedures.

3. Form joints with smooth, uniform double-rolled back beads made while applying proper melt, pressure and alignment. Joints will be inspected by the Engineer before insertion.

B. Preparation: After completing insertion pit excavation, remove top of existing sanitary sewer line down to spring line. Connect power winch cable to end of liner by use of suitable pulling head equal to outside diameter of liner. Secure pulling head to liner and attach to power winch cable so that liner can be satisfactorily fed and pulled through sanitary sewer line. Prevent ragged edges of existing pipe from scarring liner pipe. Follow insertion procedures in ASTM F 585. Do not allow sand or other debris to enter liner.

C. Pulling Liner:

1. Maximum length of continuous liner assembled above ground and pulled at any one time: do not exceed length recommended by manufacturer's printed instructions.

2. Limit pulling force exerted on liner to that indicated below for the appropriate outside diameter of the polyethylene liner. Provide a suitable pulling force measuring device connected to the winch or pulling mechanism.

Polyethylene Liner O.D. (Inches)	Maximum Pulling Force (Tons)
7.125	3.5
8.625	5.0
10.750	8.0
12.750	12.0
14.0	14.0
16.0	19.5
20.0	29.0
28.0	52.0

D. Alternate Insertion Techniques: Pushing, or a combination of pulling and pushing, may be used subject to the Engineer's approval. Avoid liner buckling or dimpling by limiting stroke of pushing implement. Cut out and remove portions damaged during insertion process.

3.05 FRP LINER PIPE INSTALLATION

A. FRP liner pipe may be pushed or pulled into existing sewers. Insert pipes, spigot end first, with bell end trailing. Apply pushing force to pipe wall end inside bell in accordance with manufacturer's instructions. Do not apply jacking loads to end of bell. Maximum allowable joint angular deflection shall be one degree. Keep within safe jacking loads as follows:

Nominal Diameter (Inches)	Maximum Jacking Load (Tons) for 46 psi Stiffness
21	22
24	30
30	42
36	50
42	65
48	80
54	100
60	120
66	140
72	160
78	180

3.06 PROFILE WALL PIPE INSTALLATION

A. PVC Profile Wall Pipe

1. Evaluation: Prior to each installation of PVC profile wall pipe, pull trail liner approximately 15 feet long and of the same diameter proposed, to make sure proposed pipe will completely pass through existing line.

2. Preparation:

   a. After completing insertion pit excavation, remove top of existing sanitary sewer host pipe down to spring line to expose channel for liner placement. Prevent ragged edges of host pipe from scarring liner pipe.

   b. Regulate sewer flow so pipe is flowing approximately one-third full. Do not allow sand or other debris to enter liner or annular space during pipe insertion.

3. Installation:

   a. Pushing Liner: Place liner pipe in channel and push forward. Use pushing plate or insertion ring to distribute load from hydraulic or mechanical pipe pusher to end of profile wall pipe. Attach device for measuring jacking/pushing force to pipe pusher. Constantly monitor jacking/pushing force. If jacking/pushing force exceeds 12 tons, stop insertion and consult pipe manufacturer for specific instructions and recommendations. Notify the Engineer each time there is deviation from proposed installation plan. Maximum length of PVC profile wall pipe inserted/pushed: Do not exceed manufacturer's recommendations.

   b. Joints: After insertion of liner pipe, lubricate gasketed couplings and grooved spigots with special subaqueous lubricant furnished by pipe manufacturer.

   c. Closely monitor grouting pressures; not to exceed 5 psi. Remove liner pipe collapsed by excess grouting pressure or improper procedure and replace with undamaged liner pipe.

B. Polyethylene Profile Wall Pipe

1. Evaluation: Prior to each installation of profile wall pipe, pull trial liner approximately 15 feet long and of the same diameter proposed, to make sure proposed pipe will completely pass through existing line.

2. Preparation:

   a. After completing insertion pit excavation, remove top of existing sanitary sewer host pipe down to spring line to expose channel for liner placement. Prevent ragged edges of host pipe from scarring liner pipe.

   b. Do not allow sand or other debris to enter liner or annular space during pipe insertion.

3. Installation:

a. Jack or push liner pipe into host pipe without obstruction such as dropped or shifted joints. Constantly monitor jacking/pushing force during the insertion. Place insertion ring or pushing plate between pushing/jacking device and end of pipe. Jacking/pushing force shall not exceed 10 tons.

b. Joints:

(1) Place gasket facing correct direction and properly seated in spigot groove.

(2) Apply lubricant to entire spigot groove, to exposed gasket surface and to entire inner surface of bell.

(3) Seat spigot in "home" position in bell.

c. Grout pressure: Do not exceed collapse resistance of the liner. Remove liner pipe collapsed by excess grouting pressure or improper procedure and replace with undamaged liner pipe.

3.07 CLAMP INSTALLATION

A. Where excavations for liner pipe insertion are made between two manholes, cut ends of liner pipe smooth and square to pipe axis. Join liner pipes with appropriately sized stainless steel universal clamp couplings. Butt together gap between ends of liner pipe with space between ends not exceeding 2 inches.

B. Bedding: Install cement-stabilized sand in accordance with Section 02321 – Cement Stabilized Sand. Extend bedding 12 inches above clamp/liner pipe.

3.08 FRP COLLAR/CLOSURE

A. Install FRP collar closure pieces in accordance with manufacturer's recommendations.

3.09 FIELD QUALITY CONTROL

A. After liner installation, perform the following tests:

1. Low pressure air test: Perform before sealing liner in place at manholes, and before making service reconnections to liner. Check integrity of joints made and verify that liner has not been damaged.

2. Service lateral connection test: After all service laterals have been completed for a particular sewer section, verify integrity of re-connections at points where they join liners and existing service lines by performing smoke test.

3. Refer to Section 02533 - Acceptance Testing for Sanitary Sewers, for applicable test procedures.

3.10 SEALING LINER IN MANHOLE

A. Allow liner pipe to normalize to ambient temperatures and recover from imposed stretch before cutting to fit between manholes, sealing at manholes and shaping manhole invert. Allow at least 12 hours for normalization of polyethylene.

B. Cut liner so it extends 4 inches into manholes. Make smooth, vertical cuts and slope areas over top of exposed liner using non-shrink grout.

C. Seal annular spaces between liner and sanitary sewer main at each manhole with chemical seal and non-shrink grout or mechanical seals.

D. Finish seal liner pipe to host pipe with non-shrink grout placed around annular space from inside manhole. Apply grout in a band at least 6 inches wide. Obtain the Engineer's approval of sealing methods, including seal chemicals and materials.

E. Use cementitious grout to form smooth transitions with reshaped inverts and raised manhole benches to eliminate sharp edges of liner pipe, concrete benches, and channeled inverts. Build up and smooth manhole invert to match flow line of new liner.

F. Build up the existing invert, in accordance with Document 02555 – Manhole Rehabilitation.

3.11 GROUTING ANNULAR SPACE

A. Obtain approval of grouting plan from the Engineer before proceeding with the Work.

B. Grout annular space between the outside of liner and inside of existing pipe for sewer pipe 18 inches in diameter and larger.

3.12 POST-INSTALLATION VIDEOTAPE RECORDING

A. Provide the Engineer with video inspection showing completed work including condition of restored connections. Comply with Section 02533 - Acceptance Testing for Sanitary Sewers, and Section 02558 - Cleaning and Television Inspection.

3.13 FINAL CLEANUP

A. Upon completion of installation and testing, clean and restore project area affected by work of this Section. Restore site in accordance with Section 01740 - Site Restoration.

END OF SECTION

SECTION 02551

SANITARY SEWER RENEWAL BY SPIN CAST PIPE LINING METHOD

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Proposed methods and materials for the renewal of deteriorated gravity sewer pipes by the Spin Cast Pipe Lining (SCPL) method.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01506 – Diversion Pumping

D. Section 01740 – Site Restoration

E. Section 02553 – Point Repairs and Obstruction Removals

F. Section 02558 – Cleaning and Television Inspection

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. Measurement and payment for SCPL is on a linear foot basis, measured along centerline of pipe from centerline to centerline of manholes or junction boxes, and shall be considered full compensation for all labor and materials required to install the liner to specified requirements. The depth range for payment is based on greatest depth measured at manholes from natural ground level to flow line of sanitary sewer for each pipeline segment.

2. No separate payment will be made for the following items of work. Include cost in the unit price for installing SCPL:

    a. Sealing the liner in manholes/services.

    b. Temporary meter and municipal water obtained from a City fire hydrant.

    c. Antimicrobial System, Epoxy (only when directed by Engineer) or approved substitute.

3. No separate payment will be made for pre-installation and post-installation cleaning and television inspection as specified in Section 02558 – Cleaning and Television Inspection.

4. Where post-installation thickness measurements or physical property testing is performed, payment for installed SCPL shall be made as follows:

   a. Full payment: If thickness, compressive strength and flexural modulus of elasticity of installed SCPL are all 95 percent or better of specified values, full payment shall be made.

   b. Adjusted payment: If thickness, compressive strength or flexural modulus of elasticity is between 90 percent and 95 percent of specified values, payment shall be made based on an Adjusted Unit Price, which shall equal the Unit Price bid, multiplied by a Value Factor calculated as follows:

$$\frac{\text{actual thickness}}{\text{specified thickness}} \times \frac{\text{actual compressive strength}}{\text{specified compressive strength}} \times \frac{\text{actual modulus of elasticity}}{\text{specified modulus of elasticity}}$$

   "Value Factor" shall not exceed 100 percent.

5. Payment for point repairs and obstruction will be made according to Section 02553 – Point Repairs and Obstruction Removals.

6. Payment for repair of sags in the line will be made either according to Section 02553 – Point Repairs and Obstruction Removals, or according to the diameter and depth of the pipe if “Remove and Replace” is the method of repair designed by the Engineer.

7. Measurement and payment for repairs of defects to the interior surface of the pipe due to acid erosion or abrasion is on a cubic foot basis.

8. Refer to Section 01270 – Measurement and Payment

B. Stipulated Price (Lump Sum): If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 REFERENCES

A. ASTM C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

B. ASTM C 172 - Standard Practice for Sampling Freshly Mixed Concrete.

C. ASTM C293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading).

D. ASTM C 469 - Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression.

E. ASTM F 2414 – Standard Practice for Sealing Sewer Manholes Using Chemical Grouting.

F. ASTM E 2149 - Standard Test Method for Determining the Antimicrobial Activity of Immobilized Antimicrobial Agents under Dynamic Contact Conditions.

G. ACI Field Technician Certification Programs: Grade 1 Technician.

1.05 SYSTEM DESCRIPTION

A. SCPL involves renewal of deteriorated gravity sanitary sewer pipe that is centrifugally applied through a spin caster or hand sprayed to the interior surface of the host pipe after it has been properly prepared and cleaned. The finished surface shall have flow characteristics that closely match the original pipe.

B. A spin cast liner cures into a hard, impermeable, smooth, corrosion-resistant liner of specified thickness and physical properties, with a uniform interior surface.

C. Spin Cast Material and Installation: Comply with ASTM C 39. The City reserves the right to approve materials or installation practices which differ from these standards.

1.06 SUBMITTALS

A. Make submittals in accordance with Section 01330 – Submittal Procedures.

B. Spin Cast Geopolymer Liner Material:

1. Submit product data with physical and chemical properties.

2. Submit results of testing performed by liner manufacturer demonstrating compliance with specified chemical properties requirements for each product batch.

3. Submit manufacturer-certified batch analysis for basic physical properties performed at manufacturing facility.

C. Installed Geopolymer Liner:

1. Submit field measurements of cured liner thickness for determining payment.

2. Samples shall be obtained by ACI Certified, Grade 1 Technicians.

3. Submit representative sample(s) of the cured liner required for testing in Accordance with ASTM C 39.

4. Submit post-installation television inspection video as specified in Section 02558-Cleaning and Television Inspection.

1.07 QUALITY ASSURANCE

A. During the course of the Work, make no substitutions of materials, design values or Procedures for those specified without the prior written approval of the Engineer.

PART 2 PRODUCTS

2.01 MATERIALS

A. Geopolymer Liner:

1. The geopolymer lining material shall be a micro-fiber reinforced ultra-dense geopolymer. The material shall provide a high strength fiber reinforced mortar specifically designed for ease of mechanical pumping, spraying and spin casting. The geopolymer liner shall not clog spinner heads or spray equipment.

2. The geopolymer liner shall be designed to produce a liner with improved compressive and flexural strength, high adhesion to damp surfaces, lower permeability and increased resistance to aggressive chemical attack.

3. The fiber reinforced formula shall be engineered to improve hydraulic abrasion resistance, provide dimensional stability and protect against penetration by substances such as fats, oils, gases, and where high corrosion exists within a sanitary sewer environment.

B. Anti-Microbial System (AMS):

1. Application of Antimicrobial Liquid, or Epoxy (only when directed by Engineer), to prevent Microbiologically Induced Corrosion (MIC). The work consists of rolling, spraying or centrifugally applying AMS Liquid, approved substitute, or epoxy to the inside of the newly cast pipe. Equipment required for application can include centrifugal spray mechanisms, pneumatic spray pumps, hand pumps or paint style roller.

2. The Antimicrobial Liquid, or Epoxy, shall be used full strength as received from the manufacturer and shall not be diluted.

3. The Antimicrobial Liquid, shall be applied during the application of the geopolymer liner or anytime thereafter. Epoxies shall be applied after proper curing of the liner.

4. The Antimicrobial Liquid shall be applied adequately to achieve surface saturation. Epoxies must be applied at a minimum thickness of 125 mils.

5. The Antimicrobial Liquid, or Epoxies, must be allowed to cure for a minimum of 12 hours, or meet manufacturer recommended cure time, prior to releasing bypass or opening to any traffic.

2.02 TESTING REQUIREMENTS

A. Manufacturer's Physical Properties Testing: Perform product testing according to ASTM C-39 and ASTM C-469. Test frequency and sample preparation: Follow ASTM C-172.

B. Test Results: Submit test results including at least the following:

1. Raw data for each test specimen for each test performed

2. Calculated average test results for each test performed

3. Using calculated averages for each test, calculate the average test result.

2.03 PHYSICAL PROPERTIES

A. Minimum Geopolymer Liner Thickness after Curing: As specified in the table below, the minimum liner thickness is based on the maximum sewer depth for the segment being rehabilitated. The thickness installed must meet the manufacturers written requirements. The standard conditions utilized in the table below include: a pipe in the fully deteriorated condition, the water table is assumed to be at the surface; soil is assumed at 130 lbs/cubic foot, and a traffic loading of HL-93. The installed liner system, complete in place, must meet or exceed site specific conditions.

Minimum Geopolymer Liner Thickness:

Sewer Pipe Diameter	Maximum Invert Depth 0 to 10 feet	Maximum Invert Depth 10-15 feet	Maximum Invert Depth 15-20 feet	Maximum Invert Depth 20 - 25 feet
30"	1.5 "	1.5"	1.5"	1.5"
36"	1.5"	1.5"	1.5"	1.5"
48"	1.5"	1.5"	1.5"	1.6"
54"	1.5"	1.5"	1.6"	1.7"
60"	1.5"	1.5"	1.7"	1.8"
72"	1.5"	1.6"	1.9"	2.0"
84"	1.6"	1.8"	2.0"	2.2"
96"	1.8"	1.9"	2.1"	2.4"
108"	2.4"	2.0"	2.3"	2.5"
120"	***	2.1"	2.4"	2.6"

Note: If host pipe condition is deemed to be more severe than assumed conditions, liner thickness may be increased upon approval by the Engineer.

B. The geopolymer liner material shall also conform to the minimum requirements demonstrated in the following table:

Physical Properties	ASTM Reference	Requirements
Compressive Strength	ASTM C 39	Minimum 8,000 psi @ 28 days
Modulus of Elasticity	ASTM C 469	Min. 5,000,000 psi @ 28 days
Flexural Strength	ASTM C 293	Minimum 800 psi @ 28 days

C. If different conditions are encountered in the field, design considerations may change, if required by the Project Manager. Required thickness maybe increased or decreased based on specific design. The thickness may be changed in increments of 0.2 inches and payment shall be made or deducted at the rate of 7.5% of the bid item amount for each increment. However, the Contractor shall not be allowed to change any required thickness unilaterally or offer credits after the fact as remedy for liners not meeting the required thickness. Prior approval shall always be required for any changes in geopolymer liner thickness. Refer also to "Non-Confirming Work" in Section 3.10.

2.04 FIELD TESTING

A. For each section length designated by the owner in the Contract documents, the geopolymer liner material may be collected at the mixer, immediately before discharge into the pump, at the pump discharge, or at the end of the hose near the discharge point. Use cylinders as in accordance with Test Method ASTM C 39, A 4-inch by 8-inch cylinder shall be used to sample the material. ACI grade 1 certified technicians shall be used to obtain the sample. Documentation showing the field sample technicians ACI status shall be available onsite. Sample frequency shall not be less than once daily.

B. Make cylinders for each contract specified section and label each with the date, location, project, and product batch numbers. The product batch numbers are located on each liner material bag or on the pallet. ACI technicians shall be used to properly collect and store the samples. The 4-inch by 8-inch samples cylinders must be air mist cured per manufacturers' recommendation.

C. Thickness can be verified with a wet gage at any point of the new interior surface. Thickness measurements shall be taken at the beginning and end of any section of pipe being rehabilitated. The measurements shall be written in a daily log that includes the date, properly identifies the section of pipe, the actual measurements recorded (to tenths of an inch), and the name of the person taking the measurements.

D. When requested by Project Manager, the contractor shall remove a test core from the installed liner pipe at the contractor's expense, at established intervals. Contractor shall mark the core sample with the date that the liner was installed, the date that the core was removed, and the location within the pipe segment. The inspector shall initial the test coupon and provide it to the testing lab. A caliper or other suitable measuring device shall be used to test liner thickness. When requested by Project Manager, the pipe liner sample shall be cored at three different clock positions, and the average thicknesses measured shall be taken as the actual thickness of the spin cast liner. If a sample fails the test, additional material shall be applied to meet the thickness requirements.

PART 3 EXECUTION

3.01 PRE-INSTALLATION CLEANING AND TELEVISION INSPECTION

A. Perform a pre-installation television inspection in accordance with Section 02558-Cleaning and Television Inspection. Verify that sewer is clean and pipe conditions are suitable for installation of the geopolymer liner. Notify Project Manager if conditions exist which will impact the installation.

3.02 OBSTRUCTION REMOVAL, POINT REPAIR AND SAG ELIMINATION

A. If pre-installation video inspection reveals an obstruction in the line segment (such as heavy solids, dropped joints, protruding service connections or collapsed pipe) that cannot be removed by conventional sewer cleaning equipment and the obstruction will prevent completion of the lining process, perform point repairs or obstruction removal prior to the geopolymer liner installation. Obtain approval of the Project Manager before performing work. Follow Requirements in Section 02553 – Point Repairs and Obstruction Removals.

B. If the pre-installation video inspection reveals a sag in the sewer that has a vertical displacement greater than one-half the pipe diameter, eliminate the sag by performing a point repair as specified in Section 02553 – Point Repairs and Obstruction Removals, or by removal and replacement of the sewer segment. Obtain approval of the Project Manager before performing work.

C. If the pre-installation video inspection reveals defects and failures on the interior pipe surface, due to acid erosion or abrasion, the repairs shall be made when directed by Project Manager. Measures shall be taken to provide a continuous slope to the pipe, including the use of a flowable fill or the introduction of the wall lining material onto the pipes surface.

D. If the pre-installation video inspection reveals open, separated, or offset joints, the joints shall be sealed with the geopolymer lining material prior to the lining of the pipe.

3.03 CLEANING

A. All internal debris shall be removed from the original pipeline. Gravity pipes shall be cleaned with hydraulically powered equipment, high-velocity jet cleaners, or mechanically powered equipment. If pipe diameters allow for manned entry, the use of high-pressure washers delivering a minimum of 3500-psi, may be utilized. The use of higher-pressure washers may be required to achieve the desired surface condition. In some instances, mechanical cleaning methods may be required. The surface of the pipe to be lined shall be capable of directly receiving the lining material.

3.04 DIVERSION PUMPING

A. Maintain commercial and residential sanitary sewer service during the installation process.

B. Install and operate diversion pumping equipment to maintain sewage flow around the segment of pipe being rehabilitated, and to prevent backup or overflow, as specified in Section 01506 – Diversion Pumping.

3.05 INSTALLATION PROCEDURES

A. Notification: Inform the Project Manager of work schedules for SCPL.

B. Conduct operations in accordance with applicable OSHA standards, including safety requirements involving work on elevated platforms and entry into confined spaces. Take suitable precautions to eliminate hazards to personnel near construction activities when pressurized air is being used.

C. Mixing: Combine all of the packaged geopolymer liner dry mix with the specified amount of potable water while mixing until proper consistency is obtained, as described by the manufacturer. The mixer must be capable of regulating the amount of water added to the mix on a consistent basis. Water shall not be added by hand to the mixing chamber. Water temperatures shall be monitored when ambient temperatures are above 90 degrees F or below 40 degrees F. Tempering of the material above the manufacturers published limits is not allowed. Continue to agitate the geopolymer liner material to prevent thickening beyond the desired fluidity. The working time shall be as per manufacturer’s recommendation.

D. Application: Position the rotating casting applicator within the center of the sewer pipe and commence pumping the mixed geopolymer liner material. As the geopolymer liner begins to be centrifugally cast evenly around the interior, retrieve the applicator head at the predetermined speed for applying the thickness that has been selected. The geopolymer liner is installed in several stages at a predetermined thickness per application. If flows are interrupted for any reason, arrest the retrieval of the applicator head until flows are restored. Liner thickness shall be applied to the thickness specified by the engineer but no less than ½ in. (1.3 cm). The retrieval speed is varied to create different thicknesses as the condition may dictate to provide sufficient strengths. If the measured pipe ovality is greater than five percent, a licensed engineer must review and approve application design thickness requirements. Retrieval speed will be calculated prior to application and will be adjusted for conditions, pipe diameter, design thickness, and pumping rate to meet the engineer's specifications. The retrieval mechanism must be capable of producing a consistent retrieval rate and be repeatable within 5 percent of the speed specified. Where the geopolymer liner meets other pipes/liners, the joints shall be flush with no gaps, providing a uniform surface.

E. Curing:

1. Follow manufacturer's recommended cure schedule in curing of the geopolymer liner.

2. Refer to ACI 305R-99 Hot Weather Concreting. Do not apply geopolymer liner material when ambient and surface temperatures are 100°F or 35°C and above. Shade the material and prepare the surface to keep it cool. To extend working time, mix the material with cool water or ice-cooled water. The substrate shall be saturated surface dry (SSD) before application begins. Follow ACI 305R-99 guidelines for the proper use of curing agents.

3. The geopolymer liner shall not be placed when the ambient temperature is 37 degrees Fahrenheit and falling or when the temperature is anticipated to fall below 32 degrees Fahrenheit during the next 24 hours, unless specific precautions are employed. At temperatures near 45°F or 7°C, warm the material, water, and substrate. Properly ventilate the area when heating. Protect the new liner from freezing.

F. If additional thickness is desired at any section, place the spin cast applicator at that level and recommence pumping and retrieval until that area is thickened. The geopolymer product design and application process shall result in a monolithic liner.

G. Finished Pipe: The spin cast renewal system using the geopolymer liner material produces a finely textured surface that requires no additional troweling or finishing.

3.06 SEALING AT MANHOLES/SERVICES

A. Form tight seals between the geopolymer wall liner and the manhole walls at pipe penetrations and form tight seals at service connections. Place the geopolymer material around the pipe opening from inside the manhole in a band at least 4 inches wide. Complete sealing procedures for each liner segment as required.

B. Reshape and smooth the manhole invert and build up the existing invert until it is full pipe depth (equal in depth to the diameter of the largest/outgoing pipe) across the manhole bottom up to 15" pipe diameter.

C. Build inverts for all lateral sewers entering the manhole whose flow line elevation is between the crown and flowline elevations of the outgoing/downstream pipe. Maximum depth of lateral invert shall be up to full pipe depth (equal in depth to the diameter of lateral/upstream sewer when the top of the proposed sloped bench is the same elevation as the crown of the lateral sewer) at the upstream end and full pipe diameter of the outgoing/downstream sewer at the downstream end up to 15" maximum pipe diameter.

3.07 POST-INSTALLATION TELEVISION INSPECTION

A. Make and submit videos showing complete work, including condition of restored Connections. Refer to Section 02558 – Cleaning and Television Inspection.

B. All manhole bench/invert work shall be completed at time of Post-TV, with Post-TV being verification of completion.

3.08 FINAL CLEANUP

A. Upon completion of renewal work and testing, clean and restore project area affected by the Work in accordance with Section 01740 – Site Restoration.

3.09 NON-CONFORMING WORK

A. If the thickness, or the compressive strength or the compressive modulus of elasticity of the installed spin cast pipe lining is less than 90 percent of the specified values, the product is considered unacceptable. Submit a proposed method of repair or replacement for review and approval by the Project Manager. Work required to remedy non-conforming work shall be at no additional cost to the City.

B. If it is determined that the geopolymer liner material did not match the submitted manufacturers claims, the product is considered unacceptable and non-conforming. Submit proof that the geopolymer liner meets the requirements of the specification through the use of samples analyzed or retained at the manufacturing facility or submit a method for replacement of the sewer segment liner for review and approval by the City. Work required to remedy non-conforming work shall be at no additional cost to the City.

C. For all instances, where the geopolymer liner is deemed unacceptable, other than thickness, or compressive strength, as described in this specification section, submit a proposed method of repair or replacement for review and approval by the Project Manager. Work required to remedy non-conforming work shall be at no additional cost to the City.

END OF SECTION

SECTION 02553

POINT REPAIRS AND OBSTRUCTION REMOVALS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Repair of sanitary sewer lines by replacing short lengths of failed pipe with new pipe.

B. Repair of service lines located within the utility easement or street right-of-way, by replacing short lengths of failed pipe with new pipe.

C. Obstruction removal by remote device or excavation.

1.02 RELATED SECTIONS

A. Document 00410 – Bid Form

B. Section 01270 – Measurement and Payment

C. Section 01330 – Submittal Procedures

D. Section 01504 – Temporary Facilities and Controls

E. Section 01506 – Diversion Pumping

F. Section 01578 – Control of Ground and Surface Water

G. Section 01740 – Site Restoration

H. Section 02260 – Trench Safety System

I. Section 02317 – Excavation and Backfill for Utilities

J. Section 02321 – Cement Stabilized Sand

K. Section 02501 – Ductile Iron Pipe and Fittings

L. Section 02504 – Fiberglass Reinforced Pipe

M. Section 02506 – Polyvinyl Chloride Pipe

N. Section 02528 – Polyethylene Encasement/Wrap

O. Section 02533 – Acceptance Testing for Sanitary Sewers

P. Section 02534 – Sanitary Sewer Service Stubs or Reconnections

Q. Section 02558 – Cleaning and Television Inspection

R. Section 02611 – Reinforced Concrete Pipe

S. Section 03315 – Concrete for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. Point Repair:

a. Measurement for sewer line point repair is on a unit price basis for each point repair performed. The length of pipe to be replaced under each point repair pay item, as determined by depth of sewer line measured from natural ground to flowline at the location of the point of repair, is as follows:

(1) Six (6) feet minimum length for sewers up to ten (10) feet deep.

(2) Ten (10) feet minimum length for sewers over ten (10) feet deep.

b. Measurement for sewer line pipe replacement beyond point repair is on a linear foot basis in excess of minimum replacement lengths specified above.

c. Payment for service line point repair is on a linear foot basis for all sizes of service lines and for all depths (same unit price per linear foot, regardless of size and depth). No separate payment will be made for point repair done within the limits of a service line reconnection as defined in Section 02534 - Sanitary Sewer Service Stubs or Reconnections. Minimum length of service line point repair is 3 feet.

d. Measurement for hand excavation is on a cubic yard basis when authorized by the Project Manager in locations where excavation by machine is not suitable.

e. Measurement for abandonment of point repair by excavation is on a per each basis for excavation required to expose existing pipe. Separate measurement will be made for machine excavation and hand excavation.

f. Measurement for abandonment of point repair by video inspection is on a linear foot basis for TV Inspection and Cleaning.

g. The cost of the following items of work are included in the unit prices for point repairs unless included as a bid item in Document 00410 – Bid Form:

(1) Excavation, embedment and backfill.

(2) Hauling away and lawful disposal of excess excavated materials and debris.

(3) Pipe, pipe fittings, adapters and concrete collars.

(4) Smoke testing and any required testing.

(5) Restoration of site improvements, including sodding.

(6) Pre- and post-cleaning video inspection.

h. Pipe replacement required as part of a new or replacement manhole installation, due to existing deteriorated or inadequate pipe, shall be paid for under the Pipe Replacement Beyond Point Repair pay item appropriate for the size and depth of the sewer. Pipe replacement required due to damage by or for the convenience of the Contractor shall be paid by the Contractor.

i. Storm sewer replacement required to properly rehabilitate the sanitary sewer shall be paid under the Point Repair pay item appropriate to the storm sewer size and depth being replaced. Additional length shall be paid under the Pipe Replacement Beyond Point Repair pay item appropriate to the storm sewer size and depth being replaced.

j. Point Repairs performed due to sag in the sewer line shall be paid for under the Point Repair pay item appropriate for the size and depth of the line.

2. Obstruction Removal:

a. Obstruction removal by excavation will be paid on a unit price basis according to depth for each removal. Obstruction removal can be submitted for payment when the obstruction has been cleared from the sewer line to be lined. Liner work must proceed at least 6 feet before payment for removal of another obstruction will be considered (i.e., all obstruction within a distance of 6 feet is considered to be part of the same obstruction.)

b. Depth shall be measured from natural ground level to the flow line at the point of obstruction removal.

c. The cost of the following items of work are included in the unit prices for obstruction removal by remote device or excavation:

(1) Cleaning of sanitary sewers due to broken pipe, roots, dirt, loose deposits, etc.

(2) Television inspection.

(3) Excavation, embedment and backfill.

(4) Hauling away and lawful disposal of excess excavated material and debris.

(5) Restoration of site improvements, including sodding.

d. Payment will not be made for obstruction removal if the existing sewer line, service line or tap is damaged, and a point repair is required. Payment will not be made for removal of a protruding tap if the service reconnection is performed by excavation.

e. Removal of hard deposits, concrete, debris, pipes or any other material in a manhole, or that is accessible from the manhole wall, will be cleared under work items for rehabilitation of sanitary sewer pipes and manholes.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum): If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 REFERENCES

A. ASTM C-1173 – Standard Specification for Flexible Transition Couplings for Underground Piping System

1.05 PERFORMANCE REQUIREMENTS

A. Point Repair:

1. Locate and replace small lengths of one or more pipe sections where isolated line failure has occurred due to settlement, corrosion, crushing, or separation of joints.

2. The Project Manager may identify potential locations for point repair, but the Contractor is responsible for verifying locations. Point repairs to sewer lines are listed in Point Repair Rehabilitation Tables. Point repairs to service lines are listed in Lateral Line Rehabilitation Tables.

3. Determine the location of service line repairs by smoke testing the manhole section in which the failed pipe is located. The Project Manager will authorize the Contractor to make point repairs based on results of smoke testing.

4. Conduct all smoke testing in accordance with the City of Houston "Procedures to Conduct Physical Inspections of the Wastewater Collection System". Smoke testing shall not be performed within 24 hours of a rainfall event or if ponded or standing water is present on the ground or in the drainage channels in the area planned for smoke testing.

5. Smoke testing shall be accomplished utilizing two (2) minimum 1,750 CFM blowers designed specifically for smoke testing of sewers. Place blower on the upstream and downstream manhole of the line section to be tested. Place sandbags in the upstream and downstream manholes to isolate the section being tested and prevent the migration of smoke into sections not being tested. Utilize smoke bombs as necessary to ensure a continuous supply of smoke is provided for the entire duration of the test period.

6. Determine the location of point repairs by smoke testing or closed circuit television inspection of the failed pipe location. The Project Manager will authorize the Contractor to make point repairs.

7. The Project Manager will authorize each point repair after failure points are located. Do not make point repairs without prior authorization of the Project Manager. Perform point repairs only on those portions of service lines which are located in an easement or right-of-way; perform no repairs to service lines on private property.

8. Replace carrier pipe for point repairs unless otherwise directed by the Project Manager.

B. Obstruction Removal: Remove obstructions by one of the following methods:

1. Obstruction removal by remote device:

a. Protruding taps: Service lines that protrude more than one inch into the sewer.

b. Other obstructions: Hanging gaskets, fixed debris, stabilized sand, hardened mineral deposits, roots, rust scale, tuberculation, etc.

2. Obstruction removal by excavation: Obstructions encountered during liner insertion that are removed by digging and exposing the pipe.

1.06 DEFINITIONS

A. Point Repair: Repair of broken or collapsed gravity sanitary sewer lines on public property, including mains, collectors and service lines, by replacing, at the point of failure, the length of failed pipe with new pipe.

B. Obstruction Removal: Clearing sewer mains of obstructions to allow for rehabilitation.

C. Sewer Lines: Gravity flow pipe lines in the easement or right-of-way which collect sanitary sewer discharges from commercial or residential service lines and discharge into another sewer line (main or collector), or into a lift station or treatment plant.

D. Service Lines: Those gravity flow sewer lines from commercial or residential property that discharge into a sewer line.

1.07 SUBMITTALS

A. Submittals: Comply with Section 01330 - Submittal Procedures.

B. Submit product data for each pipe product, fitting and jointing material.

C. Submit Pre and Post inspection videos in accordance with Section 02558- Cleaning and Television Inspection.

1.08 SEQUENCING

A. Before rehabilitating a sewer line section between adjacent manholes, complete point repair and obstruction removal on that section.

B. Clean the line and perform a post-installation video inspection for each point repair on a sewer line not scheduled for additional rehabilitation.

C. Post-installation video inspection of the service line point repair is not required.

PART 2 PRODUCTS

2.01 PVC PIPE

A. PVC Sewer Pipe and Joints: 4-inch through 24-inch pipe complying with Section 02506 - Polyvinyl Chloride Pipe. If point repair is located at a service connection, use a full-bodied fitting for the service connection. No field fabrication of fittings allowed.

2.02 DUCTILE IRON PIPE

A. Ductile Iron Pipe: 4-inch thorough 48-inch, complying with Section 02501 – Ductile Iron Pipe and Fittings.

B. Fittings: Push-on end-joint fittings with bell-and-spigot ends, with bells modified for push- on joints, complying with Section 02501 - Ductile Iron Pipe and Fittings.

C. Interior Coating: Comply with Section 02501 - Ductile Iron Pipe and Fittings.

D. Exterior coating: 8-mil polyethylene tubular material conforming to requirements of Section 02528 – Polyethylene Encasement/Wrap.

2.03 REINFORCED CONCRETE PIPE

A. Reinforced Concrete Pipe and Joints: Comply with Section 02611 - Reinforced Concrete Pipe. Reinforced concrete pipe may be used for sewers 21 inches in diameter and larger.

2.04 FRP PIPE

A. FRP Pipe: Comply with Section 02504 - Fiberglass Reinforced Pipe.

2.05 JOINTING MATERIALS

A. Use flexible adapters secured with 1/2-inch stainless steel bands, Flexible adapter must comply with ASTM C-1173.

B. Form a concrete collar around each joint using concrete complying with Section 03315 - Concrete for Utility Construction.

PART 3 EXECUTION

3.01 PROTECTION

A. Provide barricades, warning lights and signs for excavations created by point repairs. Comply with Section 01504 - Temporary Facilities and Controls.

B. Do not allow soil, sand, debris or runoff to enter sewer system.

3.02 DIVERSION PUMPING

A. Install and operate diversion pumping equipment as required to maintain sewage flow and to prevent backup or overflow. Comply with Section 01506 - Diversion Pumping.

3.03 EXCAVATION

A. Excavate and backfill trenches in accordance with Section 02317 - Excavation and Backfill for Utilities.

B. Perform work in accordance with OSHA standards. Employ a trench safety system as required in Section 02260 - Trench Safety System.

C. Install and operate necessary dewatering and surface water control measures as required in Section 01578 – Control of Ground and Surface Water.

D. Remove and lawfully dispose of excess excavated material and debris from the work site daily.

3.04 TYPICAL SEQUENCE OF POINT REPAIR

A. Perform pre-installation video inspection to verify the location of sewer line point repairs. Perform service testing between manholes to verify location of service line point repairs.

B. After the location of a point repair, excavate the required length for the point repair.

C. Prior to replacing pipe, determine condition of the existing line on both sides of the point repair by lamping the line at least 10 feet in each direction. Determine whether additional lengths of line (beyond "minimum length" criteria) need replacement. Report need for additional replacement to the Project Manager and obtain authorization before proceeding.

D. Remove the damaged pipe and replace with new pipe, shaping the bottom of the trench and placing the required pipe bedding so that the grade of the replaced pipe matches the grade of the existing line. Establish proper grade for the pipe being replaced using methods acceptable to the Project Manager.

E. Connect the new pipe to existing pipe using flexible adapters. If joints cannot be made watertight using flexible adapters, place waterstop gaskets on each joint and encase in a reinforced concrete collar as indicated on Drawing 02531-04, Sanitary Sewer Pipe Transition for 36" Sewer and Smaller. Place concrete as specified in Section 03315 - Concrete for Utility Construction. Reconnect affected service connections or stacks using full-bodied fittings. No field fabrication of fittings allowed.

F. After completion of point repair, but prior to backfill, perform a smoke test to demonstrate the integrity of the repair, in the presence of the Project Manager. Test as specified in Section 02533 - Acceptance Testing for Sanitary Sewers. Repair and retest sections that fail until repair passes test.

G. Encase exposed pipe in cement stabilized sand complying with Section 02321 – Cement Stabilized Sand.

H. Backfill the excavation as specified in Section 02317 - Excavation and Backfill for Utilities.

I. Complete site restoration as specified in Section 01740 - Site Restoration.

J. Perform a post-installation video inspection as specified in Section 02558 - Cleaning and Television Inspection. Point repairs that show offset joints, non-uniform grade, incorrect alignment, excessive deflection or similar conditions are considered defective work. Replace pipe and bedding as required to correct defective work.

K. Extra length of Pipe Replacement beyond the Point Repair limits may be extended to the entire section either way, even to the next continuous section, as directed by the Project Manager.

3.05 ABANDONMENT OF POINT REPAIR

A. If a pipe is exposed by excavation and found to be in good condition, not requiring a point repair, the point repair shall be abandoned. Notify the Project Manager.

B. If pre-installation video inspection reveals that no point repair is required, the Contractor shall notify the Project Manager and the point repair shall be abandoned.

C. Backfill the excavation, replace pavement or sidewalk, and repair and seed or sod unpaved areas, as specified in Section 01740 - Site Restoration.

3.06 OBSTRUCTION REMOVAL

A. Remote Device: Remove obstructions identified during video inspection of a sanitary sewer line segment which could cause a non-uniform liner pipe installation or obstruction of the liner during installation. Obtain authorization from the Project Manager for obstruction removal with a remote device before proceeding.

1. Use a power-driven cutting device (robotic cutter) to remove protruding taps. Cut protruding taps so that protrusions are no greater than 3/4 inch. If a protruding tap cannot be removed by the cutting device, then a point repair may be performed. Obtain authorization from the Project Manager before proceeding.

2. To remove other obstructions, use a remote device. Pull or drive the device from manhole to manhole up to a continuous length of 500 feet using a solid steel mandrel, porcupine, root saw, bucket, robotic cutter or similar device to remove the obstruction. Select a device that is adequately sized to remove the obstruction.

B. Excavation: Use excavation as the method of obstruction removal when installation of the liner in the sanitary sewer is in progress. If during the liner insertion operation, a collapsed sewer, off-set joint or other obstruction is encountered which prevents or blocks the passage or insertion of the liner, notify the Project Manager for authorization to excavate. Uncover and remove the obstruction as follows:

1. Excavate at the point where there is an obstruction. Use a trench safety system as required.

2. Break out the existing sanitary sewer pipe (carrier pipe) as directed by the Project Manager. Remove only that amount of material which is causing the obstruction. Remove the minimum amount of carrier pipe.

3. Under such conditions, replacement of the carrier pipe is not required. Do not disturb the existing sewer bedding during excavation. However, if embedment is disturbed during the obstruction removal procedure, place cement-stabilized sand or crushed stone beneath the liner.

4. When the liner is completely in place, encase it with crushed stone or cement stabilized sand as shown on Drawing No. 02317-01, Sanitary Sewer Embedment and Trench Zone Backfill for Dry or Wet Stable Trench.

END OF SECTION

SECTION 02555

MANHOLE REHABILITATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Repair, rehabilitation or replacement of deteriorated, leaking or structurally unsound manholes and cleanouts.

1.02 RELATED SECTIONS0

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01504 – Temporary Facilities and Controls

D. Section 01506 – Diversion Pumping

E. Section 01578 – Control of Ground and Surface Water

F. Section 01740 – Site Restoration

G. Section 02082 – Precast Concrete Manholes

H. Section 02083 – Fiberglass Manholes

I. Section 02090 – Frames, Grates, Rings, and Covers

J. Section 02260 – Trench Safety System

K. Section 02317 – Excavation and Backfill for Utilities

L. Section 02533 – Acceptance Testing for Sanitary Sewers

M. Section 02911 – Topsoil

N. Section 02921 – Hydro Mulch Seeding

O. Section 02922 – Sodding

P. Section 02951 – Pavement Repair and Restoration

Q. Section 03315 – Concrete for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. Rehabilitated Manholes:

a. Measurement for manhole wall lining (including bench work) is on a vertical foot basis to the nearest tenth of a foot, measured from the bottom of the frame to the top of the bench. If the bench is not required, measurement will be from the bottom of the frame to the top of the effluent pipe. (Refer to Drawing No. 02534-03A).

b. Measurement for the adjustment using a new watertight manhole frame and cover, including raising or lowering the height of the cover within one vertical foot, is on a unit price basis, per manhole.

c. Measurement for the adjustment of an existing manhole frame and cover, including raising or lowering the height of the cover within one vertical foot, is on a unit price basis, per manhole.

d. Measurement for new or existing manhole frame and cover adjustment of over one foot is on a vertical foot basis, measured to the nearest tenth of a foot.

e. Backfill, including cement-stabilized sand, is included in the unit prices for rehabilitated manholes; no separate payment will be made.

f. Measurement for pavement restoration will be in accordance with Section 02951 - Pavement Repair and Restoration.

g. Measurement for new manhole insert dishes will be on a unit price basis, per manhole.

h. Chemical grout injection to stop water intrusion is included in the unit prices for the rehabilitated manholes; no separate payment will be made.

i. Manhole Benches constructed without wall lining, when directed by the Project Manager, will be paid for separately on a unit price basis.

j. Payment for rehabilitation of manholes or junction boxes other than 4' diameter circular manholes will be on an equivalent 4’ diameter manhole vertical foot basis. The square feet rehabilitated shall be converted to an equivalent vertical feet of a 4’ diameter manhole by dividing the square feet by 12.57.

k. Refer to Section 01270 - Measurement and Payment, for unit price procedures.

2. New/Replacement Manholes:

a. Measurement for abandoned manholes is on a unit price basis per manhole abandoned.

b. Measurement for new manholes is on a unit price basis, per manhole. Price includes excavation, removal of existing manhole/cleanout/end of line, new frame and cover, sealant and backfill materials. Price also includes up to 6 feet of sewer pipe, in each and every direction, measured from the outside wall of the manhole.

c. Backfill, including cement-stabilized sand, is included in the unit price for new/replacement manholes; no separate payment will be made.

d. Measurement for pavement restoration will be in accordance with Section 02951 - Pavement Repair and Restoration.

e. Refer to Section 01270 - Measurement and Payment.

B. Stipulated Price (Lump Sum): If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 REFERENCES

A. ASTM C 109 – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).

B. ASTM C 293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading).

C. ASTM C 490 - Standard Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete.

D. ASTM C 496 – Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.

E. ASTM C 882 – Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.

F. ASTM C 1140 - Standard Practice for Preparing and Testing Specimens from Shortcrete Test Panels.

1.05 PERFORMANCE REQUIREMENTS

A. Perform work needed to make manholes structurally sound, improve flow, prevent entrance of inflow or groundwater, prevent entrance of soil or debris, and provide protection against hydrogen sulfide gas attack.

B. Manufacturer's Product Support: When requested by the Project Manager, provide a representative employed by the manufacturer having technical training in admixture and manhole wall liner available for consultation on site with 48 hours notice.

1.06 QUALITY ASSURANCE

A. Obtain all chemical grouting materials from a single manufacturer.

B. Installation shall be completed by firms and individuals trained in methods of installation by the manufacturer with at least five years of experience.

C. Personnel shall have confined space entry certification, where needed.

D. Field verification shall be completed by the contractor prior to commencement of work.

E. Contractor shall verify the finished thickness of each rehabilitation method prior to starting the next layer and upon completion of the work. The Project Manager may obtain core samples at the Project Manager's discretion.

1.07 SUBMITTALS

A. Submittals: Comply with Section 01330 - Submittal Procedures.

B. Product Data: Submit product data, including surface preparation instructions and application instructions, from pre-approved manufacturer of wall repair materials, hydraulic cements, quick-set mortars, specialized sealants, grouts, manhole inserts, manhole frame covers and frame-to-manhole seals.

C. Installer Qualifications: Installers of liners and wall repair systems shall submit qualifications to the Project Manager. List installer's personnel who have satisfactorily completed manufacturer's training in product application within the previous 2 years. Include date of certification for each person.

1.08 PROJECT CONDITIONS

A. Manholes Containing Mechanical or Electrical Equipment:

1. Drawings may not show locations of flow monitoring equipment. If a manhole contains any mechanical hardware or electrical flow monitoring equipment, immediately notify the Project Manager. Reschedule work based on instructions provided by the Project Manager.

2. Do not subject manholes with mechanical hardware or electrical equipment to diversion or bypass pumping.

3. Damage to installed equipment, due to Contractor's failure to adhere to this instruction, will be repaired by the City and cost of repairs charged to the Contractor.

B. Field Location of Manholes, Cleanouts and End of Lines:

1. Contractor is responsible for locating and uncovering all manholes, cleanouts and ends of lines. If Contractor is unable to locate manholes, cleanouts or ends of lines, Contractor shall notify the Project Manager in writing.

2. Manholes may be located within project limits which are not part of the system being rehabilitated. Properly identify manholes before starting work.

1.09 SALVAGE

A. Manhole covers and frames from abandoned manholes remain the property of the City. Unless indicated to be re-used in the work, deliver salvaged items to location(s) designated by the Project Manager.

1.10 MATERIAL HANDLING, DELIVERY AND STORAGE

A. Materials shall be delivered in the original unopened containers. Each container shall be clearly labeled with the following:

1. Product name

2. Manufacturers name

3. Component designation

4. Product mix ratio

5. Health and safety information

B. Provide equipment and personnel to handle the materials which prevent damage. The Contractor shall promptly inspect delivered materials for damage.

C. Store materials in accordance with manufacturer’s recommendations.

PART 2 PRODUCTS

2.01 SURFACE PREPARATION

A. High Pressure Water: 3500 psi minimum force.

B. Cleaners: Detergent or muriatic acid capable of removing dirt, grease, oil and other matter which would interfere with bond of sealing material to wall; refer to sealing material manufacturer's recommendations.

2.02 WALL REPAIR MATERIALS

A. Hydraulic Cements: Use a blend of cement powders or hydraulic cement to stop active leaks in the manhole structure that meet the following:

1. Compressive strength of 5500 psi in 28-days

2. Tensile strength of 650 psi in 28-days

3. Bond strength of 880 psi in 28 days

B. Quick-set Mortar: Use a quick-set mortar to repair wide cracks, holes or disintegrated mortar.

2.03 MANHOLE WALL LINERS, BENCH FORMING AND REPAIR MATERIAL

A. Sprayable Restoration Mortar: Use blend of portland cement or polymer modified cement, micro-silica, densifiers, admixtures and other modifiers that produces a high strength and low permeability mortar for rehabilitation of deteriorated concrete and brick surfaces and meet the following requirements.

1. Compressive Strength (ASTM C109) of 9,000 psi (minimum) in 28 days

2. Flexural Strength (ASTM C293) of 1,000 psi (minimum) in 28 days

3. Tensile strength (ASTM C496) of 600 psi (minimum) in 28 days

4. Bond Strength (ASTM C882) of 2,000 psi (minimum) in 28 days

5. Shrinkage/ length change (ASTM C596) of less than 0.04% in 28 days

6. 'Very Low' Chloride Ion Penetrability at 28 days (ASTM C1202)

B. Refer to City of Houston Wastewater Approved Products List.

2.04 MANHOLES COVERS, FRAME INSERTS AND FRAME-TO-MANHOLE SEALS

A. New Covers/Frames: Comply with Section 02090 - Frames, Grates, Rings, and Covers, and with Drawing 02090-1.

B. Watertight Covers and Frames shall each have at least three bolts and a gasket to seal cover to frame, as manufactured by Neenah Foundry Company, Vulcan, or approved equal. Fabricate watertight frames and covers to comply with details shown on the Drawings and Section 02090 - Frames, Grates, Rings, and Covers.

C. Provide manhole inserts including new dishes, gaskets and relief valves. Select appropriate watertight inserts to fit walls and frames of manholes.

1. Stainless steel (18 gauge minimum) inserts; Southwestern Packing and Seals "Rain Stopper," or approved equal.

2. Stamp inserts with the words, "Property of City of Houston".

3. Inserts shall have a handle of plastic-coated stainless steel installed on the body of the insert dish. The handle shall be attached with a #6 high-grade stainless steel rivet. Each dish shall have a factory-installed 5-foot-long, 3/16" braided stainless steel retaining cable to connect the dish to the manhole frame.

D. Frame-to-Manhole Seals: As manufactured by Cretex, or approved equal.

E. Sealing materials between adjustments rings and manhole frame shall be a hydrophilic elastic sealant, which adheres to both concrete and metal, or approved substitute.

PART 3 EXECUTION

3.01 PROTECTION

A. Provide barricades, warning lights and signs for manhole or cleanout removal excavations. Comply with Section 01504 - Temporary Facilities and Controls.

B. Do not allow soil, sand, debris or runoff to enter sewer system.

3.02 EXCAVATION

A. Excavate in accordance with Section 02317 - Excavation and Backfill for Utilities.

B. Perform work in accordance with OSHA standards. Employ a trench safety system as required in Section 02260 - Trench Safety System.

C. Install and operate necessary dewatering and surface water control measures as required in Section 01578 - Control of Ground and Surface Water.

3.03 DIVERSION PUMPING

A. Install and operate diversion pumping equipment to maintain sewage flow and to prevent backup or overflow as specified in Section 01506 - Diversion Pumping.

B. In the event of accidental spill or overflow, immediately stop the overflow and take action to clean up and disinfect spillage. Promptly notify the Project Manager so that required reporting can be made to the Texas Commission on Environmental Quality and U.S. Environmental Protection Agency.

3.04 CLEANOUT/END OF LINE REMOVAL AND REPLACEMENT

A. Replace removed cleanouts/ends of lines with shallow manholes complying with Drawing No. 02082-01, if the depth is less than or equal to 5 feet. For cleanouts/ends of lines greater than 5 feet, replace with 4-foot-diameter manholes complying with Drawing No. 02082-02.

3.05 ABANDONMENT OF CLEANOUTS AND MANHOLES

A. Abandon manholes that are designated on Drawings or directed by the Project Manager to be abandoned.

B. Dismantle manholes to be abandoned, including frames, to 2 feet below ground level.

C. If a manhole is to be abandoned on a rehabilitated line, install a carrier pipe through the manhole structure and fill the manhole with cement-stabilized sand, compacted to a level 2 feet above the top of carrier pipe.

D. If a manhole is to be abandoned on an abandoned line, plug all lines in the manhole and backfill in accordance with Section 02317 - Excavation and Backfill for Utilities.

E. If a manhole to be abandoned is in a paved street, backfill manhole as described above, but with cement-stabilized sand to underside of pavement repair in lieu of select backfill material. Patch paving in accordance with Section 02951 - Pavement Repair and Restoration.

F. If an abandoned manhole is not located in a paved street, fill remainder of manhole with select backfill material to 2 feet below ground level. Restore surface in accordance with Section 01740 - Site Restoration Provide at least 4 inches of topsoil complying with Section 02911 - Topsoil, and either seed according to Section 02921 - Hydro Mulch Seeding, or Sod according to Section 02922 - Sodding, as required.

3.06 MANHOLE WALL CLEANING

A. Clean bench/invert floor and interior walls of manholes by removing deleterious material, including dirt, grease and other debris. Use high pressure water at a minimum force of 3500 psi. If required, use detergent or muriatic acid to remove grease, oil and other matter which would interfere with bond between existing manhole wall and approved repair materials.

B. Prepare interior surfaces as recommended by the wall liner material manufacturer. Remove brick steps and cast iron steps prior to wall lining.

3.07 MANHOLE WALL SEALING

A. Seal active leaks in manhole structures with a blend of cement powder or hydraulic cement.

B. Remove loose or defective wall material. Wipe or brush surfaces clean prior to application of hydraulic cements.

C. Stopping Leaks: Drill weep holes at bottom of manhole walls to relieve hydrostatic pressure. Plug pressure-relief holes after leaks are stopped using hydraulic cement materials.

D. Repair wide cracks, holes and disintegrated mortar with quick-set mortars following manufacturer's instructions and recommendations.

E. Reshape manhole inverts before wall-sealing work. Apply concrete to cleaned manhole benches as specified in Section 03315 - Concrete for Utility Construction.

F. After active leaks have been stopped, clean and prepare walls for application of selected liner material.

G. Properly apply sealing compound to provide the minimum required uniform coating to the wall surface.

H. Prevent foreign material from entering adjoining pipes. Remove droppings of foreign and wall sealant materials before they harden on the bottom of the manhole.

I. Strictly follow product manufacturers' published instructions and recommendations for surface preparation, application and proportioning.

3.08 MANHOLE REMOVAL AND REPLACEMENT

A. When indicated on the Drawings or instructed by the Project Manager, excavate and properly remove and dispose of the existing manhole, including base. Employ a trench safety system and keep the excavation dry from sewage flow and surface or ground water.

B. Replace manhole with a new manhole as specified in Section 02082 - Precast Concrete Manholes or Section 02083 - Fiberglass Manholes. New manholes shall comply with Drawings 02082-1, 02082-2, 02082N-2, 02082-3, 02083-3, New & Replacement Pre-Cast Concrete Manhole on MRC Sanitary Sewer, or New & Replacement Fiberglass Manhole on MRC Sanitary Sewer.

C. Construct or reconstruct drop connections whenever the flowline elevation of an influent line is more than 24 inches above the bench elevation.

D. Sewer pipe up to 6 feet outside new manholes may be replaced with new sewer pipe in conjunction with manhole removal and replacement.

E. Properly backfill replacement manholes as required in Section 02082 - Precast Concrete Manholes or Section 02083 - Fiberglass Manholes.

F. Furnish replacement manholes with new 32-inch frames and covers as indicated on Drawing 02090-1 and specified in Section 02090 - Frames, Grates, Rings and Covers.

3.09 MANHOLE BENCHES/INVERTS

A. Remove obstructions and loose materials from benches prior to shaping inverts. Form smooth, U-shaped inverts having minimum depths of one-half the pipe diameter and channel it across the floor of the manhole using an approved manhole rehabilitation material. Control flow to allow sufficient setting time for material used.

B. If no bench and invert exists in the manhole or if the manhole is new with a poured-in- place base then construct invert channels to provide a smooth flow transition waterway with no disruption of flow at pipe-manhole connections. Conform to the following criteria:

1. Slope of invert bench: 1 inch per foot minimum; 1-1/2 inches per foot maximum.

2. Construct full pipe depth inverts (equal in depth to the diameter of the largest or outgoing/ downstream pipe).

3. Construct inverts for laterals (upstream) sewer(s) that enters the manhole such that the flowline elevation of the lateral sewer is between the crown of the outgoing/downstream pipe and manhole invert.

4. Trim all sewer pipes that enter or exit the manhole such that they have a smooth edge and are flush with the manhole wall.

5. Begin the invert channel from where the lateral pipe enters the manhole to where the lateral invert channel intersects the invert of the through outgoing/downstream pipe.

6. The maximum depth of the lateral invert shall be up to full pipe (equal in depth to the diameter of the lateral pipe when the top of the proposed sloped bench is the same elevation as the crown of the lateral sewer) at the upstream end and full pipe diameter of the outgoing pipe at the downstream end.

7. If no inverts exist in the manhole then inverts shall be constructed such that the inverts for all laterals shall have a smooth, uniform curvature, with a maximum radius of curvature that sweeps into the direction of flow (towards the downstream/outgoing pipe.)

C. If inverts already exist in the manhole then:

1. Trim all sewer pipes that enter or exit the manhole so that they are smooth edges and flush with the manhole wall.

2. Build up the existing invert until it is full pipe depth (equal in depth to the diameter of the largest/outgoing pipe) across the manhole bottom.

3. Build inverts for all lateral sewers entering the manhole whose flowline elevation is between the crown and flowline elevations of the outgoing/downstream pipe. Maximum depth of lateral invert shall be up to full pipe (equal in depth to the diameter of lateral/upstream sewer when the top of the proposed sloped bench is the same elevation as the crown of the lateral sewer) at the upstream end and full pipe diameter of the outgoing/downstream sewer at the downstream end.

4. Invert shall match the sweep (or curvature, if any) of the existing lateral sewer invert.

5. If no inverts exist in the manhole then inverts shall be constructed such that the inverts for all laterals shall have smooth, uniform curvature, with a maximum radius of curvature that sweeps into the direction of flow (towards the downstream/outgoing pipe).

D. All benches and invert channels shall be smooth and free of sharp edges, protrusions and concrete droppings.

3.10 MANHOLE COVERS AND FRAMES

A. Adjust manhole frames and covers found above or below grade and reset loose frames. Combine precast concrete adjustment rings so that the elevation of the installed frame and cover extends 6 inches above the natural ground in unpaved areas. In paved areas, set flush and smooth with pavement grades. An approved sealant shall be applied between the top adjustment ring and the manhole frame. No less than two beads shall be applied 1/2-inch wide and 3/4-inch high. An approved manhole cementitious lining material shall be applied between the rings and no less than 1-inch of lining material shall be applied to the inside and outside face of the adjustment rings.

B. Install new watertight manhole covers and frames at locations shown on the Drawings or where instructed by the Project Manager. Use new frames and covers.

3.11 MANHOLE INSERTS

A. Install stainless steel manhole inserts at locations shown on the Drawings or where directed by the Project Manager.

B. Exercise care in selecting the proper insert dish to fit properly with the manhole frame and cover. The insert flange should have an outside diameter 3/16 inch less than the inside diameter of the manhole frame. Once proper fit is established, clean manhole frame surface of all dirt, grit and debris with a wire brush. Fully seal insert on the manhole frame, providing a watertight seal.

C. Securely attach retaining tether to the manhole frame following manufacturer's instructions with a tamper-proof anchoring device.

D. Replace damaged, tight-fitting or missing inserts identified prior to final inspection at no cost to the City.

E. For new sanitary sewer manholes subject to loading or differential movement at manhole frames, and for rehabilitated manholes, install manhole chimney seals to prevent inflow between manhole frames and masonry chimneys. Refer to Section 02090 - Frames, Grates, Rings and Covers.

3.12 FRAME-TO-MANHOLE SEALS

A. Surfaces on which the sleeve or extension is to be compressed shall be circular, clean, reasonably smooth and free of loose material and excessive voids. If a surface is rough or irregular and would not provide an effective seal, smooth it with an approved microsilica- enhanced grout. Repair flaws in manhole frames, such as cracks, pits or protrusions, by filling with concrete or grinding smooth. This type of surface work will need to be done on manholes that have not been lined; manholes that have been lined should not need any surface work in order to install the seal.

B. Install seals following manufacturer's installation instructions. Arrange for manufacturer's representative to train Installer's personnel in proper methods of installing seals and assist the Installer and Contractor with any problems they might encounter installing the seals.

C. If internal surfaces of the chimney or corbel section of the manhole exceed a slope of 1 in 3, do not use a frame-to-manhole seal.

D. Install frame-to-manhole seals so as to prevent water migration between manhole frames and manhole structures.

3.13 FIELD QUALITY CONTROL

A. Inform the Project Manager immediately if materials being used are not producing required results or need modification. The Project Manager has the right to stop the use of any material at any time.

3.14 INSPECTION

A. After manhole wall sealing or manhole rehabilitation is complete, visually inspect manholes in the presence of the Project Manager. Check for cleanliness and for elimination of active leaks.

B. At completion of manhole rehabilitation, assist the Project Manager in verifying installation of minimum coating thickness of concrete liner. Test several points on manhole walls. Repair verification points prior to final acceptance for payment.

3.15 TESTING

A. Perform leakage testing for manholes, refer to Section 02533 - Acceptance Testing for Sanitary Sewers.

B. Perform Testing on cementious products according to ASTM C 1140.

3.16 BACKFILL

A. Backfill and compact soil in area of excavation surrounding manholes in accordance with Section 02317 - Excavation and Backfill for Utilities.

B. In unpaved areas, grade surface at a uniform slope of 1 to 5 from the manhole frame to natural grade. Provide at least 4 inches of topsoil complying with Section 02911 - Topsoil, and either seed according to Section 02921 – Hydro Mulch Seeding, or sod according to Section 02922 - Sodding, as required.

END OF SECTION

SECTION 02556

CURED-IN-PLACE PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Approved methods and materials for the rehabilitation of deteriorated gravity sewer lines by the Cured-In-Place Pipe (CIPP) method.

1.02 REALTED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01506 – Diversion Pumping

D. Section 01740 – Site Restoration

E. Section 02534 – Sanitary Sewer Service Stubs or Reconnections

F. Section 02553 – Point Repairs and Obstruction Removals

G. Section 02558 – Cleaning and Television Inspection

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. Measurement and payment for cured-in-place pipe is by the linear foot, measured along centerline of pipe from centerline to centerline of manholes or junction boxes, and shall be considered full compensation for all labor and materials required to install the liner to specified requirements. Depth range for payment is based on greatest depth measured at manholes from natural ground level to flow line of sanitary sewer for each pipeline segment.

2. No separate payment will be made for the following items of work. Include cost in the unit price for installing cured-in-place pipe:

a. Sealing the liner in manholes.

b. Reworking inverts and benches for manholes.

c. Temporary meter and municipal water obtained from a City fire hydrant.

3. No separate payment for pre-installation and post-installation cleaning and television inspection as specified in Section 02558 - Cleaning and Television Inspection.

4. Where post-installation thickness measurements or physical property testing is performed, payment for installed cured-in-place pipe shall be made as follows:

   a. Full payment: If thickness, flexural strength and flexural modulus of elasticity of installed CIPP are all 95 percent or better of specified values, full payment shall be made.

   b. Adjusted payment: If thickness, flexural strength or flexural modulus of elasticity is between 90 percent and 95 percent of specified values, payment shall be made based on an Adjusted Unit Price, which shall equal the Unit Price bid, multiplied by a Value Factor calculated as follows:

$$\frac{\text{actual thickness}}{\text{specified thickness}} \times \frac{\text{actual flexural strength}}{\text{specified flexural strength}} \times \frac{\text{actual flexural modulus of elasticity}}{\text{specified flexural modulus of elasticity}}$$

   "Value Factor" shall not exceed 100 percent.

5. Payment for point repairs and obstruction removals will be made according to Section 02553 - Point Repairs and Obstruction Removals.

6. Payment for repair of sags in the line will be made either according to Section 02553 - Point Repairs and Obstruction Removals, or according to the diameter and depth of the pipe if “Remove and Replace” is the method of repair designated by the Engineer.

7. Payment for Item, 'Mobilization for short segment (<350')’ will be paid when the contractor is issued a work order containing a line segment that is less than 350' in length and is not adjacent to another line segment, or when the total of all adjacent line segments is less than 350’.

8. Refer to Section 01270 - Measurement and Payment.

B. Stipulated Price (Lump Sum): If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 REFERENCES

A. AASHTO Standard Specification for Highway Bridges.

B. ASTM C 581 - Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass Fiber Reinforced Structures, Intended for Liquid Service.

C. ASTM D 543 - Test Method for Resistance of Plastics to Chemical Reagents.

D. ASTM D 790 - Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

E. ASTM D 3567 - Standard Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings.

F. ASTM D 3574-11 - Standard Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams

G. ASTM D 3681 - Standard Test Method for Chemical Resistance of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe in a Deflected Condition.

H. ASTM D 5035 - Test Method for Breaking and Elongation of Textile Fabrics (Strip Method).

I. ASTM D 5199 - Standard Test Method for Measuring Nominal Thickness of Geosynthetics.

J. ASTM D 5813- Standard Specification for Cured-In-Place Thermosetting Resin Sewer Piping Systems.

K. ASTM E 1252 - Standard Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis.

L. ASTM F 1216 - Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube.

M. ASTM F 1743 - Standard Practice for the Rehabilitation of Existing Pipelines and Conduits by the Pulled-In-Place Installation of Cured-In-Place Thermosetting Resin Pipe (CIPP).

N. ASTM F 2019 - Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP).

1.05 SYSTEM DESCRIPTION

A. Resin-impregnated flexible tubes inserted into existing sewers, expanded against the existing sewer interior surfaces, and cured by circulating heated water, steam, ambient temperature water or air, or ultraviolet light, throughout the tube from manhole to manhole.

B. CIPP cures into a hard, impermeable, corrosion-resistant liner of specified thickness and physical properties, with a uniformly smooth interior surface.

C. CIPP Material and Installation: Comply with ASTM D 5813, ASTM F 1216, ASTM F 1743 and ASTM F 2019, as modified by this specification. The City reserves the right to approve materials or installation practices which differ from these standards.

1.06 SUBMITTALS

A. Make submittals in accordance with Section 01330 - Submittal Procedures.

B. Resin:

1. Submit product data stating physical and chemical properties.

2. Submit results of testing performed by resin manufacturer demonstrating compliance with specified chemical resistance requirements.

3. Submit manufacturer-certified infrared spectrum analysis (chemical fingerprint) of proposed resin system in accordance with ASTM E 1252.

C. Flexible Tube:

1. Submit product data stating physical properties meeting ASTM D 5035.

2. Submit tabular summary by sewer segment noting required CIPP thickness specified. Provide certification that liner's "dry" thickness meets or exceeds the required cured laminate thickness (es). Measure thickness in accordance with ASTM D 5199.

D. Cured-In-Place Pipe:

1. Submit field measurements of cured liner thickness for determining payment.

2. Submit representative sample(s) of the cured liner required for testing in accordance with ASTM D 790.

3. Submit post-installation television inspection videos as specified in Section 02558 - Cleaning and Television Inspection.

E. Chemical Grout: Submit product data, including surface preparation instructions and application instructions from the manufacturer.

1.07 QUALITY ASSURANCE

A. During the course of the Work, make no substitutions of materials, design values or procedures for those specified without the prior written approval of the Engineer.

PART 2 PRODUCTS

2.01 APPROVED MANUFACTURERS

A. Refer to City of Houston Approved Products List for acceptable product manufacturers.

B. Do not use products of manufacturers not noted on this list.

C. Use current list in effect as of the specified bid date and time for this project.

2.02 MATERIALS

A. Flexible Felt Tube:

1. Provide flexible tube manufactured and fabricated under manufacturer's quality- controlled conditions. Use tube sized so as to snugly fit the internal circumference of the existing sewer and produce specified cured thickness and physical properties.

2. Tube Length: Fully and continuously span the distance between manholes, including sufficient material for sealing at manholes and product sampling (when required).

3. Fabric tube minimum tensile strength in both longitudinal and transverse directions, when tested in accordance with ASTM D 5035: 750 psi.

4. Identify all tubes with manufactured thickness when tested in accordance with ASTM D 5199.

B. Fiberglass Tube (Ultraviolet Light Curing Application):

1. The fiberglass material shall be chemically resistant EC-R Glass.

2. The tube shall be homogeneous throughout, uniform in color, free of cracks, holes, foreign materials, blisters and other surface defects.

3. The glass fiber tubing shall include an exterior and interior film that protects and contains the resin in the liner. The exterior film shall be UV resistant.

4. The tube shall be properly sized to be fitted against and in contact with the wall of the host pipe throughout its length or remnants thereof.

5. The tube shall be constructed to withstand stretching during the pull-in process and installation pressures as required by Manufacturer's recommendations.

6. The impregnated tube shall have a uniform thickness, that when compressed at installation pressures will meet or exceed the required thickness.

7. Use tube sized so as to snugly fit the internal circumference of the existing sewer and produce specified cured thickness and physical properties.

8. The tube shall be sized to fit irregular pipe sections and negotiate bends of up to 20 degrees and shall have sufficient strength to bridge missing pipe sections with the use of canvas sleeve if necessary.

9. The wall color of the interior pipe surface of CIPP after installation shall be a light reflective color.

10. The liner shall be seamless in its cured state to insure homogenous physical properties around the circumference of the cured liner.

C. Resin for Tube Saturation: Liquid thermosetting polyester, vinyl ester, or epoxy resin meeting specified requirements.

D. Chemical Grout:

1. Chemical grout shall react freely with water to form a strong polyurethane foam.

2. Chemical grout shall be resistant to hydrogen sulfide gas.

3. Chemical grout shall meet the following criteria:

Tensile Strength: 20 psi
Elongation: 190%
Tear Strength: 4.9 lbs/in Density/Specific Gravity: 0.18

2.03 TESTING REQUIREMENTS

A. Manufacturer's Chemical Resistance Testing: Perform chemical resistance testing of resin in accordance with ASTM C 581, as modified herein. Perform testing to demonstrate chemical resistance to a solution with a pH of 0.5 and a solution with a pH of 10. Use reagents or solutions as required to establish and maintain the minimum and maximum pH values specified for the duration of the testing. Exposure to the minimum and maximum pH values shall produce an average loss of not more than 20 percent in the initial flexural properties for each test interval, and an average loss of not more than 15 percent for a period of one year, as determined according to ASTM D 790. Perform testing at a temperature of 73.4 F (plus or minus 3.6 F). Test specimens shall not have more than 1.5 percent gain or loss in weight over a period of one year. Test frequency and sample preparation: Follow ASTM C 581.

B. Test Results - Submit test results including at least the following:

1. Raw data for each test specimen for each test interval performed

2. Calculated average test results for each test interval

3. Using calculated averages for each test interval, calculate the average test result for the duration of testing.

2.04 PHYSICAL PROPERTIES FOR TRADITIONAL CIPP (FELT TUBE)

A. Minimum CIPP Thickness after Curing: As specified below, based on the liner material and the maximum sewer invert depth for the segment being rehabilitated.

MINIMUM CIPP THICKNESS (IN MILLIMETERS) FELT				
NOMINAL SEWER DIAMETER (INCHES)	MAXIMUM PIPE SEGMENT INVERT DEPTH			
	Up to 10 feet	10 - 15 feet	15 - 20 feet	20-25 feet
6	4.5	4.5	4.5	6.0
8	6.0	6.0	6.0	7.5
10	6.0	6.0	7.5	9.0
12	6.0	7.5	9.0	10.5
15	7.5	9.0	10.5	12.0
18	9.0	12.0	13.5	15.0
20-21	10.5	13.5	15.0	16.5
24	12.0	15.0	16.5	19.5
30	15.0	18.0	21.0	24.0
36	16.5	21.0	24.0	28.5
42	19.5	25.5	31.5	36.0
48	22.5	28.5	34.5	40.5
54	25.5	31.5	39.0	45.0
60	27.0	34.5	42.0	48.0
66	30.0	36.0	45.0	52.5
69-72	33.0	39.0	48.0	58.5

B. CIPP minimum flexural properties after curing using steam, hot water or ambient temperature water or air:

PROPERTY	REFERENCE	MINIMUM
Flexural Strength (Modulus of Rupture)	ASTM D 790	4,500 psi
Tangent Modulus of Elasticity	ASTM D 790	250,000 psi

C. If different conditions are encountered in the field, design considerations may change, if required by the Project Manager. Required thickness maybe increased or decreased based on specific design. The thickness may be changed in increments of 1.5 mm and payment shall be made or deducted at the rate of 2.50% of the bid item amount for each increment. However, the Contractor shall not be allowed to change any required thickness unilaterally or offer credits after the fact as remedy for liners not meeting the required thickness. Prior approval shall always be required for any changes in CIPP thickness. Refer also to "Non- Confirming Work" in Section 3.09.

2.05 PHYSICAL PROPERTIES FOR UV CIPP (FIBERGLASS TUBE)

A. Minimum CIPP Thickness after Curing: As specified below, based on the liner material and the maximum sewer invert depth for the segment being rehabilitated.

MINIMUM CIPP THICKNESS (IN MILLIMETERS) FIBERGLASS				
NOMINAL SEWER DIAMETER (INCHES)	MAXIMUM PIPE SEGMENT INVERT DEPTH			
	Up to 10 feet	10 - 15 feet	15 - 20 feet	20-25 feet
6	2.0	2.0	2.0	2.0
8	2.5	2.5	2.5	3.0
10	3.0	3.0	3.5	3.5
12	3.5	3.5	4.0	4.0
15	4.5	4.5	5.0	5.5
18	5.0	5.5	6.0	6.5
20-21	6.0	6.5	7.0	7.5
24	7.0	7.0	8.0	8.5
30	8.5	9.0	10.0	10.5
36	10.5	11.0	12.0	12.5
42	12.5	13.0	14.0	14.5

B. CIPP minimum flexural properties after curing using ultraviolet light:

PROPERTY	REFERENCE	MINIMUM
Flexural Strength (Modulus of Rupture)	ASTM D 790	6,500 psi
Tangent Modulus of Elasticity	ASTM D 790	725,000 psi

C. If different conditions are encountered in the field, design considerations may change, if required by the Project Manager. Required thickness maybe increased or decreased based on specific design. The thickness may be changed in increments of 1.5 mm and payment shall be made or deducted at the rate of 2.50% of the bid item amount for each increment. However, the Contractor shall not be allowed to change any required thickness unilaterally or offer credits after the fact as remedy for liners not meeting the required thickness. Prior approval shall always be required for any changes in CIPP thickness. Refer also to "Non- Confirming Work" in Section 3.09.

2.06 FIELD TESTING

A. Flexible Tube Thickness - Prior to wet-out; provide access to all flexible tubes intended for the use on the project. Clearly identify flexible tubes with their manufactured thickness. Do not use flexible tubes which fail to meet the specified thickness. Testing will be performed in accordance with ASTM D 5199.

B. Infrared Spectrum Analysis (Chemical Fingerprinting) - Provide access to the resin intended for the use on the project for sampling and chemical fingerprint testing. All testing will be performed in accordance with ASTM E 1252. If sample fails test, work is non-conforming. See paragraph 3.09.

C. Physical Property Testing - Post installation physical property testing of the cured composite tube will be performed in accordance with ASTM D 790. Provide sufficient samples for conducting the testing required under ASTM D 790. If sample fails test, work is non-conforming. See paragraph 3.09.

D. The Contractor shall provide samples for testing from the actual installed CIPP liner. Samples shall be provided from one location per 500 linear feet of CIPP installed or per line section, whichever is greater. The sample shall be cut from a section of CIPP that has been inverted or pulled through a like diameter pipe, which has been held in place by a suitable heat sink, such as sandbags. The sample shall be marked with the date the liner was installed, the date the sample was removed, and the upstream and downstream manholes. The cutting of the sample shall be witnessed by the City. On pipelines greater than 15 inches in diameter, the City may, at its discretion, require plate samples cured with the CIPP.

PART 3 EXECUTION

3.01 PRE-INSTALLATION CLEANING AND TELEVISION INSPECTION

A. Perform a pre-installation television inspection in accordance with Section 02558 - Cleaning and Television Inspection. Verify that sewer is clean and pipe conditions are suitable for installation of the CIPP. Notify Engineer if conditions exist which will impact the installation.

3.02 OBSTRUCTION REMOVAL, POINT REPAIR AND SAG ELIMINATION

A. If pre-installation video inspection reveals an obstruction in the line segment (such as heavy solids, dropped joints, protruding service connections or collapsed pipe) that cannot be removed by conventional sewer cleaning equipment and the obstruction will prevent completion of the insertion process, perform point repairs or obstruction removal prior to CIPP installation. Obtain approval of the Engineer before performing work. Follow requirements in Section 02553 - Point Repairs and Obstruction Removals.

B. If pre-installation video inspection reveals a sag in the sewer that has a vertical displacement greater than one-half the pipe diameter, eliminate the sag by performing a point repair as specified in Section 02553 - Point Repairs and Obstruction Removals, or by removal and replacement of the sewer segment. Obtain approval of the Engineer before performing work.

3.03 DIVERSION PUMPING

A. Maintain commercial and residential sanitary sewer service during the installation process.

B. Install and operate diversion pumping equipment to maintain sewage flow around the segment of pipe being rehabilitated, and to prevent backup or overflow, as specified in Section 01506 - Diversion Pumping.

3.04 INSTALLATION PROCEDURES

A. Notification: Inform the Engineer of work schedules for CIPP installation.

1. Provide 24-hour notice so that the Engineer may witness the “wet-out” procedure.

2. Provide 24-hour notice so that the Engineer may witness inversion and curing of liner.

B. Conduct operations in accordance with applicable OSHA standards, including safety requirements involving work on elevated platforms and entry into confined spaces. Take suitable precautions to eliminate hazards to personnel near construction activities when pressurized air is being used.

C. Wet-out: Designate a location where the flexible tube will be impregnated with resin. Thoroughly saturate flexible tube prior to installation. Use catalyst systems or additives compatible with resins and flexible tubes complying with manufacturer's recommendations. Handle resin-impregnated flexible tubes to retard or prevent resin setting until ready for curing.

D. Insertion: Insert flexible tubes through existing manholes or access structures by inversion, pull-in or other approved procedure in accordance with manufacturer's recommendations.

E. Curing using Steam, Hot Water or Ambient Temperature Water or Air:

1. Follow manufacturer's recommended cure schedule in curing of liner.

2. After insertion is completed, apply a suitable recirculation system capable of delivering steam, hot water or ambient temperature water or air, uniformly throughout the section to achieve consistent cure of the resin. Maintain curing temperature as recommended by the resin/catalyst system manufacturer.

3. Provide suitable monitors near the heat source to gauge temperatures of incoming and outgoing water or steam supply. Place additional temperature sensors between the impregnated tube and invert of the original pipe at each manhole to monitor the outside temperature of the liner while curing.

4. Continue uninterrupted heating until the required curing temperature is achieved. Accurately measure temperatures at both ends of the CIPP. Initial cure is considered complete when exposed portions of the flexible tube pipe appear to be cured and the remote temperature sensors have achieved the external temperature recommended by the resin/catalyst system manufacturer.

5. Cool Down: Initiate controlled cool-down of the hardened pipe to a temperature below 110° F, in accordance with the manufacturer's recommended cure schedule. Take care in releasing the water column so that a vacuum does not develop that could damage newly-installed pipe. Do not discharge water hotter than 110° F into the sanitary sewer system

F. Curing using Ultraviolet Light:

1. Curing shall be in accordance with ASTM F2019 and/or manufacturers specifications.

2. The UV light source shall be assembled in accordance with the manufacturer's specification for the liner diameter.

3. The ultraviolet curing lamps shall operate in a sufficient frequency range to insure proper curing of the resin.

4. A camera shall be located on the ultraviolet light assembly to enable the video inspection of the liner and to insure that the liner has been properly inflated and any liner problems can be identified before curing begins.

5. During the curing process, sensors shall be used to record curing data that shall be submitted to the Engineer upon request. The recording shall include rate of travel of the ultraviolet light assembly, curing speed, internal temperatures and pressures during the curing process.

G. Finished Pipe: Provide a finished CIPP which is continuous and as free as commercially practicable from visual defects such as foreign inclusions, dry spots, and pinholes.

H. If point repair is required after the liner has cured, use a tube segment to splice across the point repair. Overlap on each end shall be twice the diameter, or 12 inches, whichever is greater. Cure the segment using the same process specified for the original liner.

3.05 SERVICE RECONNECTIONS

A. Complete service reconnections within 24 hours after completion of the cured-in-place process.

B. Reconnect services by excavation, man-entry or remote-operated cutting tool. Follow procedures for reconnecting sewer service specified in Section 02534 - Sanitary Sewer Service Stubs or Reconnections.

3.06 SEALING AT MANHOLES

A. Form tight seals between the CIPP and the manhole walls at pipe penetrations. Do not leave annular gaps. Seal annular spaces with Oakum bands soaked in chemical grout following chemical grouting manufacturer’s recommendations for installation. Finish off seals with non-shrink grout or cementitious liner materials placed around the pipe opening from inside the manhole in a band at least 4 inches wide. Complete sealing procedures for each liner segment immediately after the liner is cured.

B. Reshape and smooth the manhole invert and build up the existing invert until it is full pipe depth (equal in depth to the diameter of the largest/outgoing pipe) across the manhole bottom up to 15” maximum pipe diameter.

C. Build inverts for all lateral sewers entering the manhole whose flowline elevation is between the crown and flowline elevations of the outgoing/downstream pipe. Maximum depth of lateral invert shall be up to full pipe depth (equal in depth to the diameter of lateral/upstream sewer when the top of the proposed sloped bench is the same elevation as the crown of the lateral sewer) at the upstream end and full pipe diameter of the outgoing/downstream sewer at the downstream end up to 15” maximum pipe diameter.

3.07 POST-INSTALLATION TELEVISION INSPECTION

A. Make and submit video(s) showing completed work, including condition of restored connections. Refer to Section 02558 - Cleaning and Television Inspection.

B. All manhole bench/invert work and annular seal shall be completed at time of Post-TV, with Post-TV being verification of completion.

3.08 FINAL CLEANUP

A. Upon completion of rehabilitation work and testing, clean and restore project area affected by the Work in accordance with Section 01740 - Site Restoration.

3.09 NON-CONFORMING WORK

A. If the thickness, flexural strength or flexural modulus of elasticity of the installed CIPP is less than 90 percent of the specified values, the product is considered unacceptable. Submit a proposed method of repair or replacement for review and approval by the Engineer. Work required to remedy non-conforming work shall be at no additional cost to the City.

B. If it is determined that the resin utilized did not match the submitted and approved resin via the Infrared Spectrum Analysis, the product is considered unacceptable and non- conforming. Submit proof that the resin actually utilized meets the requirements of the specification or submit a method for replacement of the sewer segment liner for review and approval by the City. Work required to remedy non-conforming work shall be at no additional cost to the City.

C. For all instances where CIPP is deemed unacceptable, other than thickness, flexural strength, and flexural modulus of elasticity, as described in this specification section, submit a proposed method of repair or replacement for review and approval by the Engineer. Work required to remedy non-conforming work shall be at no additional cost to the City.

END OF SECTION

SECTION 02557

FOLDED AND FORMED PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Rehabilitation of existing gravity sewer lines using the Folded and Formed Pipe process.

1.02 RELATED SECTIONS

A. Document 00200 – Instructions to Bidders

B. Section 01330 – Submittal Procedures

C. Section 01506 – Diversion Pumping

D. Section 02534 – Sanitary Sewer Service Stubs or Reconnections

E. Section 02553 – Point Repairs and Obstruction and Removals

F. Section 02555 – Manhole Rehabilitation

G. Section 02558 – Cleaning and Television Inspection

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. Measurement for installing folded and formed pipe is on a linear-foot basis for actual footage of liner pipe installed from centerline to centerline of manholes. Payment shall be based on the depth of the deeper flow line of the rehabilitated segment.

2. Costs for the following are included in the unit price for the liner; no separate payment for them will be made.

a. The cost of sealing the liner in the manholes and reworking the manhole inverts and benches.

b. The cost for eliminating offset joints with greater than 90 percent clearance.

c. The cost for testing the liner pipe after installation.

B. Stipulated Price (Lump Sum): If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 REFERENCES

A. ASTM D 638 - Standard Test Method for Tensile Properties of Plastics.

B. ASTM D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

C. ASTM D 1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

D. ASTM D 1693 - Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.

E. ASTM D 1784 - Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

F. ASTM D 2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.

G. ASTM D 3034 - Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.

H. ASTM D 3350 - Specification for Polyethylene Plastic Pipe and Fittings Materials.

1.05 DEFINITIONS

A. Folded and Formed Pipe: The Folded and Formed Pipe process is the reconstruction of sanitary sewers by insertion of a folded liner pipe into the existing sewer and the reformation of the folded liner pipe into a circular liner pipe. The liner is reformed by a combination of hot water circulation and pressurization, or similar technique, to reform the folded liner pipe into its original extruded configuration. When reformed, the new liner pipe extends over the length of the insertion in a continuous pipe-within-a-pipe installation.

1.06 SYSTEM DESCRIPTION

A. Folded and formed pipe is installed by insertion within the carrier pipe to create a continuous liner over the entire length of each pipe segment from manhole to manhole. The liner pipe passing through or terminating in a manhole is carefully cut to form an invert or termination as described in these Specifications and shown on the Drawings. The invert and benches are streamlined and improved for smooth flow. The finished liner pipe is pressure tested to meet the leakage requirements test as specified.

1.07 SUBMITTALS

A. Make submittals accordance with Section 01330 - Submittal Procedures.

B. Submit engineering data covering design and installation. Required data includes the following:

1. Before beginning work, submit the vendor's specific technical data with complete physical properties of pipe and pipe dimensions pertinent to this job. Submit full descriptions of component materials and their properties to the City Engineer for approval. Include a "Certificate of Compliance" with Specification for materials to be incorporated in the work, and manufacturer's standard printed instructions.

2. Submit a work plan for review by the City Engineer. In the work plan address procedures required for pre-installation and installation. Describe procedures to be followed for installation of the Folded and Formed Pipe method selected, even though the process is pre-approved. Before installation, submit the standard reforming temperature/pressure/cool-down schedule. Proposed changes in preinstallation or installation procedures require submittal of revised procedures for review by the City Engineer.

3. Submit post-installation video inspection tapes as specified in Section 02558 - Cleaning and Television Inspection.

1.08 QUALITY ASSURANCE

A. Though the installation process is licensed and proprietary in nature, Contractor shall not change any material, thickness, design values or installation procedure stated in submittals without the City Engineer's prior written approval.

PART 2 PRODUCTS

2.01 PREAPPROVED MANUFACTURERS

A. Folded and Formed Pipe Process:

1. Pipeliners, Inc., Metairie, Louisiana.

2. AM Liner Process of American Pipe and Plastics, Binghamton, New York.

B. Other manufacturers of similar processes must be preapproved by the City. Refer to Document 00200 - Instructions to Bidders for information regarding product preapproval procedures.

2.02 MATERIALS

A. Properties:

1. Solid Wall High-Density Polyethylene Pipe:

a. Provide liner pipe manufactured from a high-density high-molecular-weight polyethylene resin complying with ASTM D 1248, meeting requirements for Type III, Class B, Grade P34, Category 5, and having a PPI rating of PE 3408 when compounded.

b. Pipe produced from the specified resin shall have a minimum cell classification of 345434D or E (inner wall shall be light in color) under ASTM D 3350, and demonstrate a lone-term hydrostatic strength rating of 1600 psi or more, in accordance with ASTM D 2837. When the environmental stress crack resistance of the compound is measured in accordance with ASTM D 1693, Condition C, the compound shall withstand not less than 192 hours in 100 percent solution Igepal CO-630 at 100 F before reaching a 20 percent failure point.

c. The liner pipe shall have the following minimum physical properties:

Flexural Stress (Yield):	3,000 psi	ASTM D 638
Flexural Stress (Break):	4,500 psi	ASTM D 638
Flexural Stress of Elasticity:	133,000 psi	ASTM D 790

2. Poly Vinyl Chloride (PVC) Pipe:

a. The PVC compound used for the folded pipe shall conform to ASTM D 1784 classification 13223-B or 12344-B. Compound that have different cell classifications because one or more properties are superior to those of the specified compounds are also acceptable.

b. The installed pipe shall have the following minimum physical properties:

Flexural Modulus of Elasticity:	320,000 psi
Flexural Strength:	9,000 psi
Tensile Strength:	5,000 psi

B. Alternative Materials: Alternative materials for liner pipe shall be pre-approved. Refer to Document 00200 - Instructions to Bidders for information regarding product preapproval procedures.

C. Markings: Use liner pipe marked at not more than 5-foot intervals with a coded number system to indicate manufacturer, size (diameter and SDR), material, extrusion date and production shift that fabricated the pipe liner. Have the marking code changed with each production shift change.

D. Dimensions:

1. Diameter and Wall Thickness: Select fabricated pipe with an outside diameter and minimum wall thickness that will fit the internal circumference of the carrier pipe with a close mechanical fit leaving a minimum annular space.

2. Standard Dimension Ratio (SDR) of liner pipe: SDR 26.

3. Length: Minimum length is that length necessary to effectively span the distance from the inlet to the outlet of adjacent manholes, unless otherwise specified. Verify lengths in the field before manufacturing. Individual insertion runs may be made over more than one pipe segment through adjacent manholes as determined in the field by the Contractor and approved by the Project Manager.

2.03 SOURCE QUALITY CONTROL

A. Inspect and test each production lot of polyethylene liner pipe at the time of manufacture for defects in accordance with ASTM D 2837 and ASTM D 1963. Verify that liner pipe is homogeneous, uniform in color, free of cracks, holes, foreign materials, blisters and deleterious faults. Mark each production lot of liner pipe with unique markings to clearly differentiate one production lot from another.

B. Inspect and test each manufactured length of PVC pipe for extrusion quality, workmanship, impact resistance and pipe flattening in accordance with ASTM D 3034. Verify that pipe is homogeneous, uniform in color, free of cracks, holes, foreign materials, blisters and deleterious faults.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine liner pipe for gashes, nicks, abrasions, or any such physical damage which may have occurred during storage or handling which produced physical damage deeper than 10 percent of the wall thickness. Inspect liner pipe to verify that it is free from visual defects such as foreign inclusions, concentrated ridges, discoloration, pitting, varying wall thickness and other deformities. Reject and remove from the project site liner pipe with physical damage or visual defects. The liner pipe passing through or terminating in a manhole shall be carefully cut out in a shape and manner approved by the Project Manager. The invert and benches shall be streamlined and improved for smooth flow. The installed liner pipe shall meet the leakage requirements of the pressure test as specified.

3.02 PREPARATION

A. Safety: Conduct operations in strict conformance with applicable OSHA standards and regulations. Particular attention is drawn to those safety requirements involving work on an elevated platform and entry into a confined space.

B. Cleaning: Clean the sewer to be rehabilitated and remove debris immediately before the videotape inspection, as specified in Section 02558 - Cleaning and Television Inspection.

C. Pre-installation Videotape Inspection: Perform a pre-installation videotape inspection of the sewer pipe immediately before the pipe installation to ensure that pipe conditions are acceptable to receive Folded and Formed pipe, as specified in Section 02558 - Cleaning and Television Inspection.

D. Diversion Pumping: When required for acceptable completion of the Folded and Formed Pipe process, provide for continuous sewage flow around the sections of pipe designated for the installation of liner pipe by use of diversion pumping. Select pumps and bypass lines with adequate capacity and size to handle the flow in accordance with Section 01506 - Diversion Pumping.

E. Sewer Obstructions: If pre-installation videotape inspection reveals an obstruction in the existing sewer, such as heavy solids, dropped joints, protruding service taps or collapsed pipe, which will prevent pipe installation, and that cannot be removed by conventional sewer cleaning equipment, then an obstruction removal (by remote device) or point repair may be made with the approval of the City Engineer. Refer to Section 02553 - Point Repairs and Obstruction Removals.

F. Protruding Taps: If service reconnection is not by excavation, remove protruding taps which will obstruct or hinder insertion of the liner pipe. Refer to Section 02553 - Point Repairs and Obstruction Removals.

G. Offset Joints: If pre-installation videotape inspection reveals an offset joint with less than 90 percent clearance, take the necessary steps to eliminate the offset joint as a part of the liner installation. If pre-installation video inspection reveals an offset joint with less than 80 percent clearance, the Contractor shall eliminate the offset joint by use of a point repair in accordance with Section 02553 - Point Repairs and Obstruction Removals. Percentage of clearance will be determined by the Project Manager.

H. Sags in Sewer: If pre-installation videotape inspection reveals a sag in the existing sewer that is greater than 30 percent of the length of the line or one-half the diameter of the existing pipe, notify the Project Manager prior to performing any line rehabilitation. Take necessary steps, with approval of the City Engineer, to eliminate these sags.

3.03 INSTALLATION

A. Liner Insertion:

1. Insert liner pipe into the existing sewer with an inside diameter equal to or greater than the formed outside diameter of the liner pipe. Use a power winch and steel cable connected to the end of the liner using an appropriate pulling head. A second pulling head may be attached to the trailing end of the liner for attachment of a tag line to pull the liner back out of the sewer, if necessary. Length of the liner pipe to be inserted is governed by the winch drum capacity and the winching power available with consideration for the size and condition of the sewer.

2. During insertion, provide a bumper to prevent the ragged edges of the existing pipe from scarring the outside of the liner as it is pulled into the pipe.

3. Once insertion is initiated, continue the pull to completion without interruption.

B. Perform liner reformation and PVC liner reformation according to manufacturer's printed instructions submitted to City Engineer for review.

C. Manhole Sealing and Benches:

1. Install liner pipe with tight-fitting seals at manholes with no annular gaps. Seal annular spaces at each manhole with oakum soaked in Scotchseal 5600 gel. Finish with non-shrink grout placed from inside the manhole, covering the a nailer space and circling the pipe penetration in a band not less than 6 inches wide.

2. Neatly cut the top half of the pipe within the manhole at least four inches away from the manhole walls. Do not break or shear off the pipe penetration. Form a channel in the manhole that is a smooth continuation of the pipes, merged with other lines or channels, if any. Make the channel cross-section U-shaped, with a minimum length of half the pipe diameter for 6-inch to 12-inch diameter pipe, and between half the pipe diameter and three- fourths the diameter for 15-inch and larger pipe. Build up the sides of the channels with mortar or concrete, as specified in Section 02555 - Manhole Rehabilitation, to provide benches at not more than 1 in 12 pitch toward the channel.

3. Seal liner pipe in the manhole as specified above before proceeding on to the next manhole section. The Project Manager will individually inspect manholes for liner pipe cut-offs, benches and sealing work.

D. Service Reconnection by Excavation or Remote: After the liner pipe has been reformed and pressure tested, reconnect existing live service connections. Reconnect services by excavation or remote cutting method in accordance with Section 02534 - Sanitary Sewer Service Stubs or Reconnections.

3.04 FIELD QUALITY CONTROL

A. Test liner pipe after it has been installed in existing pipe. Perform a low-pressure air test of the liner pipe before it has been sealed in place at the manholes and before any service connections to the liner pipe have been made. This test checks the integrity of the liner pipe and verifies that the liner pipe has not been damaged during insertion.

B. Low Pressure Test:

1. After a manhole-to-manhole section of sewer pipe has been lined, plug it at each manhole with pneumatic plugs. Use plugs designed so that they will hold against the test pressure without requiring external blocking or bracing. One of the plugs shall have three air hose connections, one for inflation of the plug, one for reading of the air pressure into the sealed line, and one for introducing air into the sealed line.

2. Pressurize the test section to 4 psi and hold it above 3.5 psi for not less than 2 minutes. Add air if necessary to keep the pressure above 3.5 psi. At the end of this two-minute stabilization period, record the pressure (at least 3.5 psi minimum) and start the time period. If the pressure drops 0.5 psi in less than the time given in the table below, the section of pipe fails the test. Use a pressure gauge having minimum divisions of 0.010 psi.

3. When the prevailing groundwater is above the sewer liner pipe being tested, increase the test pressure 0.43 psi for each foot that the water table is above the invert of the pipe.

SEWER SIZE (inches)	MINIMUM TEST TIME (Minutes)
8	4
10	5
12	6
15	7.5

4. If the time of the pressure to drop 0.5 psi is 125 percent or less of the time given in the table, immediately re-pressurize the line to 3.5 psi and repeat the test.

C. Post-installation Videotape Inspection: Provide post-installation videotape inspections, tapes, and reports in accordance with Section 02558 - Cleaning and Television Inspection.

END OF SECTION

SECTION 02558

CLEANING AND TELEVISION INSPECTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Cleaning sewer lines to remove solids, roots, soil, sand, pieces of broken pipe, bricks, grease, grit from sewer lines and manholes and other debris, thus improving flow and facilitating television inspection for sewer evaluation. Cleaning includes initial manhole wall washing by high-pressure water jet.

B. Television inspecting the line to obtain quality video and Television Inspection Reports upon which the City can make decisions regarding needed sewer rehabilitation.

1.02 REALTED SECTIONS

A. Section 01330 – Submittal Procedures

B. Section 01506 – Diversion Pumping

C. Section 02555 – Manhole Rehabilitation

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices:

1. Survey Normal Cleaning Equipment: Measurement for cleaning sanitary sewer mains with normal cleaning equipment is on a linear-foot basis. The Contract unit price for cleaning with normal equipment is full payment for sewer line actually cleaned and accepted. Cleaning using normal cleaning equipment includes:

a. Charges for transient water meter setup and water usage;

b. Collection, removal, transportation and legal disposal of liquid wastes, soil, sand and other debris for lines less than or equal to 48-inches in diameter;

c. Locating, exposing and opening manholes on sewers to be cleaned;

d. Initial manhole wall washing with high-pressure water. Payment for additional cleaning and scrubbing of manhole walls which may be required for manhole rehabilitation is included in the unit price for manhole wall sealing as specified in Section 02555 - Manhole Rehabilitation; and

e. Reconstruction of manholes dismantled for cleaning equipment access, and repair of damage caused by dismantling or cleaning equipment.

2. Cleaning Using Mechanical Cleaning Equipment: Measurement for cleaning sanitary sewer mains with mechanical cleaning equipment is on a linear-foot basis for the quantity approved by the Project Manager. The Contract unit price for cleaning sanitary sewer mains with mechanical cleaning equipment is paid in addition to the unit price for cleaning using normal cleaning equipment. Mechanical cleaning is limited to locations approved by the Project Manager on a case-by-case basis after normal cleaning methods have failed to produce satisfactory results, as determined by viewing video.

   a. Mechanical cleaning prior to normal cleaning does not relieve the Contractor of the responsibility for fully cleaning the pipe with normal cleaning equipment.

   b. Reconstruction of manholes dismantled for cleaning equipment access, and repair of damage caused by dismantling or cleaning equipment.

   c. Unit price for cleaning using mechanical equipment is compensation in full for all collection, removal, transportation and legal disposal of liquid wastes, soil, sand and debris regardless of quantity of material.

3. Survey Television Inspection: Measurement of survey television inspection for pipe segments selected by the Project Manager is on a linear-foot basis from centerline to centerline of manholes. Payment for survey television inspection is made for the actual lengths of television inspection footage, as measured in the field at grade, as submitted for evaluation prior to final recommendations of sewer rehabilitation method. No separate payment will be made for the following:

   a. Poor or unacceptable-quality video (hazy, unclear images will not qualify for payment).

   b. Re-recording of any segment without prior approval of the Project Manager.

   c. Portions of sanitary sewer not recorded (no payment will be made for length of sewer through which the camera could not pass).

   d. Reverse setups required to bracket an obstruction; or

e. Sewer flow control.

4. Payment for video inspection by floating camera shall be made based on bid item for TV Inspection of appropriate line size.

5. Pre-Installation Cleaning:

   a. No separate payment will be made for pre-installation cleaning using normal cleaning equipment of pipes less than or equal to 48-inches in diameter. Include cost for pre-installation cleaning in cost of line work for which the rehabilitation effort is performed. If a line is inspected and, in the opinion of the Project Manager, found to require no rehabilitation work, payment of cleaning will be made on the basis of survey normal cleaning.

   b. Payment will be made for Pre-installation cleaning of pipes greater than 48- inches in diameter.

6. Pre-Installation Television Inspection: No separate payment will be made for pre- installation television inspection, except for lines inspected but not rehabilitated. Include cost for pre-installation television inspection in the cost of line work for which the rehabilitation effort is performed. If a line is inspected and, in the opinion of the Project Manager, found to require no rehabilitation work, Contractor will be paid for pre-installation television inspection on the basis of survey television inspection.

7. Post-Installation Television Inspection: No separate payment will be made for post-installation television inspection. Include cost for post-installation television inspection in the cost of line work for which the rehabilitation is performed. The post-installation television inspection policy allows payment for work based on field-measured lengths indicated on the inspector's daily reports, but still requires the Contractor to submit a post-installation video within one calendar month after segment completion. If no video is received within that period, credit for the previously paid line segment will automatically be deducted from pay estimates in following months until the required video is submitted.

8. Footage paid for survey cleaning, under some circumstances, may exceed the footage paid for survey television inspection, as approved by the Project Manager.

9. If the Contractor is unable to complete the TV inspection of a mainline section after performing a reverse setup (i.e., obstructions are encountered from both the upstream and downstream manhole that prevents the passage of the camera), the Contractor shall be paid for television inspection of the actual footage of pipe successfully televised, if the TV inspection video and report are of acceptable quality.

10. Payment for cleaning of siphon shall be by pipe diameter, all depths, and on a linear foot basis measured along the centerline of the siphon pipe and from centerline of upstream manhole or junction box to centerline of downstream manhole or junction box. Cleaning of siphon shall include cleaning of both the upstream and downstream manholes or junction boxes unless they are included in the cleaning of the adjacent upstream and/or downstream gravity sewer section. Both hydraulic cleaning and mechanical cleaning equipment may be employed to clean a siphon using the cleaning of siphon pay item. No separate payment for mechanical cleaning.

11. Payment for TV inspection of siphon shall be by pipe diameter, all depths, and on a linear foot basis measured along the centerline of the siphon pipe from centerline of the upstream manhole or junction box to centerline of downstream manhole or junction box. Payment for TV inspection of siphon shall include any dewatering, excluding bypass pumping, required to provide a clear picture of the pipe in the depressed portion of the siphon, with camera lens centered in the pipe and above water surface level such that pipe defects and debris may be visually detected.

12. Payment for the collection, removal, transportation and legal disposal of liquid wastes, soil, sand and other debris removed from sanitary sewer or siphon greater than or equal to 48-inches in diameter while performing cleaning shall be by cubic yard. Measurement shall be by properly executed waste manifest for roll- off container. The container shall be available on site as needed. The container shall not be loaded with material other that debris from the sanitary sewer system, shall not contain excessive free water, and shall be filled to the appropriate capacity for transportation.

B. Stipulated Price (Lump Sum): If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 DEFINITIONS

A. Normal Cleaning Equipment: Cleaning devices such as rods, metal pigs, porcupines, root saws, snakes, scooters, sewer balls, kites, and other approved equipment in conjunction with hand-winching devices and gas or electric rod-propelled devices. Variable-pressure water nozzles (3000 psi) are considered normal cleaning equipment.

B. Mechanical Cleaning Equipment: Buckets, scrapers, scooters, porcupines, kites, heavy- duty brushes, metal pigs and other debris-removing equipment and accessories used in conjunction with approved power winching machines. High-to very-high-pressure water nozzles (10,000 psi) are considered mechanical cleaning equipment.

C. Survey Cleaning and Television Inspection: Video inspection of existing sanitary sewers to evaluate lines and determine whether conditions exist which would require line rehabilitation.

D. Pre-Installation Television Inspection: Video inspection by Contractor of sewer lines designated for rehabilitation to confirm cleaning, location of service connections and constructability of line rehabilitation according to Drawings and Specifications.

E. Post-Installation Television Inspection: Video inspection to determine whether rehabilitation of a sanitary sewer has been completed according to Drawings and Specifications.

F. Television Inspection Report: A report that is submitted in pdf format for each line segment using NASSCO PACP codes.

G. Siphon or Inverted Siphon: A depressed section of gravity sanitary sewer that allows a graded or sloped sewer to convey flow across a conflicting underground utility or open drainage channel by passing under it.

1.05 PERFORMANCE REQUIREMENTS

A. Clean designated sanitary sewers and manholes using mechanical, hydraulically-propelled or high-velocity sewer cleaning equipment. Select cleaning processes which will remove grease, soil, sand, silt, solids, rags and debris from each sewer segment and associated manholes.

1.06 SUBMITTALS

A. Comply with Section 01330 - Submittal Procedures.

B. Submit equipment manufacturer’s operational manuals and guidelines to the Project Manager for review. Strictly follow such instructions unless otherwise directed by the Project Manager.

C. Submit a list of lawful disposal sites proposed for dumping debris from cleaning operations.

D. Submit and maintain Liquid Waste Manifests conforming to City of Houston Health and Human Services requirements. Send the owner’s and regulator’s copies of the completed manifests to the Project Manager within 24 hours after disposal of waste materials.

E. The Contractor shall provide the City with the sewer video (including audio), a hard copy report and an electronic report in pdf format for the inspections for each line segment. The electronic report and video shall be named by line segment. The sewer video shall be MPEG4 format. The Contractor shall utilize the latest NASSCO PACP codes at the time of the Contract notice to proceed. Prior to commencing the work the NASSCO PACP codes to be utilized shall be submitted. All work on the contract shall follow the same codes. Inspection Software must be NASSCO PACP Certified and proof of certification of Software shall be submitted prior to commencing the work. Contractor shall be current on NASSCO training. All electronic data shall be submitted in MS Access. Any variation from the requirements shall be subject to approval by the Project Manager. Submittal of the CCTV videos and the reports for review can be submitted through a data storage device, such as a flash drive, or through Contractor's FTP site and will be available for download. An email of the information availability and phone calls to the Inspector, Senior Inspector and/or specific contact shall be made.

F. At the end of the contract, the Contractor shall submit a hard drive including all videos and reports for the entire contract.

G. The digital information shall contain files which store each line segment as a unique digital record.

1.07 QUALITY ASSURANCE

A. Qualifications: Use experienced personnel to operate cleaning equipment and devices.

B. Acceptance of sewer cleaning work is subject to successful completion of the television inspection. If inspection shows solids, sand, grease, grit or other debris remaining in the line, the cleaning is considered unsatisfactory. Repeat cleaning and video inspection of the sewer line until cleaning is acceptable by the Project Manager.

C. Unable to Penetrate: If the Contractor is unable to penetrate a line during cleaning or CTV inspection, the Contractor will call the Houston Service Center at 311 (inside city limits) or (713) 837-0311 (outside city limits) within 24 hours of the event.

D. The work shall comply with current NASSCO standards.

PART 2 PRODUCTS

2.01 CLEANING EQUIPMENT

A. Select cleaning equipment and methods based on the condition of the sanitary sewer mains at the time work begins. More than one method or type of equipment may be required on a single project or at a single location.

B. When requested by the Project Manager, demonstrate at the performance capabilities of cleaning equipment and methods proposed for use on the project. If results obtained by demonstration are not satisfactory, provide other equipment that will clean the sewer line.

C. For high-velocity cleaning use a water jet capable of producing a minimum volume of 50 gpm with a pressure of 1500 psi at the pump. Install a gauge to indicate working pressure on the discharge of high-pressure water pumps. In addition to conventional nozzles, use a nozzle which directs the cleaning force to the bottom of the pipe for sewers 18-inches and larger.

D. When hydraulic or high-velocity cleaning equipment is used, install a suitable sand trap, weir, dam or suction device in the downstream manhole so that solids and debris are trapped for removal.

E. When approved by the Project Manager, both hydraulic cleaning and mechanical cleaning equipment (including pumps) may be employed to clean a siphon.

2.02 CLEANING ACCESSORIES

A. When an additional quantity of water from the public water supply is needed to meet the cleaning requirements of the equipment and the sewer, obtain transient water meters from the City for installation on trucks or at fire hydrants.

B. Obtain prior written approval when using a fire hydrant located in the Downtown Houston area as required by Houston Fire Department Regulations. However, prior written approval from Houston Public Works is not needed to use fire hydrants located elsewhere within the City of Houston.

C. All cleaning equipment must be equipped with backflow preventers to prevent contamination to the public water supply.

D. If approved by the Project Manager, pneumatic or hydraulically powered “knockers” or chain flails may be used to remove heavy tuberculation in cast iron siphon pipes.

2.03 VIDEO EQUIPMENT

A. Video Equipment: Select and use video equipment that will produce color videos.

B. Pipe Inspection Camera: Produce a video using a pan-and-tilt radial-viewing pipe inspection camera that pans ± 275 degrees and rotates 360 degrees. Use a camera with an accurate footage counter, which displays on the monitor the exact distance of the camera from the centerline of the starting manhole. Use a camera with a camera height adjustment so that the camera lens is always centered at one-half the inside diameter, or higher in the pipe being inspected. Provide a lighting system that allows the features and condition of the pipe to be clearly seen. A reflector in front of the camera may be required to enhance lighting in dark or large diameter pipe.

PART 3 EXECUTION

3.01 EXAMINATION

A. Do not begin cleaning until both upstream and downstream manholes have been checked for flow monitors and other mechanical devices. Refer to Section 02555 - Manhole Rehabilitation.

3.02 PREPARATION

A. Take precautions to protect sanitary sewer mains and manholes from damage that might be inflicted by the improper selection of cleaning processes or improper use of equipment. When using hydraulically-propelled devices take precautions to ensure that the water pressure created does not cause damage to or flooding of public or private property. Do not surcharge any sanitary sewer to an elevation that could cause overflow of sewage into area waterways, homes or buildings, or onto the surface.

B. Do not use or obstruct fire hydrants when there is a fire in the area. Remove water meters, fittings and piping from fire hydrants at the end of each working day.

C. Exercise care to prevent contamination of the potable water system. Use an appropriately sized backflow preventer as required by the City of Houston Water Department when drawing water from a public hydrant.

D. Where possible, use the flow of wastewater present in the sanitary sewer main to provide fluid for hydraulic cleaning devices.

3.03 CLEANING

A. Conserve Water. Do not waste water from the public water supply through poor connections, hydrants left open, or any other cause.

B. Collapsible Dams: Use collapsible dams for hydraulically-propelled devices which require a head of water to operate. Dam shall be easily collapsible to prevent damage to the sewer, public property and private property.

C. High Velocity Cleaning: Operate high-velocity cleaning equipment so that the pressurized nozzle moves continuously. Turn off or reduce the flow to the nozzle to prevent damage to the line any time the nozzle becomes stationary.

D. Mechanical Cleaning: In addition to normal cleaning equipment, perform mechanical cleaning when required and approved using equipment and accessories as defined in this Section.

E. Debris Disposal: Remove sludge, soil, sand, rocks, grease, roots and other solid or semi-solid material resulting from the cleaning operation at the downstream manhole of the section being cleaned. Passing debris from any sewer section to any other sewer section is not allowed. Load debris from the manholes into an enclosed container permitted by the Houston Health Department for liquid waste hauling. Remove solids and semi-solids resulting from cleaning operations from the site and dispose them lawfully at the end of each work day. Do not accumulate debris, liquid waste, or sludge on the site except in totally enclosed containers approved by the Project Manager.

F. Disposal Sites: Dispose of waste at a lawfully-permitted disposal site using a transporter having a valid City Liquid Waste Transporter Permit.

3.04 TELEVISION INSPECTION

A. Immediately after cleaning, video inspect the sanitary sewer line to document the condition of the line and to locate existing service connections. Notify the Project Manager 24 hours in advance of any television inspection so that the Project Manager may observe inspection operations.

B. Perform television inspection of sanitary sewers as follows:

1. Perform a survey television inspection on sanitary sewers within the boundary of the project, as directed by the Project Manager. After reviewing survey video the Project Manager will determine which sanitary sewers will be rehabilitated or need additional work.

2. Perform pre-installation television inspection immediately after cleaning and before line rehabilitation work. Pre-installation video inspection is not required for sewer lines designated to be removed and replaced. Verify that the line is clean and ready to accept the line rehabilitation. Prepare Television Inspection Report forms. Maintain copies of all video reports for reference by the Project Manager for the duration of the project.

3. Videos shall pan all manholes showing benches, walls, annular spaces, and debris removal. Camera operator shall slowly pan each service connection, clamped joint and pipe material transition from one material to another. Complete and submit a Television Inspection Report for every sewer segment video submitted to the Project Manager.

4. Perform post-installation television inspection to confirm completion of rehabilitation work, including removal and replacement. Verify that rehabilitation work conforms to the requirements of the Drawings and Specifications. Provide a video showing the completed work including the condition of restored service connections. Prepare and submit Television Inspection Report forms providing the location of service connections along with the location of any discrepancies. Post-installation video of completed manholes may be substituted for photographic documentation, as described in Section 02555 – Manhole Rehabilitation. Manhole work, including benches, inverts and pipe penetrations into manhole, should be complete prior to post-installation video work.

5. Contractor shall make actual measurement of pipe inside diameter and record measurement to nearest tenth of one inch as "pipe size" on "Television Inspection Report" and on "Video Header".

C. Survey television inspection videos shall be continuous for pipe segments between manholes. Do not leave gaps in the video recording of a segment between manholes and do not show a single segment on more than one video, unless specifically allowed by the Project Manager.

D. Videos shall include audio.

3.05 FLOW CONTROL

A. Perform survey television inspection on one manhole section at a time. Adequately control the flow in the section being inspected. Do not exceed the depth of wastewater flow shown below:

Pipe Diameter (Inches)	Depth of Flow (Percentage of Pipe Diameter)
6 - 10	10
12 - 24	15
Over 24	20

B. If during survey television inspection of a manhole section, the wastewater flow depth exceeds the maximum allowable, reduce the flow depth to an acceptable level by performing the survey television inspection during minimum flow hours, by diversion pumping or by pulling a camera with swab, high-velocity jet nozzle or other acceptable dewatering device. Video inspections made while floating the camera is not acceptable unless approved by the Project Manager.

C. Minimize flow in the line while performing pre-installation television inspection. Divert the normal flow as specified in Section 01506 - Diversion Pumping and clean the line to be inspected.

D. No flow is allowed in the line while performing post-installation video inspection.

3.06 PASSAGE OF VIDEO CAMERA

A. Do not pull or propel the video camera through the line at a speed greater than 30 feet per minute.

B. If during survey television inspection of a manhole section, the camera is unable to pass an obstruction even though flow is unobstructed, televise the manhole section from the other direction (reverse setup) in order to obtain a complete video of the line. Whenever such a condition arises, notify the Project Manager to determine whether an obstruction removal or point repair is necessary. If a point repair is authorized, repair the pipe at the designated location and then re-televise the manhole section to verify completion of the point repair, unless waived by the Project Manager.

1. When the camera is being pulled from the other direction in order to survey on either side of an obstruction and a second obstruction or repair location is encountered away from the first obstruction, notify the Project Manager and request a review of the video. The Project Manager may direct the Contractor to make one or both repairs. No downtime shall be allowed.

2. Once point repairs are completed, re-inspect the manhole section.

3. The City makes no guarantee that the sanitary sewer designated for survey television after cleaning is clear for the passage of the camera set-up. Select the appropriate equipment, tools and methods for securing safe passage of the camera.

C. During pre-installation television inspection, camera passage should show the line is ready for rehabilitation. Report to the Project Manager any variations between previous reported (existing data) conditions and actual conditions encountered.

D. For post-installation television inspection, exercise the full capabilities of the camera equipment to document the completion of the rehabilitation work and the conformance of the work to the Drawings and Specifications. Provide a full 360-degree view of pipe, joints and service connections.

3.07 TELEVISION INSPECTION REPORT

A. Provide a television inspection report in pdf format for each line segment using NASSCO PACP codes. The electronic report shall be named by line segment.

3.08 FIELD QUALITY CONTROL

A. Do not under any circumstances, allow sewage or solids removed in the cleaning process to be released onto streets or into ditches, catch basins, cleanouts, storm drains, or sanitary or storm sewer manholes.

B. Acceptance of sewer cleaning work is subject to successful completion of the television inspection. If the television inspection shows solids, soil, sand, grease, grit, or other debris remaining in the line, cleaning will be considered unsatisfactory. Repeat cleaning and inspection of the line segment until cleaning is judged satisfactory by the Project Manager.

3.09 MANHOLE REPAIR

A. Repair manholes dismantled or damaged during the cleaning process, and replace manhole frames and covers damaged during the cleaning process.

END OF SECTION

SECTION 02571

PIPE BURSTING/CRUSHING SANITARY SEWERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pipe bursting/crushing existing sanitary sewers.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01340 – Shop Drawings, Product Data, and Samples

D. Section 01504 – Temporary Facilities and Controls

E. Section 01506 – Diversion Pumping

F. Section 01576 – Waste Material Disposal

G. Section 01578 – Control of Ground and Surface Water

H. Section 01740 – Site Restoration

I. Section 02260 – Trench Safety System

J. Section 02317 – Excavation and Backfill for Utilities

K. Section 02320 – Utility Backfill Materials

L. Section 02321 – Cement Stabilized Sand

M. Section 02533 – Acceptance Testing for Sanitary Sewers

N. Section 02553 – Point Repairs and Obstruction Removals

O. Section 02555 – Manhole Rehabilitation

P. Section 02558 – Cleaning and Television Inspection

1.03 UNIT PRICES

A. Measurement for installing replacement pipe using pipe bursting/crushing method is on a linear foot basis for installed liner pipe, measured from center line of upstream manhole to center line of downstream manhole. Depth range for payment is based on greatest depth measured at manholes from natural ground level to flow line of sanitary sewer for each pipeline segment.

B. Insertion or access pits, clamp installation, embedment (bedding, haunching and initial backfill), field quality control (testing), sealing liner at manholes, grouting annular space, pipe connection to existing manholes using sanded manhole adapters for 8 inch to 12 inch sewer lines, building up, shaping and reworking manhole inverts and benches, and pre-installation and post-installation cleaning and television inspection of completed work are included in pipe bursting/crushing unit price and not paid for separately.

C. Measurement for removal or cutting of plastic pipe to allow for pipe bursting of the sewer is on a linear foot basis for all diameters and depth ranges of the plastic pipe to be removed or cut. Payment for removal or cutting of plastic pipe to allow for pipe bursting of the sewer shall also include excavating, sheeting/shoring, maintaining/securing, closing/backfilling and area restoration of all access pits necessary to accomplish the removal or cutting of the plastic pipe sewer.

D. Excavations initially begun as obstruction removals or point repairs which the Contractor later decides to use as insertion pits are considered as insertion pits and not paid for separately.

E. Trench safety systems, well pointing, backfill with cement-stabilized sand or bank sand and other applicable bid items associated with insertion pits will be paid for at their respective contract unit prices.

F. Refer to Section 01270 - Measurement and Payment, for unit price procedures.

G. Payment for Item, 'Mobilization for short segment (<100 feet) will be paid when the Contractor is issued a work order containing a line segment that is less than 100 feet in length and is not adjacent to another line segment, or when the total of all adjacent line segments is less than 100 feet.

H. No additional compensation will be made for slow production due to existing soil conditions.

1.04 REFERENCES:

A. ASTM D 1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

B. ASTM D 1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

C. ASTM D 2122 – Standard Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings.

D. ASTM D 2241 - Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).

E. ASTM D 2412 – Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.

F. ASTM D 2992 – Standard Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting- Resin) Pipe and Fittings.

G. ASTM D 3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.

H. ASTM D 3262 – Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe.

I. ASTM D 3350 – Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

J. ASTM D 3681 – Standard Test Method for Chemical Resistance of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe in a Deflected Condition.

K. ASTM D 4161 – Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals.

L. ASTM F 585 - Standard Guide for Insertion of Flexible Polyethylene Pipe Into Existing Sewers

M. ASTM F 714 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

1.05 DEFINITIONS

A. Pipe bursting/crushing: Reconstruction of sanitary sewers by insertion of liner pipe within the bore of the existing pipe, enlarged by breaking and expanding the old pipe.

1.06 SYSTEM DESCRIPTION

A. Pipe bursting/crushing involves rehabilitation of deteriorated gravity sewer pipe by installing new pipe material within the enlarged bore created by using a static, hydraulic, or pneumatic hammer “moling” device, suitably sized, to break old pipe, or by using a modified boring “knife” with a flared plug that crushes existing sewer pipe. Forward progress of the “mole” or “knife” may be aided by hydraulic equipment or other apparatus. Replacement pipe is either pulled or pushed into the bore.

1.07 QUALITY ASSURANCE

A. Liner Acceptance: Provide liner material manufactured without defects to standards and dimensions specified. Causes for rejection include physical liner defects such as concentrated ridges, discoloration, excessive spot roughness, pitting, visible cracks, foreign inclusions and varying wall thickness.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Prevent injury to or abrasion of pipe during loading, transportation and unloading. Do not drop pipe from vehicles, nor allow pipe to roll down skids or slopes without proper restraining ropes. Use suitable pads, strips, skids or blocks for each pipe during transportation and while awaiting installation.

B. Do not use, and remove from construction site, pipe with physical damage such as cuts, gashes, nicks or abrasions which may have occurred during shipping, storage, or handling, which are deeper than 10 percent of wall thickness.

C. Use wide belly band slings for lifting and moving pipe. Do not use bare chains in contact with pipe.

1.09 PERFORMANCE REQUIREMENTS

A. Maintain sewage flow by diversion pumping or other method approved by the Project Manager.

B. Clear existing sewers of debris, obstructions and other foreign material and make point repairs to existing sewers as specified in Section 02553 - Point Repairs and Obstruction Removals.

C. Perform pipe bursting/crushing according to this Section.

D. Shape manhole inverts as specified in Section 02555 - Manhole Rehabilitation.

E. Test lines as specified in Section 02533 - Acceptance Testing for Sanitary Sewers.

F. Inspect lines by video inspection as specified in Section 02558 - Cleaning and Television Inspection.

1.10 SUBMITTALS

A. Comply with Section 01330 - Submittal Procedures, and Section 01340 – Shop Drawings, Product Data and Samples.

B. Submit manufacturer's product data with complete information on pipeline materials including physical properties and dimensions pertinent to this job. Furnish certificates of compliance with specifications for materials to be supplied.

C. Submit independent testing laboratory test reports certifying that specified pipe materials conform to the requirements of the applicable ASTM.

1. Polyethylene pipe: ASTM D 1248 and ASTM D 3350

2. Restrained Joint PVC: ASTM D 2241 and ASTM D 1784

3. Fiberglass Reinforced Plastic (FRP) pipe: ASTM D 3262 and ASTM D 3681

D. Submit manufacturer's product data on clamps and couplings.

E. Submit video inspection as specified in Section 02558 - Cleaning and Television Inspection.

F. Submit product data for chemical grout, including surface preparation instructions and application instructions from the manufacturer.

1.11 TESTING

A. City may have tests performed on field samples by an independent laboratory following applicable ASTM specifications to verify physical properties and characteristics of supplied materials. Provide product samples as requested by Project Manager.

B. City will pay for tests on materials which meet specification requirements. Contractor shall pay for failed tests and consequent retesting.

PART 2 PRODUCTS

2.01 PIPE BURSTING/CRUSHING SYSTEMS

A. Contractor shall be certified by the pipe bursting system manufacturer as a fully trained user of the pipe bursting system.

2.02 POLYETHYLENE LINER PIPE AND FITTINGS

A. Provide polyethylene liner pipe, manufactured of solid-wall, high-density, high-molecular-weight polyethylene meeting ASTM D 1248, Type III, Class B, Grade P-34, Category 5, with a PPI rating of PE 3408 or PE3608. Use polyethylene material with a minimum cell classification of 345434D or E under ASTM D3350. Higher-numbered cell classification limits yielding desirably higher primary properties, according to ASTM D 3350, are also acceptable. Dimensions and workmanship: Meet ASTM F 714 and ASTM D 2122. Inner wall of pipe shall be of light color for television inspection purposes.

B. Provide pipe with maximum Standard Dimension Ratio (SDR), and ratio of outside pipe diameter to wall thickness, as specified below. Select SDR for the deeper of two manholes in each particular pipeline segment.

Existing Nominal Diameter (Inches)	Minimum Outside Diameter (Inches)	Minimum Wall Thickness (Inches)		
		≤15' Deep	>15' ≤20' Deep	>20' Deep
		SDR 19	SDR 17	SDR 11
6-8	8.625	0.454	0.507	0.784
10	12.75	0.671	0.750	1.159
12	14.0	0.737	0.824	1.273
15	16.0	0.842	0.941	1.455
18	20.0	1.053	1.176	1.818

2.03 RESTRAINED JOINT PVC SEWER PIPE

A. Provide restrained joint PVC pipe conforming to all ASTM D 2241 wall thickness and pressure requirements.

B. Pipe shall be restrained joint PVC pipe, where restraint is achieved using matching precision machine grooves on the spigot and integral bell ends of the pipe, and a locking nylon spine. Pipe, joints and all locking spline components shall be completely non-metallic to eliminate corrosion problems. Proper assembly shall eliminate over belling or over insertion.

C. Thrust-restrained pipe shall be furnished in sizes 6-inch, 8-inch, 10-inch and 12-inch, and shall be furnished in standard lengths of ten (10) feet and twenty (20) feet. Dimensions of the pipe thrust restraint grooves shall be in accordance with manufacturer's specifications.

D. Provide pipe with maximum Standard Dimension Ratio (SDR), and ratio of outside pipe diameter to wall thickness, as specified below. Select SDR for the deeper of two manholes in each particular pipeline segment.

Existing Nominal Diameter (Inches)	Minimum Outside Diameter (Inches)	Minimum Wall Thickness (Inches)		
		≤15' Deep	>15' ≤20' Deep	>20' Deep
		SDR 19	SDR 17	SDR 11
6	6.625	0.310	0.310	0.310
8	8.625	0.411	0.411	0.411
10	10.75	0.413	0.413	0.413
12	12.75	0.490	0.490	0.490

2.04 FRP LINER PIPE AND FITTINGS

A. Pipe, Joints and Fittings: ASTM D 3262, Type 1, Liner 2, Grade 3. Minimum stiffness: 72 psi, measured according to ASTM D 2412. Pipe with a stiffness greater than 72 psi may be used with prior approval of the Project Manager.

B. FRP Liner Pipe: Glass-fiber-reinforced aggregate-filled plastic mortar pipe manufactured by the centrifugal casting process resulting in a dense, nonporous, corrosion-resistant, consistent composite structure.

C. Resin systems: Thermosetting polyester epoxy resin, with or without filler, meeting ASTM D 3262.

D. Reinforcing Glass Fibers: Commercial grade E-type glass filaments, with binder and sizing compatible with impregnating resins.

E. Filler: Sand with at least 98 percent silica content, and maximum moisture content of 0.2 percent.

F. Joints: Low-profile FRP jacking bell-and-spigot joints with watertight elastomeric sealing gaskets meeting ASTM D 4161.

G. Dimensions and Tolerances:

1. Pipe outside diameters and tolerances: Comply with ASTM D 3262, Cast Iron Pipe Equivalent Outside Diameters, and the table below.

2. When possible, supply pipe in nominal lengths of 20 feet. Where radius curves in existing pipe or limitations in entry pit dimensions restrict pipe length, shorter lengths may be used.

3. FRP pipe minimum outside diameter and minimum wall thickness:

Existing Sewer Nominal Diameter (Inches)	Minimum Liner Outside Diameter (Inches)	Minimum Wall Thickness, 46 psi Stiffness (Inches)	Minimum Wall Thickness, 72 psi Stiffness (Inches)
12	13.45	0.34	0.48
18	19.50	0.34	0.48

4. Fabricate pipe ends square to pipe axis plus or minus 0.25 inches, or plus or minus 0.5 percent of nominal diameter, whichever is greater.

H. Fittings:

1. Flanges, elbows, reducers, tees, wyes and other fittings: Capable of withstanding operating conditions.

2. Fabrication: Contact-molded, or manufactured from mitered sections of pipe joined by glass-fiber-reinforced overlays.

2.05 LINER PIPE SEAL AT MANHOLES

A. Sealer for annular space between liner pipes and manholes for sanitary sewers 15 inches in diameter and larger: Oakum strips soaked in chemical grout.

B. Chemical grout shall react freely with water to form a strong polyurethane foam, shall be resistant to hydrogen sulfide gas, and shall meet the following criteria:

1. Tensile strength: 20 psi

2. Elongation: 190%

3. Tear Strength: 4.9 lbs/inch

4. Density/Specific Gravity: 0.18

2.06 SANDED MANHOLE ADAPTERS

A. Pipes shall be connected to existing manholes using a sanded manhole adapter for sanitary sewers ranging in size from 8 to 12 inches in diameter.

B. Sanded Manhole Adapters shall be fabricated by manufacturer (not field made), exceed 10.8 psi pressure testing and withstand a vacuum of 22 in. Hg for zero infiltration of groundwater.

2.07 CLAMPS AND GASKETS

A. Clamps: Stainless steel, including bolts and lugs; Type 108, as manufactured by JCM Industries or approved equal. Furnish full circle, universal clamp couplings with at least 3/16-inch thick neoprene grid-type gaskets. Select clamps to fit outside diameter of liner pipe as follows:

Liner Pipe Outside Diameter (Inches)	Minimum Clamp Length (Inches)
8.625	18
10.750 or greater	30

B. Full length PVC Gasketed Repair Couplings: Couplings shall conform to the requirements of ASTM D 3139. Full length couplings shall be furnished to fit the outside diameter of restrained joint PVC pipe, conforming to ASTM 2241, where restraint is achieved using matching precision machined grooves on the spigot and integral bell ends of the pipe, and a locking nylon spline. Couplings shall be furnished in sizes 6-inch, 8-inch, 10-inch and 12-inch nominal outside diameters and minimum length shall be 18-inches.

2.08 BEDDING MATERIAL

A. Bedding: Comply with Section 02320 - Utility Backfill Materials, and Section 02321 - Cement Stabilized Sand.

PART 3 EXECUTION

3.01 OBSTRUCTION REMOVAL AND POINT REPAIR

A. Make point repairs and remove obstructions, such as roots, rocks and other debris, prior to installing liner pipe. Remove and dispose of debris in accordance with Section 01504 - Temporary Facilities and Controls, or Section 01576 - Waste Material Disposal.

B. Refer to Section 02553 - Point Repairs and Obstruction Removals, for requirements and procedures for point repairs and obstruction removals.

3.02 DIVERSION PUMPING

A. Refer to Section 01506 - Diversion Pumping.

3.03 INSERTION OR ACCESS PITS

A. Locate pits so that total number is minimized and footage of liner pipe installed in a single pull is maximized. Where possible, use excavations at point repair locations for insertion pits.

B. Prior to excavation, the Contractor shall check with all utility providers (e.g., Reliant Energy, SBC, City of Houston, Centerpoint Energy, etc.) and determine locations of utilities in or near the work area. Costs of utility repairs, temporary service and other costs arising out of damage to or interruption of utilities resulting from operations under this contract shall be borne by Contractor at no additional cost to the City.

C. Perform excavation and backfill in accordance with requirements of Section 02317 - Excavation and Backfill for Utilities.

D. Perform work in accordance with OSHA standards. Comply with Section 02260 - Trench Safety System for excavations requiring trench safety.

E. Install and operate necessary dewatering and surface water control measures in accordance with Section 01578 - Control of Ground and Surface Water.

3.04 REMOVAL OR CUTTING OF PLASTIC PIPE TO ALLOW FOR PIPE BURSTING/CRUSHING OF THE SEWER

A. If a pipe that is scheduled to receive rehabilitation is found to have received sliplining or pipe bursting on a previous occasion, the Contractor shall notify the Project Manager immediately. The Project Manager may direct the Contractor to clean and televise the line segment and/or cut or remove the existing liner in conjunction with the installation of a new pipe via pipe bursting/crushing. Removal or cutting of the existing liner shall be performed upon approval and notification from the Project Manager.

B. The Contractor shall provide the means, method, equipment and labor to cut or remove the plastic pipe to allow for the successful pipe bursting/crushing of the sewer.

1. The means or method utilized by the Contractor shall not disturb the surrounding soil or host pipe to the degree where it will effect the installation and operation of the new pipe to be installed.

2. Cutting of the liner or removal of the existing liner shall not interfere or damage the connections beyond the extent required to disconnect and reconnect the service laterals to the main line.

3. Removal of the existing liner will only be allowed if cutting is not possible.

4. Liner cutting or removal shall be considered complete when the existing pipe has been cut or removed and the new pipe has been successfully installed and accepted.

C. During the liner removal or cutting effort the Contractor may encounter conditions that inhibit pipe removal or the cutting of the pipe. These include, but are not limited to obstructions, couplings, pipe clamps, or cement stabilized sand. When these conditions stop the advancement of the head, the Contractor shall request approval for an obstruction removal from the Project Manager. Once approved, the Contractor shall perform all work necessary to remove the obstruction and allow for the resumption of progress of the liner removal or cutting effort.

D. Line segments with existing conditions that prevent the successful removal or cutting of the liner pipe by conventional methods shall be evaluated on a case by case basis.

3.05 POLYETHYLENE LINER PIPE INSTALLATION

A. Joints:

1. Assemble and join sections of polyethylene liner pipe on site, above ground. Make joints by heating and butt-fusion method in strict conformance to manufacturer's instructions.

2. Use operators who are experienced with butt-fusion jointing of pipe. Operators shall be trained in fusing polyethylene pipe with similar equipment using proper jigs and tools in accordance with pipe manufacturer's standard procedures.

3. Form joints with smooth, uniform double-rolled back beads made while applying proper melt, pressure and alignment. Joints must be inspected and approved by the Project Manager before insertion.

B. Preparation: After completing insertion pit excavation, remove top of existing sanitary sewer line down to the spring line. Connect power winch cable to end of liner by use of suitable pulling head equal to outside diameter of liner. Secure pulling head to liner and attach to power winch cable so that liner can be satisfactorily fed and pulled through sanitary sewer line. Prevent ragged edges of existing pipe from scarring liner pipe. Follow insertion procedures in ASTM F 585. Do not allow sand or other debris to enter liner.

C. Puling Liner:

1. Maximum length of continuous liner assembled above ground and pulled at any one time: Do not exceed length recommended by manufacturer's printed instructions.

2. Limit pulling force exerted on liner to that indicated below for the appropriate outside diameter of the polyethylene liner. Provide a suitable pulling force measuring device connected to the winch or pulling mechanism.

Polyethylene Liner O.D. (Inches)	Maximum Pulling Force (Tons)
8.625	4.0
10.75	7.5
14.0	10.5
16.0	12.0
18.0	21.5

D. Alternate Insertion Techniques: Pushing, or a combination of pulling and pushing, may be used subject to the Project Manager's approval. Avoid liner buckling or dimpling by limiting stroke of pushing implement. Cut out and remove portions damaged during insertion process.

3.06 FRP LINER PIPE INSTALLATION

A. FRP liner pipe may be pushed or pulled into existing sewers. Insert pipes spigot end first, with bell end trailing. Apply pushing force to pipe wall end inside bell in accordance with manufacturer's instructions. Do not apply jacking loads to end of bell. Keep within safe jacking loads as follows (Maximum allowable joint angular deflection shall be one degree):

FRP Liner O.D. (Inches)	Maximum Jacking Load (Tons) for 72 psi Stiffness
13.45	22
17.40	30

B. Prior to pulling or pushing the liner, the contractor shall enlarge the pipe opening at the wall and bench/invert of the manholes by chipping or sawing. If the contractor fails to enlarge the opening of the manhole and the manhole is damaged, the contractor shall replace the manhole at no cost to the City.

3.07 PVC LINER PIPE INSTALLATION

A. Joints:

1. Assemble and join sections of PVC liner pipe on site, above ground, or in excavated insertion pit that will accommodate ten (10) foot or twenty (20) foot pipe joints.

2. Use operators who are experienced with installation and assembly of restrained joint PVC pipe where restraint is achieved using matching precision machined grooves on the spigot and integral bell ends of the pipe, and a locking spline.

3. PVC restrained joint liner pipe shall be assembled using proper tools in accordance with pipe manufacturer’s standard procedures and written instructions. Joints must be inspected and approved by the Project Manager prior to insertion.

B. Preparation: After completing insertion pit excavation, remove top of existing sanitary sewer line down to the spring line. PVC liner pipe shall be installed utilizing static pipe bursting equipment. Hydraulic or pneumatic hammer bursting equipment shall not be used. Secure pulling head to liner and attach to static pipe bursting equipment, so that PVC liner pipe can be satisfactorily fed and pulled through the sanitary sewer line. Prevent ragged edges of existing pipe from scarring liner pipe. Follow insertion procedures in ASTM F 585 as applicable for PVC liner pipe. Do not allow sand or debris to enter liner.

C. Pulling Liner:

1. Maximum length of continuous line assembled above ground and pulled at any one time shall not exceed length recommended by manufacturer's printed instructions. PVC pipe shall be installed segmentally, one joint at a time, and pulled with a static pipe bursting machine. Do not exceed manufacturer's written instructions for pulling force.

2. Limit pulling force exerted on liner to that indicated below for the appropriate outside diameter of the PVC pipe liner. Provide a suitable pulling force measuring device connected to the winch or pulling mechanism.

PVC Liner O.D. (Inches)	Maximum Pulling Force (Tons)
6.625	4.10
8.625	7.75
10.75	9.25
12.75	11.0

D. Alternate Insertion Techniques: Pushing, or a combination of pulling and pushing, may be used subject to the Project Manager's approval. Pushing force shall not exceed manufacturer's data and recommendation. Avoid liner buckling or dimpling by limiting stroke of pushing implement. Cut out and remove portions damaged during the insertion process.

3.08 CLAMP AND COUPLING INSTALLATION

A. Where excavations for liner pipe insertion are made between two manholes, cut ends of liner pipe smooth, square to pipe axis. Join liner pipes with appropriately sized stainless steel universal clamp couplings for polyethylene pipe or PVC gasketed repair couplings for restrained joint PVC pipe. Butt together gaps between ends of liner pipe with space between ends not exceeding one inch.

B. Bedding: Install cement-stabilized sand bedding in accordance with Section 02321 - Cement Stabilized Sand. Extend bedding 12 inches above clamp/liner pipe.

3.09 FRP COLLAR/CLOSURES

A. Install FRP collar closure pieces in accordance with manufacturer's recommendations.

3.10 FIELD QUALITY CONTROL

A. After liner installation, perform the following tests:

1. Low pressure air test: Perform before sealing liner in place at manholes, and before making service reconnections to liner. Check integrity of joints made, and verify that liner has not been damaged.

2. Refer to Section 02533 - Acceptance Testing for Sanitary Sewers for applicable test procedures.

3.11 SEALING LINER IN MANHOLES

A. Allow polyethylene liner pipe to normalize to ambient temperatures and recover from imposed stretch before cutting to fit between manholes, sealing at manholes, and shaping manhole inverts. Allow at least 12 hours for normalization of polyethylene liners. Restrained joint PVC pipe does not require a recovery period from pulling forces imposed during typical pipe bursting operations.

B. Cut liner so it extends 4 inches into manholes. Make smooth, vertical cuts and slope areas over top of exposed liner using non-shrink grout.

C. For sanitary sewers 15 inches in diameter and larger, use Oakum with a chemical grout to seal annular spaces between liner and sanitary sewer main at each manhole. The oakum soaked in chemical grout shall form an effective water-tight gasket in the annular space between liner and existing pipe in manhole. Follow chemical grouting manufacturer's recommendations for installation.

D. Finish seal of liner pipe to host pipe with non-shrink grout placed around annular space from inside manhole. Apply grout in a band at least 6 inches wide.

E. Reshape and smooth manhole inverts as specified in Section 02555 – Manhole Rehabilitation. Use approved manhole rehabilitation material to form smooth transitions with reshaped inverts and raised manhole benches to eliminate sharp edges of liner pipe, concrete benches and channeled inverts. Build up and smooth manhole inverts to match flow line of new liner.

3.12 INSTALLATION OF SANDED MANHOLE ADAPTER

A. For sanitary sewers ranging in size from 8 to 12 inches in diameter, secure pipe to existing manhole with specified manhole adapter in accordance with the manufacturer's instructions.

B. Installation of the sanded manhole adapter shall be such that the bell portion of the adapter is adjacent and external to the wall of the manhole, and spigot shall protrude through and into the manhole 3-inches beyond the interior of the manhole wall.

C. The connections shall be bonded, anchored, and finished using an approved non-shrink grout.

3.13 POST-INSTALLATION VIDEOTAPE INSPECTION OF COMPLETED WORK

A. Provide the Project Manager with video inspection showing completed work including condition of restored connections. Comply with Section 02533 - Acceptance Testing for Sanitary Sewers and Section 02558 - Cleaning and Television Inspection.

3.14 FINAL CLEANUP

A. Upon completion of installation, testing and inspection, clean and restore project area affected by work of this Section. Restore site in accordance with Section 01740 - Site Restoration.

END OF SECTION

SECTION 02581

STREET LIGHTING CONDUIT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pull box and conduit installation for electrical service to thoroughfare street lights.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for conduit is on linear foot basis measured horizontally between pull holes, pull boxes and terminal poles.

2. Refer to Section 01270 - Measurement and Payment for Unit Price Procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this section is included in total Stipulated Price.

1.04 REFERENCES

A. CenterPoint Energy Specification Number 007-371-08. Specification for Installation of Conduit System for Thoroughfare Street Lighting.

PART 2 PRODUCTS

2.01 MATERIALS

A. CenterPoint Energy furnished material:

1. Materials Specifications in Paragraph 3.0 of CenterPoint Energy Specifications Number 007-371-08.

B. Provide following material:

1. Materials specified in Paragraphs 7, 8, and 9 of CenterPoint Energy Specifications number 007-371-08.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify lines and grades are correct. Determine if existing underground utilities or other obstructions may conflict with conduit installation shown on Drawings. Notify Project Manager of potential conflicts.

3.02 PREPARATION

A. Order pull boxes and warning tape from CenterPoint Energy Customer Relations Representative three working days in advance of need. Verify requirements for "driveway" pull boxes for concrete areas subject to vehicular traffic and confirm total number of pull boxes required with CenterPoint Energy Customer Relations Representative.

B. Obtain CenterPoint Energy furnished materials Tuesday through Friday, excluding holidays, from Street Light Office at 4700 South Shaver St., Bldg. 1, Houston, Texas 77034.

3.03 INSTALLATION

A. Notify CenterPoint Energy street lighting Engineer at least 2 working days in advance of scheduled conduit installation.

B. Install conduit in accordance with Paragraphs 7 through 9 and drawings pages 9 through 12 of CenterPoint Energy Specification Number 700-371-08.

3.04 FIELD QUALITY CONTROL

A. Correct nonconforming conduit and pull box installations and obtain written notification from inspector that installation meets CenterPoint Energy requirements.

B. Forward one copy of notification to CenterPoint Energy Customer Relations Representative.

3.05 PROTECTION

A. Protect conduits and pull holes from damage or blockage until street light and circuit installation by CenterPoint Energy.

B. Clear blockage in conduits prior to CenterPoint Energy circuit installation.

END OF SECTION

SECTION 02582

TRAFFIC POLE ASSEMBLIES - STEEL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Steel traffic pole assemblies, including anchor bolts and foundation.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01554 – Traffic Control and Street Signs

D. Section 02465 – Drilled Shaft Foundations

E. Section 02893 – Traffic Signal Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for Traffic Pole Assemblies will be measured by each Traffic Pole Assembly including foundation.

2. The price shall be full compensation for Work performed and materials furnished in accordance with this price item. Foundation is incidental to the cost of the Work. Document 00410 - Bid Form short description includes the type and size of the steel Traffic Pole Assembly. Payment for traffic signal heads, pedestrian signal heads, pedestrian push button stations, and other transportation related devices are paid for separately.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. AASHTO LTS: Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals including interim revisions.

B. AISC: American Institute of Steel Construction

C. AISI: American Iron and Steel Institute

D. ASTM A36: Standard Specification for Carbon Structural Steel

E. ASTM A123: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

F. ASTM A153: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

G. ASTM A501: Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing

H. ASTM A563: Standard Specification for Carbon and Alloy Steel Nuts (Inch and Metric)

I. ASTM A572: Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

J. ASTM A595: Standard Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use

K. ASTM A1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

L. ASTM F1554: Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

M. ASTM F3125 - Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength

N. AWS D1.1 – Structural Welding Code – Steel

1.05 SUBMITTALS

A. The Contractor shall furnish mill test report(s) on steel used in pole fabrication. The mill test report(s) shall be furnished prior to or at the time of pole delivery.

B. Four (4) copies (minimum) of shop drawings shall be furnished for City of Houston review and approval prior to pole fabrication unless otherwise requested by the City but no more than six (6) copies.

C. Two (2) copies of shop drawings will be returned by the City of Houston to the manufacturer for its files.

D. Conform to requirements of Section 01330 - Submittal Procedures.

1.06 DEFINITIONS

A. Traffic Pole Assembly - a steel pole that supports luminaires, traffic signals, pedestrian push button stations, and other transportation related devices. The pole assembly may support a combination of these items.

1. Traffic Pole Assemblies include, but are not limited to:

a. Traffic signal poles;

b. Mast arms;

c. Luminaire arms;

d. Street light poles;

e. Pedestrian push button station support poles;

f. Pedestal poles; and

g. The equivalents.

2. This excludes poles use for purposes that fall outside of the scope of AASHTO's Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

3. This excludes roadside sign structures. Refer to 01554 - Traffic Control and Street Signs for specifications.

PART 2 PRODUCTS

2.01 MATERIALS

A. All items shall be new materials of the latest product in production to the commercial trade and shall be of the highest quality as to materials used and workmanship. The manufacturer of these items shall be experienced in design and construction of such items and shall furnish evidence of having supplied similar items, which have been in successful operation, for not less than three (3) years.

2.02 SILENCE OF SPECIFICATION

A. The apparent silence of these specifications as to any detail, or the apparent omission from it of a detailed description concerning any point, shall be regarded as meaning that only the best commercial practice shall prevail and that only material and workmanship of the finest quality shall be used. All interpretations of these specifications shall be made on the basis of this statement.

2.03 TRAFFIC POLE ASSEMBLIES

A. The Traffic Pole Assemblies shall be designed in accordance with the latest edition of the AASHTO standard specifications.

B. Anchorage: Included with each pole shall be a minimum of four steel anchor bolts, complete with double hex nuts, lock washers and flat washers. Nuts, washers and entire length of the anchor bolts shall be hot-dip galvanized to ASTM - A153. Anchor bolts shall meet the requirements of ASTM F1554, Gr. 55. An anchor bolt template shall be included with each pole assembly.

C. Wind Resistance: Entire pole and arm assembly to be rated to withstand AASHTO requirements for 90 mile per hour wind.

D. Welds: All welds shall meet the requirements of AWS D1.1

E. Material Certification: Material certifications shall be provided for all ASTM numbers referred to in this specification.

F. Complete design drawings and complete technical data must be submitted for approval to the City of Houston prior to starting fabrication. Shop drawings shall be signed and sealed by a Registered Professional Engineer.

G. The pole unit and all materials used in its manufacture shall meet the requirements of the American Association of State Highway and Transportation Officials (AASHTO), specifically LTS: Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals including interim revisions.

H. Pole shaft and arms shall be circular or octagonal in cross-section with no transverse joints or welds and no more than one (1) longitudinal welds per pole or arm. Refer to the standard drawings for exact sizes on the pole diameters. They shall be uniform in cross-section and shall uniformly taper from the pole shaft to the end of the arm. The end of the arm shall be at a height above the pavement, as detailed on the standard drawing, with design vertical loadings, when installed on the pole.

2.04 POLE SHAFT

A. The pole shaft for the Type 1 poles shall be fabricated from a minimum of 3-gauge (0.2391 inch) hot rolled commercial steel. The shaft shall have only one (1) longitudinal, automatically, electrically welded joint, and shall have no intermediate horizontal joints nor welds. After forming and welding, the tapered shaft shall be longitudinally cold rolled over a hardened steel mandrel under sufficient hydraulic pressure to flatten the weld and increase the physical characteristics of the shaft. The shaft shall meet the chemical and physical properties of ASTM-A595 GR. A, having a minimum yield strength of 55,000 psi. Only one length of steel sheet shall be used, which shall be formed into a continuously tapered shaft, having a taper of approximately 0.14 inch per foot.

B. The pole shaft for the Type 2 poles shall be fabricated from a minimum 0.375 inch hot rolled commercial steel. The shaft shall have only one (1) longitudinal, automatically, electrically welded joint, and shall have no intermediate horizontal joints nor welds. The shaft shall meet the chemical and physical properties of ASTM-A572 GR. 55, having a minimum yield strength of 55,000 psi. Only one (1) length of steel sheet shall be used, which shall be formed into a continuously tapered shaft, having a taper of approximately 0.14 inch per foot.

C. The base plate shall conform to ASTM-A36 or ASTM A572 steel. It shall telescope the shaft and be attached by means of two continuous welds, one on the inside of the base at the end of the shaft, the other on the outside at the top of base. The base plate shall be arranged to accept four (4) 2-1/4 inch diameter anchor bolts on an 18 inch bolt circle.

D. The pole shaft shall be furnished with a reinforced handhole frame with steel cover and a 1/2 inch - 13 UNC grounding provision. Dimensions shall be as shown on the detail drawings.

E. Each pole shaft shall include a steel pole plate welded to shaft for the mast arm connection. It shall be arranged to accept four (4) connecting bolts. Pole plate material shall conform to the requirements of ASTM-A36 or ASTM A572 Grade 50 steel.

F. As required, each pole shall be provided with an ornamental pole top. The final shaped pole top shall be mechanically attached to the top of the shaft to provide access for wiring signals secured by a J-hook wire support; also provided. Pole top material shall conform to the requirements of AA-319.0-F aluminum.

G. The pole shaft shall be drilled in the field at required signal locations.

2.05 MAST ARM

A. The mast arm shall be fabricated from a minimum 7-gauge (0.179 inch) hot rolled commercial steel in accordance with ASTM A595 Grade A and shall have a yield of not less than 55,000 psi. It shall be fabricated and formed into a round shape as required, using the same cold rolling process as the pole shaft and shall have the same physical properties and yield strength. Arm dimensions shall be equivalent in strength for the loads shown in the plans.

B. Mast arm shall be a straight flange plate mounted style and shall include a steel arm plate with four (4) connecting bolts. Arm plate material shall conform to the requirements of ASTM-A36 or ASTM A572 Grade 42 steel. Bolts shall be internally mounted to pole plate and meet the requirements of ASTM-F3125.

C. A slip joint shall be permissible for arms forty (40) feet and greater in length. The slip joint shall be made in the shop but may be match marked and shipped disassembled. An automatic submerged arc process shall weld pole shaft and arm. Pole and arm diameters shall be uniform at any cross-section and shall be reasonably straight.

D. Tenons for mounting the vehicle signal head assemblies shall be provided on the mast arm at locations required. Refer to the standard drawings for tenon details.

2.06 LUMINAIRE ARM

A. The luminaire arm shall be fabricated from 2-inch Schedule 80 pipe.

B. The length of the luminaire arm shall be as shown in the standard drawings or required in the plans.

C. The luminaire arm shall be connected to the pole shaft with simplex fittings, and in accordance with details shown on the standard drawings.

2.07 HOT-DIP GALVANIZING

A. Surface Preparation.

1. Prior to being incorporated into an assembled product, steel plates 3/4 inch or more in thickness may require blast cleaning to remove rolled-in mill scale, impurities, and non-metallic foreign materials. After assembly, all weld flux shall be mechanically removed.

2. The iron or steel product is degreased by immersion in an agitated 4.5%-6% concentrated caustic solution elevated to a temperature ranging from 150 to 190- degrees Fahrenheit. It is then pickled by immersion in a heated sulfuric acid solution of 6%-13% concentration, controlling the temperature between 150 and 190-degrees Fahrenheit. It is next rinsed clean from any residual effects of the caustic or acid solutions by immersion in a circulating fresh water bath.

3. Final preparation is done by immersion in a concentrated zinc ammonium chloride flux solution heated to 130-degrees Fahrenheit. The solution's acidity content is maintained between 4.5-5.0 pH. The assembly is air dried to remove any moisture remaining in the flux coat and/or trapped within the product.

B. Pole shaft and arm shall be hot-dip galvanized after fabrication in conformance with ASTM A123 requirements, with a minimum of two (2) ounces per square foot of galvanized coating.

C. All ancillary parts for pole structures shall be hot-dip galvanized after fabrication in conformance with ASTM A153 requirements. The galvanized coating shall be a minimum thickness of two (2) ounces per square foot. All threaded material shall be brushed or retapped after galvanizing. Fabricated products shall be free and clear of teardrop edges, flaking zinc, rough appearance, holes covered with zinc membrane, and similar unattractive finishes. In general, the complete product shall be smooth, clean and unscarred when delivered. Any part of the structures not meeting these requirements shall be rejected.

2.08 POWDER COATING OVER GALVANIZING

A. Surface Preparation. The pole shaft, arm and ancillary parts shall be prepared in accordance with the hot-dip galvanizing requirements of Part 2.07 in this section.

B. Top Coat. All galvanized exterior surfaces visually exposed are to be coated with a Urethane or Triglycidyl Isocyanurate (TGIC) Polyester Powder to a minimum film thickness of 2.0 mils. The galvanized exterior should be etched, preheated, then powder coated. The coating shall be electrostatically applied and cured in a gas-fired convection oven by heating the steel substrate to a minimum of 350-degrees Fahrenheit and a maximum of 400-degrees Fahrenheit.

C. Packaging. In order to protect the finish during transportation, a wrapping of 3/16" U.V. inhibited plastic-backed packing foam must be applied prior to shipment of small poles. Larger poles are cradled in a 1-inch rubberized foam base. A nylon ripcord shall be placed beneath the wrapping the entire length of the pole for removal of the wrapping without the use of knives or any other sharp instrument that may damage the painted surface.

2.09 FOUNDATION

A. Construct foundation in accordance with Section 02465 – Drilled Shaft Foundations, 02893 – Traffic Signal Construction, and as shown on Drawings.

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 02590

STREETLIGHT LUMINAIRES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Traffic Signal Pole Luminaire

B. Major Thoroughfare Luminaire

C. Collector Street Luminaire

D. Local Street Luminaire

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for luminaires will be measured by each luminaire type.

2. Payment for the work performed and materials furnished in accordance with this specification will be paid for at the unit price bid for "Traffic Signal Pole Luminaire", "Major thoroughfare Luminaire", "Collector Street Luminaire", or "Local Street Luminaire".

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. The approved luminaires shall meet the standards referenced below:

1. Publications are referenced within the text by their basic designation only. Versions listed shall be superseded by updated versions as they become available.

a. ANSI C78.377-2017, R2022 (or latest), American National Standard for Electrical Lamps – Specifications for the Chromaticity of Solid State Lighting (SSL) Products

b. ANSI C82.77-2021 (or latest), American National Standard for Lighting Equipment - Harmonic Emission Limits - Related Power Quality Requirements

c. ANSI C136.2-2018(or latest), American National Standard for Roadway and Area Lighting Equipment - Dielectric Withstand and Electrical Transient Immunity Requirements

d. ANSI C136.10-2017 (or latest), American National Standard for Roadway and Area Lighting Equipment - Locking-Type Photocontrol Devices and Mating Receptacles- Physical and Electrical Interchangeability and Testing

e. ANSI C136.15-2020 (or latest), American National Standard for Roadway and Area Lighting Equipment - Luminaire Field Identification

f. ANSI C136.22-2019 (or latest), American National Standard for Roadway and Area Lighting Equipment - Internal Labeling of Luminaires

g. ANSI C136.25-2019 (or latest), American National Standard for Roadway and Area Lighting Equipment - Ingress Protection (Resistance to Dust, Solid Objects and Moisture) for Luminaire Enclosures

h. ANSI C136.31-2018 (or latest), American National Standard for Roadway and Area Lighting Equipment - Luminaire Vibration

i. ANSI C136.37-2019 (or latest), American National Standard for Solid State Light Sources Used in Roadway and Area Lighting

j. ANSI C136.41-2021 (or latest), American National Standard for Roadway and Area Lighting Equipment-Dimming Control Between an External Locking Type Photocontrol and Ballast or Driver

k. ANSI/IEEE C62.45: IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and less) AC Power Circuits

l. ANSI/IEEE C62.41.2: IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits

m. ANSI/IES LM-80-21: Measuring Maintenance of Light Output Characteristics of Solid-State Light Sources

n. ANSI/IES TM-21-21: Projecting Long-Term Luminous, Photon, and Radiant Flux Maintenance of LED Light Sources

o. ASTM B117: Standard Practice for Operating salt Spray (Fog) Apparatus

p. ASTM D523: Standard Test Method for Specular Gloss

q. ASTM D1654: Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

r. ASTM G154: Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Materials

s. ISO 17025-2017: General requirements for the competence of testing and calibration laboratories

t. U.S. Department of Energy & Municipal Solid-State Street Lighting Consortium model specification for LED roadway luminaires electrical immunity requirements for High Test Level 10kV/10kA

1.05 SUBMITTALS

A. The Contractor shall furnish six (6) copies of luminaire submittal package to the CITY OF HOUSTON. Submittal package shall include luminaire cut sheet, LED light source cut sheet, LED driver cut sheet, surge protective device cut sheet, LM-79 luminaire photometric report with photometric file in LM-63 format, LM-80 data, ISTMT report, energy star TM-21 calculator, 3G vibration test, UL1598 certification and warranty.

B. Conform to requirements of Section 01330 - Submittal Procedures.

1.06 WARRANTY

A. Luminaire shall come with a 10-year warranty on product and finish.

PART 2 PRODUCTS

2.01 MATERIALS

A. All items shall be new materials of the latest product in production to the commercial trade, and shall be of the highest quality as to materials used and workmanship. The manufacturer of these items shall be experienced in design and construction of such items and shall furnish evidence of having supplied similar items, which have been in successful operation, for not less than ten (10) years.

2.02 SILENCE OF SPECIFICATIONS

A. The apparent silence of these specifications as to any detail, or the apparent omission from it of a detailed description concerning any point, shall be regarded as meaning that only the best commercial practice shall prevail and that only material and workmanship of the finest quality shall be used. All interpretations of these specifications shall be made on the basis of this statement.

2.03 LUMINAIRE HOUSING

A. Luminaire shall have cobra head style/shape/aesthetic. An internal bubble level shall be provided with mounting provisions that permit ±5° leveling in 2.5° increments. Color shall be gray.

B. Luminaire finish shall exceed a rating of 6 per ASTM D1654 after 1000 hours & 1500 hours, and shall meet or exceed a rating of 6 after 3000 hours, testing per ASTM B117, surpasses ANSI C136.37. The coating shall exhibit no greater than 30% reduction of gloss per ASTM D523, after 500 hours of QUV testing at ASTM G154 Cycle 6.

C. Vibration shall meet ANSI C136.31, Level 2 (bridge/overpass, 3G)

D. QR Code Label: Luminaire shall be equipped with a unique QR label that is visible on the outside of the luminaire. The QR label shall be supported by a dedicated smartphone app. App shall be able to access detailed product specific information as well as mounting instructions. The QR code label app shall enable product registration on site, after installation, and record GPS location of installed fixture, installed location photo and provision for additional information. Additionally, app shall provide diagnostic support and enable identification of the specific spare parts available for repairs.

2.04 ELECTRICAL, ELECTRONIC DRIVERS AND LED MODULES

A. Luminaire shall have Luminaire Useful Life of 94,500+ hours to 100,000+ hours based on ISMT in-situ thermal testing per UL 1598, LED driver data, LED light source(s) LM-80 and TM-21 data, and system reliability tool data. Luminaire shall start and operate in -40C to +40C temperature range.

B. Electronic driver must be able to dim 0-10 volts and operate per the following line voltages noted for each application. All electrical components must be RoHS compliant.

Traffic Signal Pole Luminaire - 120-277V
Major Thoroughfare Luminaire - 480V
Collector Street Luminaire - 120-277V
Local Street Luminaire - 120-277V

C. LED module shall be composed of distinct, individual high performance LEDS, No Chip on Board will be accepted. LED light source(s) shall have no wire bond, which prevents open circuit failures in the LED light source(s) and enhances long-term reliability and useful life. If individual LED(s) fail, they shall fail short keeping the rest of the LED light source and the entire LED luminaire operating. LED light engines must be IP66 sealed, UV stabilized surpassing ANSI C136.37. LEDs shall be tested by ISO 17025-2017 accredited lab in accordance with ANSI/IES LM-80 guidelines in compliance with EPA ENERGY STAR, extrapolations in accordance with ANSI/IES TM-21.

2.05 PERFORMANCE REQUIREMENTS:

A. Traffic Signal Pole Luminaire:

1. Luminaire shall have a maximum weight of 12.3 pounds and a maximum effective projected area of 0.523 square feet. Light output must exceed 12,750 lumens with distribution Type III. System wattage must not exceed 106 watts. Color temperature as per ANSI/NEMA bin Neutral White, 4000 Kelvin nominal (3985K +/- 275K or 3710 to 4260K), CRI 70 Minimum. Lumen maintenance shall be 94% minimum of initial output at 60,000 hours operation. BUG Rating shall be B3-U0-G2.

B. Major Thoroughfare Luminaire:

1. Luminaire shall have a maximum weight of 12.3 pounds and a maximum effective projected area of 0.523 square feet. Light output must exceed 12,750 lumens with distribution Type II. System wattage must not exceed 106 watts. Color temperature as per ANSI/NEMA bin Neutral White, 4000 Kelvin nominal (3985K +/- 275K or 3710 to 4260K), CRI 70 Minimum. Lumen maintenance shall be 94% minimum of initial output at 60,000 hours operation. BUG Rating shall be B3-U0-G2.

C. Collector Street Luminaire:

1. Luminaire shall have a maximum weight of 12.3 pounds and a maximum effective projected area of 0.523 square feet. Light output must exceed 8,500 lumens with distribution Type II. System wattage must not exceed 75 watts. Color temperature as per ANSI/NEMA bin Neutral White, 4000 Kelvin nominal (3985K +/- 275K or 3710 to 4260K), CRI 70 Minimum. Lumen maintenance shall be 94% minimum of initial output at 60,000 hours operation. BUG Rating shall be B2-U0-G2.

D. Local Street Luminaire:

1. Luminaire shall have a maximum weight of 9.4 pounds and a maximum effective projected area of 0.520 square feet. Light output must exceed 4,950 lumens with distribution Type II. System wattage must not exceed 45 watts. Color temperature as per ANSI/NEMA bin Warm White, 3000 Kelvin nominal (3045K +/- 175K or 2870 to 3220K), CRI 70 Minimum. Lumen maintenance shall be 94% minimum of initial output at 60,000 hours operation. BUG Rating shall be B1-U0-G1.

2.06 SURGE PROTECTION:

A. Integral surge protector tested in accordance with ANSI/IEEE C62.45 per ANSI/IEEE C62.41.2 Scenario 1 Category C High Exposure with elevated 20kV/20kA waveforms for line-ground, line neutral and neutral ground, and in accordance with U.S. Department of Energy & Municipal Solid-State Street Lighting Consortium model specification for LED roadway luminaires electrical immunity requirements for High Test Level 10kV/10kA.

2.07 CONTROLS:

A. Provide 7 pin receptacle with photoelectric cell, twist-lock type, "fail on", extended life, input voltage of 120-277 VAC or 480 VAC to match Luminaire driver voltage rating. Operating range 50/60 Hz. Max rated load of 1000W/1800VA. Integrated standard surge protection of 640J. Rated for operation in an ambient temperature of -40°C/-40°F up to +70°C/+158°F. 10-year limited warranty from supplier.

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 02611

REINFORCED CONCRETE PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Reinforced concrete pipe for sanitary sewers and storm sewers.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02426 – Sewer Line in Tunnels

D. Section 02427 – Plastic Liner for Large-Diameter Concrete Sewers and Structures

E. Section 02431 – Tunnel Grout

F. Section 02441 – Microtunneling

G. Section 02445 – Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels

H. Section 02448 – Pipe and Casing Augering for Sewers

I. Section 02531 – Gravity Sanitary Sewers

J. Section 02631 – Storm Sewers

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for reinforced concrete pipe under this Section. Include cost in unit price Work as specified in following Sections:

a. Section 02426 - Sewer Line in Tunnels.

b. Section 02531 - Gravity Sanitary Sewers.

c. Section 02631 - Storm Sewers.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.

B. ASTM C 443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.

C. ASTM C 497 - Standard Test Method for Concrete Pipe, Manhole Sections, or Tile.

D. ASTM C 506 - Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain and Sewer Pipe

E. ASTM C 507 – Standard Specification for Reinforced Concrete Elliptical Culverts, Storm Drains and Sewer Pipe

F. ASTM C 655 - Standard Specification for Reinforced Concrete D-load Culvert, Storm Drain and Sewer Pipe.

G. ASTM C 877 - Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections.

H. ASTM C 990 – Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections using Preformed Flexible Joint Sealants.

I. ASTM C 1479 – Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit complete product data for pipe, fittings and gaskets for approval. Indicate conformance to appropriate reference standards.

C. Submit manufacturer’s certificate that concrete pipes meet applicable standards.

D. For jacking pipe, submit drawings and data describing grouting port design and closure procedures when required by Section 02431 - Tunnel Grout, including liner repair, as applicable.

PART 2 PRODUCTS

2.01 REINFORCED CONCRETE PIPE

A. Conform circular reinforced concrete pipe to requirements of ASTM C 76, Class III. Conform to rubber gasket joints for sanitary sewers and storm sewers per ASTM C443 and tongue and groove joints for roadside ditch culverts with joints per ASTM C 990.

B. Conform reinforced concrete arch pipe to requirements of ASTM C 506 for Class A-III. Joints shall conform to ASTM C 443 or tongue & groove joints shall conform to ASTM C990 with external sealing bands conforming to ASTM C 877. For roadside ditch culverts only, external sealing bands are not required.

C. Reinforced concrete elliptical pipe, either vertical or horizontal, shall conform to requirements of ASTM C 507 for Class VE-III for vertical or Class HE-III for horizontal. Use rubber gasket joints conforming to ASTM C 877. Rubber gasket joints shall conform to ASTM C443. Tongue & groove joints shall conform to ASTM C 990 with external sealing bands conforming to ASTM C 877. For roadside ditch culverts only, external sealing bands are not required

D. Conform reinforced concrete D-load pipe requirements of ASTM C 655.

E. Third-Party Certification Requirement:

1. Precast concrete manufacturers supplying precast concrete products shall maintain active certification from an accepted third-party quality control program at the time of manufacture.

2. Accepted third-party quality control programs are the National Precast Concrete Association (NPCA) Plant Certification Program and the American Concrete Pipe Association (ACPA) Q-Cast Program.

3. Copies of certificates demonstrating compliance with the above third-party plant certification requirements shall be furnished upon the first delivery to the project. Certifications shall be resubmitted annually thereafter or upon request by the Project Manager.

2.02 GASKETS

A. When no contaminant is identified, furnish joints per Article 2.01

B. Use the following gasket materials for pipes to be installed in potentially contaminated areas, especially where free product is found near elevation of proposed sewer:

CONTAMINANT	GASKET MATERIAL REQUIRED
Petroleum (diesel, gasoline)	Nitrile Rubber
Other Contaminants	As recommended by pipe manufacturer, Engineer of the Record and approved by City Engineer prior to installation

2.03 LINERS FOR SANITARY SEWER PIPE

A. Reinforced concrete pipe for sanitary sewers shall be PVC lined and conform to Section 02427 - Plastic Liner for Large-Diameter Concrete Sewers and Structures.

B. Reinforced concrete pipes to be installed in potentially contaminated areas shall have liners recommended by manufacturer as resistant to contaminants identified in Phase II Environmental Site Assessment Report.

2.04 SOURCE QUALITY CONTROL

A. Representatives of City Engineer will inspect manufacturer's plant and casting operations as deemed necessary.

B. Precast Unit Identification: Mark date of manufacture and name or trademark of manufacturer clearly on inside of pipe.

C. Rejection: Precast units rejected for non-conformity with these specifications and for following reasons:

1. Fractures or cracks passing through shell, except for single end crack that does not exceed depth of joint.

2. Surface defects indicating honeycombed or open texture.

3. Damaged or misshaped ends, where damage would prevent making satisfactory joint.

D. Replacement: Immediately remove rejected units from Work site and replace with acceptable units.

E. Repairs: Occasional imperfections resulting from manufacture or accidental damage may be repaired if, in opinion of Project Manager, repaired units conform to requirements of these specifications

PART 3 EXECUTION

3.01 INSTALLATION

A. Conform to requirements of following Sections, as applicable:

1. Section 02441 - Microtunneling

2. Section 02445 - Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels

3. Section 02448 - Pipe and Casing Augering for Sewers

4. Section 02531 - Gravity Sanitary Sewers.

5. Section 02631 - Storm Sewers.

B. Install reinforced concrete pipe in accordance with ASTM C 1479 and manufacturer's recommendations.

END OF SECTION

SECTION 02612

PRECAST REINFORCED CONCRETE BOX SEWERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Precast reinforced concrete box for storm sewers.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02631 – Storm Sewers

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for precast reinforced concrete box sewer under this Section. Include payment in unit price for Sections 02631 - Storm Sewers.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 1577 – Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers Designed According to AASHTO LRFD.

B. ASTM C 990 – Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Flexible Joint Sealants.

C. ASTM C 1677 – Standard Specification for Joints for Concrete Box, Using Rubber Gaskets.

D. ASTM C 1675 – Standard Practice for Installation of Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains and Sewers.

E. ASTM C 1837 – Standard Specification for Production of Dry Cast Concrete for Manufacturing Pipe, Box and Precast Structures.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit shop drawings and data on box sections, fittings, gaskets, and appurtenances for approval. Indicate conformance to reference standards.

PART 2 PRODUCTS

2.01 PRECAST REINFORCED CONCRETE BOX SEWERS

A. Conform to ASTM C 1577, as indicated on Drawings.

B. Pipe and boxes shall be machine-made or cast by process which will provide for uniform placement of concrete in forms and compaction by mechanical devices to produce dense, structurally sound concrete.

C. Box culverts may be supplied with a tongue and groove joint per ASTM C 990. Rubber gaskets per ASTM C 1677 may be used if indicated on drawings.

D. Third-Party Certification Requirement:

1. Precast concrete manufacturers supplying precast concrete products shall maintain active certification from an accepted third-party quality control program at the time of manufacture.

2. Accepted third-party quality control programs are the National Precast Concrete Association (NPCA) Plant Certification Program and the American Concrete Pipe Association (ACPA) Q-Cast Program.

3. Copies of certificates demonstrating compliance with the above third-party plant certification requirements shall be furnished upon the first delivery to the project. Certifications shall be resubmitted annually thereafter or upon request by the Project Manager.

2.02 CONCRETE

A. Conform to requirements of ASTM C 1837.

B. Use concrete mixed in central batch plant or other batching facility from which quality and uniformity of concrete can be assured. Transit-mixed concrete is not acceptable.

2.03 SOURCE QUALITY CONTROL

A. Representatives of City Engineer will inspect manufacturer's plant and casting operations as deemed necessary.

B. Precast Unit Identification: Mark date of manufacture and name or trademark of manufacturer clearly on inside of box sewer.

C. Rejection: Precast units rejected for non-conformity with these specifications and for following reasons:

1. Fractures or cracks passing through shell, except for single end crack that does not exceed depth of joint.

2. Surface defects indicating honeycombed or open texture.

3. Damaged or misshaped ends, where damage would prevent making satisfactory joint.

D. Replacement: Immediately remove rejected units from Work site and replace with acceptable units.

E. Repairs: Occasional imperfections resulting from manufacture or accidental damage may be repaired if, in opinion of Project Manager, repaired units conform to requirements of these specifications

PART 3 EXECUTION

3.01 INSTALLATION

A. Install concrete box sewer in accordance with ASTM C 1675.

3.02 BEDDING

A. Bed box sections on foundation of firm and stable material accurately shaped to conform to their bases. Install bedding as specified in Section 02317 - Excavation and Backfill for Utilities. When required by Drawings, use special bedding material. When single-cell box sections are placed in parallel for multi-cell installation, place in conformance with details shown on Drawings.

3.03 PLACEMENT

A. Carefully lower box sections to bottom of trench and lay accurately in line and grade, with spigot or tongue end downstream entering bell or groove end to full depth and in such manner as not to drag foreign material into annular space.

3.04 JOINTING

A. Join box sections together and match so that they will form continuous smooth and uniform.

3.05 BACKFILLING

A. After box has been properly jointed and bedded, commence backfilling.

B. Backfill in accordance with Section 02317 - Excavation and Backfill for Utilities.

END OF SECTION

SECTION 02613

BAR WRAPPED STEEL CYLINDER PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnishing and installing new bar wrapped steel cylinder pipe and fittings for buried water lines for sizes 20 inches to 60 inches in diameter.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02425 – Tunnel Excavation and Primary Liner

E. Section 02502 – Steel Pipe and Fittings

F. Section 02511 – Water Lines

G. Section 02518 – Steel Pipe and Fittings for Large Diameter Water Lines

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for bar wrapped steel cylinder pipe under this Section. Include cost in price for water lines.

2. Maintain, on site, minimum of two 3-degree and two 5-degree grade angle adapters. Adapters are considered “extra unit price.” When used during construction, adapter will be paid at unit price.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AASHTO - Standard Specifications for Highway Bridges.

B. AREMA - Manual of Railway Engineering, Volume II, Chapter 15.

C. ASTM A 615 - Standard Specification for Deformed and Plain Billet Carbon Steel Bars for Concrete Reinforcement.

D. ASTM C 33 - Standard Specification for Concrete Aggregates.

E. ASTM C 35 - Standard Specification for Inorganic Aggregates for Use in Gypsum Plaster.

F. ASTM C 150 - Standard Specification for Portland Cement.

G. ASTM C 497 - Standard Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile.

H. ASTM D 512 - Standard Test Methods for Chloride Ion in Water.

I. ASTM C 1107 (CRD C-621) - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).

J. ASTM D 1293 - Standard Test Methods for pH of Water.

K. ASTM E 165 - Standard Practice for Liquid Penetrant Testing for General Industry.

L. ASTM E 340 - Standard Test Method for Macroetching Metals and Alloys.

M. ASTM E 709 - Standard Guide for Magnetic Particle Testing.

N. ASTM E 1032 - Standard Test Methods for Radiographic Examination of Weldments.

O. ANSI/AWS A3.0 - Standard Welding Terms and Definitions.

P. AWWA C 200 - Standard for Steel Water Pipe 6 in. and Larger.

Q. AWWA C 206 - Standard for Field Welding of Steel Water Pipe.

R. AWWA C 207 - Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 in. through 144 in.

S. AWWA C 301 - Prestressed Concrete Pressure Pipe, Steel-Cylinder Type

T. AWWA C 303 - Standard for Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type.

U. AWWA C 304 - Standard for Design of Prestressed Concrete Cylinder Pipe.

V. AWWA M 9 - Concrete Pressure Pipe.

W. NSF 61 - Drinking Water System Components - Health Effects.

X. SSPC SP 7 - Surface Preparation Specification No. 7 Brush Off Blast Cleaning.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit shop drawings and certification signed and sealed by Professional Engineer registered in State of Texas showing following:

1. Manufacturer's pipe design calculations

2. Provide lay schedule of pictorial nature indicating alignment and grade, laying dimensions, welding procedures, fabrication, fitting, flange, and special details, with plan view of each pipe segment sketched, detailing pipe invert elevations, horizontal bends, welded joints, and other critical features. Indicate station numbers for pipe and fittings corresponding to Drawings. Do not start production of pipe and fittings prior to review and approval by Project Manager. Provide final approved lay schedule on CD-ROM in Adobe portable document format (*PDF).

3. Include hot tapping procedure.

4. Submit certification from manufacturer that design was performed for project in accordance with requirements of this section.

C. Submit inspection procedures to be used by manufacturer and for quality control and assurance for materials and welding. Submit standard repair procedures that describe in detail shop and field work to be performed. Repair defects such as substandard welds, excessive radial offsets (misalignment), pitting, gouges, cracks, etc.

D. Submit following within 45 days after manufacturing of pipe and fittings:

1. Steel:

a. Steel reports as required in AWWA C303, Section 5.2.5.

b. Results of other tests of steel reinforcement required in AWWA C303, Section 5.2.

2. Test Results.

a. Hydrostatic testing, acid etching, magnetic particle and x-ray weld test reports as required.

b. Compressive strength (7 and 28 day) test results for each type of coating and lining mix design.

3. Submit pipe manufacturer's certification that Bar Wrapped Steel Cylinder Pipe:

a. Cylinder assembly has been hydrostatically tested at factory.

b. Mortar coatings and linings were applied or allowed to cure at temperature above 32 degrees Fahrenheit.

E. Submit following for non-shrink grout for special applications:

1. Manufacturer's technical literature including specifications for mixing, placing, and curing grout.

2. Results of tests performed by certified independent testing laboratory showing conformance to ASTM C 1107, Non-shrink Grout and requirements of this specification.

3. Certification product is suitable for use in contact with potable water.

F. Submit certification for welder and welding operator demonstrating their certification in accordance with AWWA C 206. Indicate certified procedures and position each welder is qualified to perform.

G. Calibrate within last 12 months for equipment such as scales, measuring devices, and calibration tools used in manufacture of pipe. Each device used in manufacture of pipe is required to have tag recording date of last calibration. Devices are subject to inspection by Project Manager.

1.06 QUALITY CONTROL

A. Manufacturer to have permanent quality control department and laboratory facility capable of performing inspection and testing required. Inspection procedures and manufacturing process are subject to inspection by Project Manager. Perform manufacturer tests and inspections required by AWWA C 303 as modified by these Specifications. Correct nonconforming conditions.

1. Cylinder and Joint Ring Assembly:

a. Review mill certifications for conformance to requirements of Specifications.

b. Perform physical testing of each heat of steel for conformance to applicable ASTM standards.

c. Inspect physical dimensions and overall condition of joint rings and cylinder/joint ring assembly to verify compliance with requirements of AWWA C 303. Maximum allowable thickness variation of cylinder shall not be less than determined thickness.

d. Test cylinder/joint ring weld for tensile strength. Test one specimen for each 500 cylinder/joint ring assemblies in addition to those tests required by AWWA C 301.

e. Reject pipe with dented steel cylinders.

2. Bar Rod

   a. Review mill certifications for conformance to requirements of Specifications.

   b. Inspect rod spacing during placement on cylinder.

   c. Test rod splices for each production run or minimum of once a week, whichever is less, for conformance with minimum strength criteria.

3. Pipe Lining Coating:

   a. Review mill certificates for each load of cement for conformance to ASTM C 150.

   b. Perform sieve analyses weekly for each source of coarse and fine aggregate for conformance to ASTM C 33.

   c. Inspect kiln recorder charts daily to confirm proper curing environment.

   d. Verify mortar thickness on each size of pipe to a tolerance of 1/16th of an inch of required thickness.

   e. Perform absorption tests in accordance with ASTM C 497, Method A, on cured mortar samples taken from pipes.

   f. Check mortar batch proportions, moisture content and slurry application rate. Check coating thickness over wire on each pipe.

   g. Check physical integrity of cured mortar coating. Check cured mortar coating for soundness on every pipe in field in addition to manufacturing plant.

   h. Reject pipe with cracks in mortar coating exceeding 0.01 inches wide.

4. Protective Coatings: Check daily application rate and resulting dry film thickness.

B. Gaskets:

1. Randomly test rubber cord for diameter, tensile strength, elongation, compression set, hardness, and specific gravity after oven aging on one out of 100 gaskets.

2. Stretch test each gasket splice to twice its unstretched length and inspect for defects.

C. Weld Testing

1. Perform macroetching tests for complete penetration production welds on normal production weld tests. Complete joint penetration welds are defined in ANSI/AWS A3.0. Verify complete joint penetration by means of macroetch of joint weld cross section. Macroetch technique in accordance with ASTM E 340.

2. Perform x-ray, ultrasonic, magnetic particle, or dye penetrant testing per AWWA C200 of manual welds on special pipe and fittings.

3. Perform minimum of one set of weld test specimens in accordance with ANSI/AWS A3.0 on each size, grade and wall thickness at minimum of every 3,000 feet of pipe manufactured; but perform no less than one test per project by each welding machine and each operator.

D. Cast four standard test cylinders each day for each 50 cubic yards of concrete mortar coating or portion thereof for each coating and lining mix design placed in day. Perform compressive strength test at 28 days. No cylinder test result shall be less than 80 percent of specified strength. Reject pipe that does not meet minimum strength requirements.

E. Make available copy of Physical and Chemical testing reports for steel cylinders and provide reports at request of Project Manager.

F. Check physical dimensions of pipe and fittings: Physical dimensions to include at least pipe lengths, pipe I.D., pipe O.D. and bend angles.

PART 2 PRODUCTS

2.01 MATERIALS

A. Furnish pipe by same manufacturer. Do not ship over salt water.

B. Provide bar wrapped steel cylinder pipe in conformance with AWWA C 303 and AWWA M 9, except as modified herein. Produce pipe cylinder to conform to AWWA C 303 except modify Section 4.5 to require that total cross-sectional area of bell ring plus cross-sectional area of bar reinforcement over bell ring exceed circumferential steel area in like length of barrel area by one-third.

C. Use of pipe from inventory is permitted only if specifications and certifications are met. Provide testing records for such pipe.

D. Do not use bar wrapped steel cylinder pipe in aerial crossings, exposed or other unburied areas.

E. Pipe Manufacturer.

1. Must have minimum of 5 years of manufacturer's pipe installations that have been in successful and continuous service.

2. Must maintain on site or in plant minimum of four 22.5 bends per 10,000 linear feet of water line. Any combination of bends may be substituted at manufacturer's option (i.e. two 11.25 bends are equivalent to one 22.5 bend and shall be counted as one fitting). Must be capable of delivering bends to job site within 12 hours of notification. These fittings are in addition to any fittings called out on Drawing and must be available at all times.

F. Pipe Design Conditions:

1. Working pressure: 150 psi.

2. Hydrostatic field test pressure: 150 psi.

3. Maximum pressure due to surge: 225 psi.

4. Minimum pressure due to surge: -10 psi.

5. Unit weight of soil: 120 pcf minimum, unless otherwise specified.

6. Minimum trench width: O.D. of pipe + 4 feet.

7. Pipe and Fittings: Designed to withstand most critical simultaneous application of external loads including construction loads and internal pressures.

8. Design: Design pipe and fittings to withstand most critical simultaneous application of external loads and internal pressures. Base design on minimum of AASHTO HL-93 loading, AREMA E-80 loads and depths of bury as indicated on Drawings. Design pipes with Marston's earth loads for transition width trench for all heights of cover.

   a. Calculate moments and thrusts in wall based on earth load.

9. Increase longitudinal steel area (cylinder thickness) to prevent cylinder stress from exceeding 40 percent of minimum yield point at rated working pressure and 67 percent of minimum yield point at rated maximum surge pressure where pipe and fittings are subjected to longitudinal stresses induced by restrained joints or thrust blocks.

10. Groundwater Level: Design for most critical ground water level condition.

11. Modulus of elasticity (E) = 30,000,000 psi.

12. Design stress due to working pressure to be no greater than 50 percent of minimum yield, and stress not to exceed 16,500 psi for mortar coated pipe.

13. Design stress due to maximum hydraulic surge pressure to be no greater than 75 percent of minimum yield, and stress not to exceed 24,750 psi for mortar coated pipe.

14. Modulus of soil reaction (E) < 1500 psi. If E > 1000 psi, do not use silty sand (SM) for embedment.

15. Deflection lag factor (Dl) = 1.2.

16. Bedding constant (K) = 0.1.

17. Fully saturated soil conditions: hw = h = depth of cover above top of pipe.

18. Provide minimum inside clear diameter for tunnel liners or casing in accordance with Section 02425 - Tunnel Excavation and Primary Liner.

19. Exclude structural benefits associated with primary liner in design of pipe in tunnel installations.

    a. Design pipe and joints to carry loads including overburden and lateral earth pressures, subsurface soil and water loads, grouting, other conditions of service, thrust of jacks, and stresses anticipated during handling and construction loads during installation of pipe.

    b. Do not use internal removable stiffeners for pipe in tunnel, unless approved by Project Manager.

    c. External welded stiffeners shall be permitted in design calculations for pipe, provided wall thickness is minimum of 1/2 inch. Minimum clearances specified between exterior pipe wall and tunnel liner applies to distance between outside diameter of external welded stiffener and tunnel liner.

20. Design pipe for transmitting potable water, unless otherwise shown on Drawings. Tunnel and Augered Sections: Provide constant outside diameter from bell to spigot end for pipe. Exclude structural benefits associated with primary liner. Design pipe and pipe joints to carry loads including but not limited to: overburden and lateral earth pressures, subsurface soil, grouting, other conditions of service, thrust of jacks, and any stress anticipated during handling and installation.

G. Coatings and Linings:

1. Provide Portland cement; ASTM C 150, Type I or II. Provide one type of cement for entire project.

2. Water Absorption Test: ASTM C 497, Method A; perform on samples of cured mortar coating taken from each working shift. Cure mortar coating samples in same manner as pipe.

    a. Test Value: Average minimum of 3 samples taken from same working shift, no greater than 9 percent for average value, and 11 percent for individual value.

b. Test Frequency: Perform tests each working shift until conformance to absorption requirements has been established by 10 consecutive passing test results, at which time testing may be performed weekly. Resume testing for each working shift if absorption test results fail until conformance to absorption requirements is reestablished by 10 consecutive passing test results.

3. Apply one coat of primer to exposed steel parts of steel bell and spigot rings. Prior to coating, blast clean in accordance with SSPC-SP7 (Brush Off Blast Cleaning). Apply primer in accordance with manufacturer's recommendations.

4. Coat and line access inlets, service outlets, test inlets and air release/vacuum relief riser pipe with same coating and lining of water line pipe in accordance with AWWA C 303, Section 4, unless otherwise indicated on Drawings.

5. Do not defer placing of coating of any portion of pipe length. Verify cement mortar coating thickness on each size of pipe by nondestructive method before removing pipe from coating machine.

6. Remove and replace disbonded lining or coating. Reject pipe requiring patches larger than 100 square inches or 12 inches in greatest dimension. Allow no more than one patch on either lining or coating of pipe. Provide WELD-CRETE Probond Epoxy Bonding Agent ET-150, parts A and B; Sikadur 32 Hi-Mod, or approved equal bonding agent for pipe patching.

H. Fittings and Specials:

1. Design fittings to same internal and external loads as straight pipe.

2. Manufacture in accordance with Section 02518 - Steel Pipe and Fittings for Large Diameter Water Lines.

3. Provide fabricated bends or fittings with minimum radius of 2-1/2 times pipe diameter.

4. Design test plugs to withstand forces generated by hydrostatic test and test pressure from either side. Do not exceed 50% of minimum yield for design stresses due to hydrostatic pressure. Assume opposite side of plug does not contain water.

5. Provide no specials less than 4 feet in length unless indicated on Drawings or approved by Project Manager.

6. Butt Straps for Closure Piece: Provide at locations indicated on Drawings or authorized by Project Manager. Minimum 12-inch-wide split butt strap; minimum plate thickness equal to thinnest member being joined; fabricated from material equal in chemical and physical properties to thinnest member being joined. Permit no angular deflection at butt-strap joints.

7. Provide minimum 6-inch welded outlet for inspecting each closure section, unless access manway is within 40 feet of closure section.

8. Provide Densco petroleum based tape or approved equal for exposed portions of nuts and bolts.

I. Joints:

1. AWWA C 303 rubber-gasketed or welded bell-and-spigot type except where flanged joints are required for valves and fittings as shown on Drawings. Refer to Section 02511 - Water Lines for details on joints and jointing.

2. Rubber-Gasketed Joints: Attach joint ring to steel cylinder with full-thickness fillet welds, welded inside and out (double welded). Bond as shown on Drawings to provide electrical continuity along pipeline.

3. Restrained Joints: Restrain joints by welding or harnessing joints.

   a. Design Pressure: 1.5 times working pressure.

   b. Harnessed Joints: AWWA M 9, clamp or snap ring type, except where prohibited. Snap ring joints permitted up to 30-inch diameter.

   c. Groundwater Level: Assumed to be equal to natural ground surface.

   d. Provide restrained joint pipe with adequate cylinder thickness to transmit full thrust generated by internal pressure across joints.

      (1) Calculate distance of restrained joints based on resistance along each leg of bend with thrust based on bend angle.

      (2) Cylinder thickness not to be less than that defined in AWWA C303, Table 2, and minimum nominal cylinder thickness.

      (3) Allow cylinder thickness to reduce linearly from maximum calculated thickness to minimum thickness required by design over required length (as determined in Paragraph 2.01 J.3.d.1) of restrained joints.

      (4) Provide full circumferential welds at joints required to be welded. Double weld joint rings in areas of thrust.

J. Use only fully circumferentially welded joints in areas considered potentially petroleum contaminated, within tunnels and under foreign pipelines. Perform welding in accordance with Section 02502 - Steel Pipe and Fittings and Section 02518 - Steel Pipe and Fittings for Large Diameter Water Lines.

K. Pipe Flanges: AWWA C 207 for standard steel flanges of pressure class corresponding to pipe class.

L. Pipe lengths: Provide pipe sections in standard lengths with minimum length of 16 feet and maximum length of 25 feet, and as indicated on approved shop Drawings or approved by Project Manager. Gasketed joints are allowed on standard lengths of pipe. Non-standard pipe lengths must be approved by Project Manager and joints must be welded as specified herein to achieve equal to or greater than standard pipe length before gasketed joints can be used. Internally and externally mark pipe section with durable marking to show location and pipe pressure.

M. Hydrostatic Test of Cylinder: In accordance with AWWA C 303, at point of manufacture. Hold test for minimum 2 minutes for thorough inspection of cylinder. Repair or reject cylinders revealing leaks or cracks.

N. Transport fittings with end caps. Remove end caps just prior to installation.

O. Transport fittings 36 inches in diameter and larger with stulls. Remove stulls after completion of backfill.

P. Provide radius of curve as indicated on Drawings unless approved by Project Manager. Make curves and bends by deflecting joints, by use of beveled joints, or by combination of two methods, unless otherwise indicated on Drawings. Do not exceed deflection angle recommended by pipe manufacturer. Provide beveled pipe sections of standard length used in curved alignment, except when shorter sections are required to limit radius of curvature. In such case, provide sections throughout curve of substantially equal length.

Q. When manufacturing straight pipe sections, manual welding is allowed for following:

1. Tack welding of coils and plates during continuous pipe making process.

2. Rewelding and repairing structural defects in plate and automatic machine welds.

3. Attaching new coil of steel to previous coil.

2.02 BAR ROD

A. Conform to requirements of ASTM A 615, AWWA C 303 and this specification.

B. Test foreign manufactured rod by local independent laboratory.

C. Rod manufacturer is responsible for performing mechanical tests required in ASTM A 615.

D. Pipe manufacturer is responsible for requiring rod manufacturer to submit certified results of chemical and mechanical tests, performed by rod manufacturer. Pipe manufacturer is responsible for performing mechanical tests, and is required to attest to such in affidavit of compliance.

E. Do not use rod with visible pitting.

2.03 GROUT FOR JOINTS AND SPECIAL APPLICATION

A. Joint Grout:

1. Cement Grout Mixture: One part cement to two parts of fine, sharp clean sand. Mix interior joint mortar with as little water as possible until very stiff but workable. Mix exterior joint mortar with water until it has consistency of thick cream.

2. Water: Potable water with total dissolved solids less than 1000 mg/l; ASTM D 512 chloride ions less than 100 mg/1 for slurry and mortar cure; ASTM D 1293 pH greater than 6.5. Use potable water with 250ppm limit on chlorides and sulfates.

3. Portland Cement: ASTM C 150, Type I or II. Provide one type of cement for entire project.

4. Sand:

   a. Interior joints: ASTM C 35 fine graded plaster sand.

   b. Exterior joints: ASTM C 33 natural sand with 100 percent passing No. 16 sieve.

5. Mix cement grout to specific gravity of 19 lb/gallon or greater as measured by grout/slurry balance. Use balance manufactured grout/slurry balance manufactured by Baroid or approved equal. Perform test in presence of and as requested by Project Manager. Add additional cement grout or water to mixed cement grout to bring mix to proper moisture content or specific gravity. Discard cement grout mixed more than 20 minutes that is not at proper moisture content or specific gravity.

B. Non-shrink Grout for Special Applications, Patches and Repairs.

1. Conform to requirements of ASTM C 1107, Non-shrink Grout.

2. Pre-blended factory-packaged material manufactured under rigid quality control.

3. Contain non-metallic natural aggregate, be nonstaining and noncorrosive.

4. Meeting NSF 61 Standard suitable for use in contact with potable water supply.

5. Exterior: Highly flowable to fill joint wrapper without leaving voids or trapped air. Interior capable of being placed with plastic consistency.

6. Non-bleeding and non-segregating at fluid consistency.

7. Contain no chlorides or additives which may contribute to corrosion of bar wrapped steel cylinder pipe.

8. Free of gas-producing, gas-releasing agents.

9. Resist attack by oil or water.

10. Mix, place, and cure in accordance with manufacturer's recommendations. Upon 72 hours' notice, provide services of qualified representative of non-shrink grout manufacturer to aid in use of product under job conditions.

11. Mix non-shrink grout to specific gravity of 17.7 lb/gallon or greater as measured by grout/slurry balance. Use grout/slurry balance manufactured by Baroid or approved equal. Perform test in presence of and as requested by Project Manager. Add additional non-shrink grout to mixed non-shrink grout to bring to proper moisture content or specific gravity. Discard grout mixed more than 20 minutes that is not at proper moisture content or specific gravity.

12. Compressive strength: ASTM C 1107 2500 psi minimum 7-day unconfined; 5000 psi minimum 28-day unconfined.

C. Finished surface of lining and interior joint to be comparable to surface rubbed with No. 16 Carborundum stone. Rub joint mortar sufficiently to bring paste to surface, to remove depressions and projections, and to produce smooth, dense surface. Add cement to form surface paste as necessary. Leave interior with clean, neat and uniform-appearing finish.

D. Joint Wrapper: Minimum width of 9 inches for 33-inch diameter and smaller; minimum width of 12 inches for diameters greater than 33-inch hemmed at edge to allow threading with minimum 5/8-inch wide steel strap. Provide minimum 6-inch wide Ethafoam strip sized, positioned, and sewn such that two circumferential edges of Ethafoam are 1-1/2-inches from outer edge of wrapper.

2.04 CATHODIC PROTECTION

A. Connect each joint of pipe with bonding straps or approved devices to maintain continuity of current. Provide bonding straps free of foreign material.

B. Electrically isolate water line from other connections. Use insulating type joints or non- metallic pipe unless otherwise indicated on Drawings.

C. Provide flange adapter with insulating kit as required when connecting new piping to existing piping.

2.05 INSPECTION AND SHIPPING

A. Permit Project Manager to inspect pipes or witness pipe manufacturing. Inspection shall not relieve manufacturer of responsibilities to provide products that comply with applicable standards and these Specifications. Should Project Manager elect not to inspect manufacturing, testing, or finished pipes, it in no way implies approval of products or tests.

B. Manufacturer's Notification to Customer: Should Project Manager wish to see specific pipes during manufacturing process, manufacturer shall provide Project Manager with minimum of three (3) weeks advance notice of when and where production of those pipes will take place. Repair damage to pipe or protective lining per manufacture specifications before final acceptance.

C. Shipping: Where required, provide pipe and fittings with sufficient interior strutting or cross bracing to prevent deflection under their own weight.

PART 3 EXECUTION

3.01 INSTALLATION

A. Conform to requirements of Section 02511 - Water Lines. Do not install pipe without approved lay schedule.

B. Install pipe within six months of pipe being manufactured.

C. Manufacturer shall make available services of representative, throughout project duration when deemed necessary by Project Manager, to advise aspects of installation including but not limited to handling, storing, cleaning and inspecting, coatings and linings repairs, and general construction methods affecting pipe.

D. Bedding and Backfilling

1. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities.

2. Take necessary precautions during bedding and backfilling operations to prevent deformation or deflection of cylindrical shape of pipe by more than allowable pipe deflection.

3. Do not move trench support system (trench safety system) once bedding material is compacted.

4. Align pipe at proper grade prior to joint connection and do not shift after jointing operation has been completed.

5. Excavate outside specified trench section for bell holes, and for spaces sufficient to permit removal of slings. Provide bell holes at proper locations for unrestricted access to joint. Form bell holes large enough to facilitate joint wrapping and to permit visual examination of process. Enlargement of bell holes as required or directed by Project Manager. Subsequent backfilling thereof shall not be considered as authorized additional excavation and backfill. Backfill bell holes and spaces to satisfaction of Project Manager.

6. Remove blocking after placing sufficient backfill to hold pipe in position.

E. Follow non-shrink grout manufacturer's specifications for non-shrink grouting.

F. Store pipe at job-site with securely-fastened plastic end caps to maintain moist pipe interior. Promptly replace damaged end caps to avoid shrinkage or cracking of cement-mortar lining. Immediately replace damaged plastic end caps. Do not leave uncapped for more than 4 hours.

G. Use adequate surveying methods, procedures and employ competent surveying personnel to ensure pipe sections are laid to line and grade and within stipulated tolerances. Measure and record, in form approved by Project Manager, in-place survey data for pipe laid each day and submit copy of data to Project Manager at end of that day. Survey data to include unique pipe number, deflection angle at pipe joint and whether beveled ends were used, invert elevation at pipe joint, deviation of joint from project line, deviation of joint from project grade, inside pipe joint lap measured at top, bottom, and at springline (each side).

H. Static Electricity:

1. Properly ground steel pipeline during construction as necessary to prevent build-up of static electricity.

2. Electrically test where required after installation of pipeline is complete.

3.02 DEFLECTION

A. Allowable deflection from specified diameter determined as follows:

Allowable Deflection = (D)2/4000, (D= Nominal inside pipe diameter in inches).

B. Deflection may be measured by Project Manager at location along pipe. Arithmetical averages of deflection are not acceptable.

C. If deflection exceeds that specified, remove entire portion of deflected pipe section and install new pipe as directed by Project Manager at no cost to City.

3.03 CLOSURES AND APPROVED PIPE MODIFICATIONS.

A. No modifications of standard pipe for closures shall be permitted in field. No field cutting of pipe or exposure of bar wire is permitted without written approval from Project Manager.

B. Pipe manufacturer's representative and Project Manager to entirely witness closures and approved pipe modification efforts.

C. Provide minimum lap of 4 inches between member being joined and edge of butt strap. Weld on both interior and exterior, unless otherwise approved by Project Manager.

D. Provide full circumferential welds on joints required to be welded. Employ independent certified testing laboratory, approved by Project Manager, to perform weld tests on field welds. Include cost of such testing in contract unit price for water line. Use magnetic particle test method for lap welds or X-ray methods for butt welds, for 100 percent of joint welds. Maintain records of tests. If defective weld is revealed, repair defective weld, and retest. Use wire and flux from same manufacturer throughout entire project.

E. Fill wrapper in field and allowing excess grout water to seep out. Refill wrapper as necessary. When joint mortar level has stabilized and begun to mechanically stiffen, lap Ethafoam wrapper over top of joint, and secure in place.

F. Stretch test each gasket splice to twice its unstretched length and inspect for defects.

3.04 VISIBLE CRACKS

A. No visible cracks longer than 6 inches, measured to be within 15 degrees of line parallel to pipe longitudinal axis, are permitted except:

1. In surface laitance of centrifugally cast concrete,

2. In sections of pipe with steel reinforcing collars or wrappers, or

3. Within 12 inches of pipe ends.

B. Repair interior lining cracks that exceed 1/16-inch (0.0625 inches) wide.

C. Reject pipe with exterior coating cracks that exceed 0.01 inches wide.

D. Immediately remove pipe from site if pipe has cracks exceeding limitations and cracks are not repairable.

3.05 FIELD REPAIR PROCEDURES FOR COATING/LINING

A. Areas less than or equal to 6 inches in diameter: Patch honeycomb and minor defects in concrete surfaces with non-shrink grout conforming to section 2.03 B. Use only manual or small (low pressure) air chisels to chip away mortar coating or lining. Cut out unsatisfactory material and replace with non-shrink grout, securely bonded to existing coating or lining. Finish junctures between patches and existing concrete as inconspicuous as possible. Strike off non-shrink grout flush with surrounding surface after patch has stiffened sufficiently to allow for greatest portion of shrinkage. Finish surface in accordance with lining requirements.

B. Pipe with defective coating areas greater than 6 inches in diameter cannot be used. Immediately remove pipe from project.

C. Reject pipe if steel cylinder is dented while making field repair. Immediately remove pipe from project.

END OF SECTION

SECTION 02614

LARGE DIAMETER LINE STOPS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Large Diameter Line Stops for isolating existing water lines ranging from 24-inch to 96-inch in diameter.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02525 – Tapping Sleeves and Valves

1.03 MEASUREMENT AND PAYMENT

A. Large Diameter Line Stop - Payment is on unit price basis for each Line Stop installed in place for each diameter. Payment includes:

1. Procurement of materials, labor, and equipment required to install Line Stop Sleeve for Line Stop, including all excavation and concrete foundation required for the installation of a Line Stop.

2. Installation of secondary sleeves and taps for additional outlets required for the tapping and line stopping process.

3. Labor, equipment and material to install Line Stop, remove the Line Stop and complete closure after removal of Line Stop. Include adequate duration to complete necessary work requiring line stop.

B. Payment for reinsertion of existing line stop will be on a unit price basis. Payment includes materials, labor and equipment to reinstall Line Stop, remove Line Stop and complete closure of Line Stop, including all excavation and backfill.

C. Refer to Section 01270 - Measurement and Payment for unit price procedures.

D. Stipulated Price (Lump Sum): If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM A 36 - Standard Specification for Carbon Structural Steel.

B. ASTM A 105 - Standard Specification for Carbon Steel Forgings for Piping Applications.

C. ASTM A 181 - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.

D. ASTM A 283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.

E. AWWA C 111 - American National Standard for Rubber Gasket Joints for Ductile-Iron Pipe and Fittings for Water.

F. ASME B16.5 - Pipe Flanges and Flanged Fittings.

1.05 DEFINITIONS

A. Large Diameter Line Stop – Plugging mechanism used for isolating sections of existing water line temporarily.

1. Pivot Head – To be used on a size-on-size tap. Plug head is turned once inside existing pipe.

2. Folding Head – To be used for a reduced size tap. Plug head is unfolded within existing pipe after being inserted.

B. Plugged – Adequate flow stoppage to permit the completion of required work.

C. Completion Plug – After Line Stop is removed completion plug seals outlet and a blind flange is installed.

D. Line Stop Sleeve – Fitting that goes around existing pipe and to be used to hot tap existing pipe. Line Stop Sleeve to be left in place after removal of Line Stop.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit qualifications and certificate from manufacturer certifying operators are qualified to operate manufacturer’s tapping and Line Stop equipment.

C. Submit qualifications verifying recent successful completion of line stopping operations on large diameter water lines, including diameters and pipe materials required to complete work. Include list of references.

D. Submit shop drawings for approval prior to start of fabrication. Identify procedures required during and/or after tapping procedure for the specified pipe material being tapped.

E. Submit detailed work plan including flow requirements for Line Stop installation and removal. Provide contingency plan for unsuccessful line stop operation and completion, including typical causes and proposed solutions.

F. Submit foundation design for support of Line Stop, signed and sealed by a Professional Engineer registered in State of Texas.

G. Submit requirements for flow and pressure in line during tapping, Line Stop installation, line stopping, and Line Stop removal stages of the work. Include anticipated durations of each step.

H. Provide survey coordinates of Line Stop and show on record drawings.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:

1. Selection of Line Stop Sleeve and Line Stop must take into consideration pipe material and existing conditions for project.

2. Conduct welding in accordance with applicable codes and standards. Stress relieve all welds.

3. Clearly mark Line Stop Sleeve and attachments to permit proper alignment in field and to ensure ends are properly matched when installed around pipe.

B. Line Stop Sleeve:

1. Provide as a minimum sleeve and attachments fabricated in accordance with ASTM A36 or ASTM A283 standards. Provide sleeve which conforms to and adequately reinforces existing pipe to prevent distortion or failure of pipe. Line Stop Sleeve to have fusion bonded epoxy or approved equal.

2. Sleeve and attachments used in hot tapping procedure are to be in compliance with maximum working pressure of system as specified and/or shown on Drawings.

3. Provide flanges manufactured in accordance with ASTM A-181, ASTM A-105 grade steel, ASME B16.5 in sizes up to 24-inches and MSS-SP 44 in sizes 26-inches and larger.

4. Provide external bolting, studs and nuts consisting of corrosion resistant, high strength, low alloy (AWWA C 111). Denso or approved equal petroleum based tape coating. As an option, stainless steel 18-8 type 304 bolts, studs and nuts may be used.

C. Pivot Head Line Stop:

1. Pivot Head Line Stop is allowed on steel pipe only.

2. Plugging machine provided by a size-on-size tapping fitting for 36-inch diameter and below. Tapping fittings to be in accordance with Section 02525 – Tapping Sleeves and Valves. Pivot head to include a nitrile or Buna-N O-ring for plugging.

3. Design Line Stop system to withstand a minimum of 150 psi.

D. Folding Head Line Stop:

1. Plugging machine provided by a reduced size of tapping fitting for 42-inch diameter and larger, in accordance with Section 02525 – Tapping Sleeves and Valves, for steel, PCCP and bar-wrapped pipe. Folding head to include a nitrile or Buna-N O-ring for plugging.

2. Design Line Stop system to withstand a minimum of 150 psi.

PART 3 EXECUTION

3.01 INSTALLATION

A. Conduct pipe excavation in accordance with Section 02317 - Excavation and Backfill for Utilities.

B. Plan Line Stop procedure to minimize impact to the public. Notify Project Manager at least 48 hours in advance of line stopping procedure, including excavation.

C. Do not operate valves. City of Houston Drinking Water Operations (DWO) will handle, at no cost to Contractor/subcontractors, operations involving opening and closing valves. Provide at a minimum 2 weeks' notice for valve operations. Indicate the required flow needed for proper Line Stop insertion.

D. Conduct Line Stop operations in presence of Project Manager. Continue line stopping work without interruption until Line Stop operation is complete and pipe is plugged.

E. Pipe Preparation - Follow procedures below, unless otherwise approved by Project Manager:

1. Thoroughly clean pipe down to factory supplied outside diameter. Carefully inspect pipe, especially at point where tap will take place. Confirm roundness of existing pipe. Do not tap within 4 feet of an existing joint.

2. For a Folding Head Line Stop the diameter of tap should be no greater than 75% of pipe diameter.

3. Cement mortar coating may be carefully removed within the limits of tapping assembly prior to installing Line Stop Sleeve.

F. Line Stop Sleeve Installation - Follow procedures below, unless otherwise approved by Project Manager:

1. Place top half of sleeve with flanged outlet at the 12 o'clock position on pipe.

2. Install sleeve and attachments in accordance with manufacturer's recommendation. Torque bolts in accordance with the manufacturer. Any misalignment in sleeve installation will require removal of sleeve from pipe.

3. Pour concrete foundation around Line Stop Sleeve. Foundation dimensions and materials to be designed by contractor.

G. If existing pipe has concrete mortar coating remove the outer concrete core within opening of Line Stop Sleeve. For PCCP, carefully cut and remove the prestressed wires within the limits of Line Stop Sleeve once concrete foundation is in place. Record type of coating and measured outside diameter of existing pipe on plan sheet of record drawings where line stop is shown. Install gland with O-ring and tighten bolts to provide compression seal between O-ring and steel cylinder.

H. Pressure Testing: After sleeve is attached and before line tapping procedure begins, pressure test sleeve in accordance with Section 02525 - Tapping Sleeves and Valves.

I. Tap through cylinder and inner mortar lining and retrieve pipe coupon. Tap Procedure: Perform tap in accordance with Section 02525 - Tapping Sleeves and Valves.

J. Remove tapping assembly and mount Line Stop assembly.

K. If Line Stop is unsuccessful in adequately reducing existing water flow for purposes of successfully completing proposed work, mechanically clean interior of pipe with line stop head as approved by Project Manager. Do not damage pipe's interior lining during mechanical cleaning.

L. Anticipate water leakage from Line Stop and include cost of water removal in unit price bid for Large Diameter Line Stop work. Coordinate with Project Manager to reduce pressure, if needed.

M. After connection to pipe or associated work requiring installation of an isolation valve is complete, remove Line Stop equipment from pipe and seal Line Stop Sleeve with Completion Plug and blind flange.

N. Apply external coating to sleeve, flange and water main in accordance with applicable specification for the host pipe material. Unless otherwise directed by Project Manager, provide similar coating to existing pipe's coating.

END OF SECTION

SECTION 02615

INSERTION VALVES AND LINE STOPS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Insertion Valves for isolating existing water lines 12-inches in diameter and smaller.

B. Line Stops for isolating existing water lines 20-inches in diameter and smaller.

1.02 REALTED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02525 – Tapping Sleeves and Valves

1.03 MEASUREMENT AND PAYMENT

A. Insertion Valve – Payment is on unit price basis for each insertion valve installed in place for each diameter. Payment includes labor, material, excavation, and equipment to install insertion valve, foundation, and Valve Box.

B. Line Stop – Payment is on unit price basis for each line stop installed in place for each diameter. Payment includes:

1. Labor, materials, excavation, and equipment required to install Line Stop Sleeve for line stop and foundation.

2. Labor, equipment, and material to install line stop, remove line stop and complete closure. Include adequate duration to complete necessary work requiring line stop.

C. Line Stop reinsertion on existing sleeve will be on a unit price basis for each diameter. Payment includes labor, materials, excavation, and equipment to reinsert line stop into existing sleeve, remove line stop and complete closure.

D. If temporary bypass is required for the project and approved by Project Manager, payment will be on a lump sum basis.

E. Refer to Section 01270 – Measurement and Payment for unit price procedures.

F. Stipulated Price (Lump Sum): If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM A 36 – Standard Specification for Carbon Structural Steel.

B. ASTM A 105 - Standard Specification for Carbon Steel Forgings for Piping Applications.

C. ASTM A 181 - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.

D. ASTM A 283 - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.

E. AWWA C 111 - American National Standard for Rubber Gasket Joints for Ductile-Iron Pipe and Fittings for Water.

F. AWWA C 550 - Standard for Protective Epoxy Interior Coatings for Valves and Hydrants.

G. ASME B16.5 - Pipe Flanges and Flanged Fittings.

1.05 DEFINITIONS

A. Insertion Valve – Permanent resilient seat wedge valve installed while pipe is under pressure. Engineered reinforced composite polymer valve cartridge stops flow in pipe. After insertion is completed, valve is permanently installed and can be operated to open and close.

B. Line Stop – Temporary plugging of a pressurized pipe without disrupting pressure or service upstream of the stop. After line stop is no longer needed, assembly is removed and completion plug is installed.

C. Plugged – Adequate flow stoppage to permit the completion of required work.

D. Completion Plug – After Line Stop is removed completion plug seals outlet and a blind flange is installed.

E. Line Stop Sleeve– Fitting that goes around existing pipe and to be used to hot tap existing pipe. Line Stop Sleeve to be left in place after removal of line stop.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer’s product data for the proposed items for approval; as well as the sequence of work to have the item installed.

C. Submit qualifications and certificate from manufacturer certifying operators are qualified to operate manufacturer’s tapping and line stop or insertion valve equipment.

D. Submit requirements for flow and pressure in line during tapping, line stopping or valve insertion, and Line Stop removal stages of the work, if applicable. Include anticipated durations of each step.

PART 2 P R O D U C T S

2.01 MATERIALS

A. Insertion Valve:

1. Stainless Steel Body: Provide as a minimum Type 304 stainless steel saddle, bolts/nuts/washers, and body mount with reinforced composite polymer with EPDM cartridge seal.

2. Ductile Iron Body: A ductile iron body with fusion-bonded epoxy coating with ductile iron wedge fully encapsulated with EPDM rubber.

3. Refer to the City of Houston Approved Products List.

B. Line Stop:

1. Pivot Head Line Stop:

a. Plugging machine provided by a size-on-size tapping fitting for pipe. Tapping fitting to be in accordance with Section 02525 – Tapping Sleeves and Valves. Pivot head to include a nitrile or Buna-N O-ring for plugging.

b. Refer to the City of Houston Approved Products List.

PART 3 E X E C U T I O N

3.01 INSTALLATION

A. Conduct pipe excavation in accordance with Section 02317 - Excavation and Backfill for Utilities.

B. Plan Line Stop or Insertion Valve procedure to minimize impact to local residents and businesses. Notify Project Manager at least 48 hours in advance of beginning work.

C. Do not operate existing valves. Contact City of Houston personnel and provide at a minimum 2 weeks' notice for valve operations.

D. Pipe Preparation. Follow procedures below, unless otherwise approved by Project Manager:

1. Thoroughly clean pipe down to factory supplied outside diameter. Carefully inspect pipe, especially at point where tap will take place. Do not tap within 4 feet of an existing joint.

E. Line Stop Sleeve Installation. Follow procedures below, unless otherwise approved by Project Manager:

1. Place top half of sleeve with flanged outlet at the 12 o'clock position on pipe, or where shown on the Drawings.

2. Install sleeve and attachments in accordance with manufacturer's recommendation. Torque bolts in accordance with manufacturer's recommendations. Any misalignment in saddle installation will require removal of sleeve from pipe.

3. Place concrete blocking underneath Line Stop Sleeve. Foundation dimensions and materials to be designed by contractor.

F. Pressure Testing: After sleeve is attached and before line tapping procedure begins, pressure test sleeve in accordance with Section 02525 - Tapping Sleeves and Valves.

G. Tap through pipe and retrieve pipe coupon. Tap Procedure: Perform tap in accordance with Section 02525 - Tapping Sleeves and Valves.

H. Line Stops:

1. Remove tapping assembly and mount Line Stop assembly.

2. After connection to pipe or associated work is complete, remove the Line Stop equipment from pipe and seal Line Stop Sleeve with Completion Plug and blind flange.

I. Insertion Valves:

1. Install in accordance with manufacturer's recommendations.

END OF SECTION

SECTION 02621

GEOTEXTILE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Geotextile, also called filter fabric, in applications including pipe embedment wrap, around exterior of tunnel liner, around foundations of pipeline structures, and slope stabilization.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02426 – Sewer Line in Tunnels

E. Section 02517 – Water Line in Tunnels

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for Work performed under this Section. Include cost of Work in unit prices for Work requiring geotextile.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AASHTO M 288 - Standard Specification for Geosynthetic Specification for Highway Applications.

B. ASTM D 3786 - Standard Test Method for Bursting Strength of Textile Fabrics—Diaphragm Bursting Strength Tester Method.

C. ASTM D 4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

D. ASTM D 4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.

E. ASTM D 4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

F. ASTM D 4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile.

G. ASTM D 4833 - Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit standard manufacturer's catalog sheets and other pertinent information, for approval, prior to installation.

C. Submit installation methods, as part of Work plan for tunneling or for excavation and backfill for utilities. Obtain approval from Project Manager for filter fabric material and proposed installation method prior to use of filter fabric.

PART 2 PRODUCTS

2.01 GEOTEXTILE

A. Provide geotextile (filter fabric) designed for use in geotechnical applications. Filter fabric shall provide permeable layer or media while retaining soil matrix.

B. Use fabric which meets physical requirements for Class A subsurface drainage installation conditions as defined in AASHTO M 288 and as specified in Paragraph 2.02, Properties.

2.02 PROPERTIES

A. Material: Nonwoven, nonbiodegradable, fabric consisting of continuous chain polymer filaments or yarns, at least 85 percent by weight polyolefins, polyesters or polyamide, formed into dimensionally stable network.

B. Chemical Resistance: Inert to commonly encountered chemicals and hydrocarbons over pH range of 3 to 12.

C. Physical Resistance: Resistant to mildew and rot, ultraviolet light exposure, insects and rodents.

D. Minimum Test Values:

Property	Value (Min.)	Test Method
Grab Strength	180 lbs.	ASTM D 4632
Trapezoidal Tear Strength	50 lbs.	ASTM D 4533
Puncture Strength	80 lbs.	ASTM D 4833
Mullen Burst Strength	290 psi.	ASTM D 3786
Apparent Opening Size(1)	0.25 mm	ASTM D 4751
Permittivity (sec-1)	0.2	ASTM D 4491
(1) Maximum average roll value.		

PART 3 EXECUTION

3.01 LINE WORK

A. Conform use of geotextile to backfill for utilities to Section 02317 - Excavation and Backfill for Utilities.

3.02 TUNNEL WORK

A. Use geotextile outside of tunnel primary liner to prevent migration of soil fines into excavated tunnel resulting in voids or settlement. Select geotextile, subject to minimum requirements of Paragraph 2.02, meeting tunnel liner design requirements and installation conditions.

1. Sewers: Conform to Section 02426 - Sewer Line in Tunnels.

2. Waterlines: Conform to Section 02517 - Waterline in Tunnels.

END OF SECTION

SECTION 02631

STORM SEWERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. New storm sewers and appurtenances, modifications to existing storm sewer system and installation of roadside ditch culverts.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01555 – Traffic Control and Regulation

D. Section 01578 – Control of Ground and Surface Water

E. Section 02081 – Cast-In-Place Concrete Manholes

F. Section 02082 – Precast Concrete Manholes

G. Section 02086 – Adjusting Manholes, Inlets, and Valve Boxes to Grade

H. Section 02090 – Frames, Grates, Rings, and Covers

I. Section 02221 – Removing Existing Pavements, Structures, Wood, and Demolition Debris

J. Section 02317 – Excavation and Backfill for Utilities

K. Section 02320 – Utility Backfill Materials

L. Section 02321 – Cement Stabilized Sand

M. Section 02322 – Flowable Fill

N. Section 02441 – Microtunneling

O. Section 02445 – Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels

P. Section 02448 – Pipe and Casing Augering for Sewers

Q. Section 02505 – High Density Polyethylene (HDPE) Solid and Profile Wall Pipe

R. Section 02506 – Polyvinyl Chloride Pipe

S. Section 02510 – Polypropylene (PP) Corrugated Wall Pipe

T. Section 02531 – Gravity Sanitary Sewers

U. Section 02533 – Acceptance Testing for Sanitary Sewers

V. Section 02555 – Manhole Rehabilitation

W. Section 02611 – Reinforced Concrete Pipe

X. Section 02612 – Precast Reinforced Concrete Box Sewers

Y. Section 02632 – Cast-In-Pace Inlets, Headwalls, and Wingwalls

Z. Section 02633 – Precast Concrete Inlets, Headwalls, and Wingwalls

AA. Section 02642 – Corrugated Metal Pipe

BB. Section 02911 – Topsoil

CC. Section 02921 – Hydro Mulch Seeding

DD. Section 02922 – Sodding

EE. Section 02951 – Pavement Repair and Restoration

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for storm sewers, including elliptical or box storm sewer with or without seal slab, installed by open-cut, augered with or without casing, or tunneling is on linear foot basis. Measurement for storm sewers and roadside ditch culverts will be taken along center line of pipe from center line to center line of manholes or from end to end of culverts. Measurement for storm sewer will be taken along center line of storm sewer from inside wall of storm sewer junction box when installed in conjunction with storm sewer junction box. Payment will be made for each linear foot installed complete in place, including connections to existing manholes and inlets.

2. Payment for storm sewer leads, including elliptical leads, is on a linear foot basis.

3. Payment for corrugated metal pipe storm sewer outfall, including timber bents, is on a linear foot basis.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AASHTO LRFD Bridge Design Specifications, current edition.

B. City of Houston Code of Ordinances, Chapter 42 – Subdivisions, Developments and Platting, Article I – In General.

1.05 DEFINITIONS

A. Long Run Culvert: A culvert which is 40 feet or more in length.

B. Local Street: As defined in the City of Houston Code of Ordinances, Chapter 42 – Subdivisions, Developments and Platting, Section 42-1.

1.06 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer's literature for product specifications and installation instructions.

C. Submit proposed methods, equipment, materials, and sequence of operations for sewer construction. Plan operations to minimize disruption of utilities to occupied facilities or adjacent property.

D. For thermoplastic pipe products, submit detailed calculations per AASHTO LRFD Bridge Design Specifications upon request by the Project Manager for cases including but not limited to variations from City minimum cover requirements, pipe design validation, pipe failure investigations, and product substitutions. When calculations are requested by Project Manager, limit calculations to the critical pipe locations that control the pipe designs within the project limits. Critical locations shall be approved by the Project Manager. Calculations shall be signed and sealed by a Professional Engineer licensed in the State of Texas. Engineer shall submit a cover letter for pipe design indicating that it is in full accordance with AASHTO’s analysis and design criteria.

1.07 QUALITY ASSURANCE

A. The Condition for acceptance shall be watertight storm sewer that is watertight both in pipe-to-pipe joints and in pipe-to-manhole connections

B. Provide manufacturer's certification to Specifications.

1.08 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Comply with manufacturer's recommendations.

B. Handle pipe, fittings, and accessories carefully with approved handling devices. Do not drop or roll pipe off trucks or trailers. Do not use Materials cracked, gouged, chipped, dented, or otherwise damaged shall not be use materials for installation.

C. Store pipe and fittings on heavy timbers or platforms to avoid contact with ground.

D. Unload pipe, fittings, and appurtenances as close as practical to location of installation to avoid unnecessary handling.

E. Keep interiors of pipe and fittings free of dirt and foreign matter.

F. Store HDPE and PP pipes out of direct sunlight unless manufacturer's specifications allow.

G. Store PVC pipes out of direct sunlight.

PART 2 PRODUCTS

2.01 PIPE

A. Provide piping materials for storm sewers shall be of sizes and types specified unless otherwise indicated on Drawings.

B. In diameters where material alternatives are available, provide pipe from single manufacturer for each pipe diameter, unless otherwise approved by Project Manager or otherwise shown on Drawings.

C. Existing pipe that has been removed during construction cannot be reused.

2.02 PIPE MATERIAL SCHEDULE

A. Storm Sewer Pipe: Use pipe materials that conform to requirements specified in one or more of the following Sections as shown on the Drawings.

1. Section 02506 - Polyvinyl Chloride Pipe. Not allowed in the following applications:

    a. Potentially Petroleum Contaminated Areas (PPCA).

    b. Augering/ jacking.

    c. Installations in the City right-of-way and easements, except to convey storm water runoff from a private residential lot through a street curb or to a roadside ditch which fronts the residential lot.

    d. Installations on projects handled by Capital Projects Service line unless allowed according to 2.02.A.1.c.

2. Section 02510 - Polypropylene (PP) Corrugated Wall Pipe.

3. Section 02505 - High Density Polyethylene (HDPE) Solid and Profile Wall Pipe. For use only where Storm Sewers are associated with Local Streets, where Local Street is defined by City of Houston Code of Ordinances 42-1.

4. Section 02611 - Reinforced Concrete Pipe.

5. Section 02612 - Precast Reinforced Concrete Box Sewers.

6. Section 02642 - Corrugated Metal Pipe use only where Corrugated Metal Pipe is shown on Drawings.

B. Driveway Culvert Pipe for Streets with Open Ditches: Use pipe materials conforming to requirements specified in one or more of the following Sections as shown on the Drawings.

1. Section 02505 - High Density Polyethylene (HDPE) Solid and Profile Wall Pipe Use for Residential Culverts only.

2. Section 02510 - Polypropylene (PP) Corrugated Wall Pipe.

3. Section 02611 - Reinforced Concrete Pipe.

4. Section 02612 - Precast Reinforced Concrete Box Sewers.

C. Provide pipe meeting minimum class, dimension ratio, or other criteria indicated.

D. Pipe materials other than those listed above shall not be used for storm sewers.

2.03 BEDDING, BACKFILL, AND TOPSOIL MATERIAL

A. Bedding and Backfill Material: Conform to requirements of Sections 02317 - Excavation and Backfill for Utilities, Section 02320 - Utility Backfill Materials, and Section 2321 - Cement Stabilized Sand, and Section 02322 - Flowable Fill.

B. Topsoil: Conform to requirements of Section 02911 - Topsoil.

PART 3 EXECUTION

3.01 PREPARATION

A. Prepare traffic control plans and set up street detours and barricades in preparation for excavation when construction will affect traffic. Conform to requirements of Section 01555 - Traffic Control and Regulation.

B. Provide barricades, flashing warning lights, and signs for excavations. Conform to requirements of Section 01555 - Traffic Control and Regulation. Maintain barricades and warning lights for streets and intersections while Work is in progress or where traffic is affected by Work.

C. Immediately notify agency or company owning utility lines which are damaged, broken, or disturbed. Obtain approval from Project Manager and agency for repairs or relocations, either temporary or permanent.

D. Remove old pavements and structures, including sidewalks and driveways in accordance with requirements of Section 02221 - Removing Existing Pavements, Structures, Wood, and Demolition Debris.

E. Install and operate dewatering and surface water control measures in accordance with Section 01578 - Control of Ground and Surface Water.

3.02 EXCAVATION

A. Earthwork. Conform to requirements of Section 02317 - Excavation and Backfill for Utilities. Use bedding as indicated on Drawings.

B. Line and Grade. Establish required uniform line and grade trench from benchmarks identified by Project Manager. Maintain this control for minimum of 100 feet behind and ahead of pipe-laying operation. Use laser beam equipment to establish and maintain proper line and grade of Work. Or use appropriately sized grade boards which are substantially supported.

C. Trench Excavation. Excavate pipe trenches to level as indicated on Standard Details. Backfill excavation with specified bedding material to level of lower one-third of pipe barrel. Tamp and compact backfill to provide bedding at indicated grade. Form bedding foundation to minimum depth of one-eighth of pipe diameter, but not less than 12-inches

3.03 PIPE INSTALLATION.

A. Install in accordance with pipe manufacturer's recommendations and as specified in this section.

B. Install pipe only after excavation is completed, bottom of trench is shaped, bedding material is installed, and trench has been approved by Project Manager.

C. Install pipe to line and grade indicated on Drawings. Place pipe so that it has continuous bearing of barrel on bedding material with no voids, and is laid in trench so interior surfaces of pipe follows grades and alignments indicated.

D. Install pipe with bells of pipe facing upstream of anticipated flow.

E. Form concentric joint with each section of adjoining pipe to prevent offsets.

F. Place and drive home newly laid sections with a sling or come-a-long winches to eliminate damage to sections. Unless otherwise approved by Project Manager, provide end protection to prevent damage while using back hoes or similar powered equipment to drive home newly laid sections.

G. Keep interior of pipe clean as installation progresses.

H. Keep excavations free of water during construction and until final inspection.

I. When work is not in progress, cover exposed ends of pipes with pipe plug specifically designed to prevent foreign material from entering pipe.

J. For Flexible Pipe Products:

1. Provide a minimum cover as per City Standard detail from top of pavement to top of pipe, but no less than 2 feet.

2. For thermoplastic pipes, provide minimum cover as shown on Drawings.

3. Accomplish transitions to different material of pipe in a manhole or inlet box. No adapter, coupling for dissimilar pipe, or saddle connections allowed.

4. Provide pipe sections in standard lengths with minimum length of 13 feet. Pipe may be field modified to shorten length no less than 4 feet, unless otherwise approved by Project Manager. Field modify pipe per manufacturer's recommendations.

5. No beveling at joint allowed. Cut to be perpendicular to longitudinal axis.

6. For thermoplastic pipes, provide gasketed bell and spigot joints installed per manufacturer's recommendations. Gasketed pipe joints; clean and free of debris, show no leakage after installation.

7. Refer to Specification 02642 – Corrugated Metal Pipe for CMP joint requirements.

3.04 PIPE INSTALLATION OTHER THAN OPEN CUT OR TUNNELING

A. Conform to requirements of Section 02448 - Pipe and Casing Augering for Sewers where required.

B. Conform to requirements of Section 02441 - Microtunneling where required.

C. Conform to requirements of Section 02445 – Jack and Bore/Jack and Mine/Pilot Tube Guided Boring Tunnels where required.

D. Not allowed for plastic sewer pipe.

3.05 INSTALLATION OF APPURTENANCES

A. Construct manholes to conform to requirements of Sections 02081 - Cast-in-place Concrete Manholes and Section 02082 - Precast Concrete Manholes. Install frames, grate rings, and covers to conform to requirements of Section 02090 - Frames, Grates, Rings, and Covers.

B. Install pipe culverts with appropriate measures (e.g., headwalls, safety end treatments, riprap, sloped paving, earthen protection, etc.) as shown on Drawings.

C. For inlets, headwalls, and wingwalls, conform to requirements of Section 02632 - Cast-in-place Inlets, Headwalls, and Wingwalls and Section 02633 - Precast Concrete Inlets, Headwalls, and Wingwalls.

D. Rehabilitate existing manholes to conform to requirements of Section 02555 – Manhole Rehabilitation. Adjust manhole covers and inlets to grade conforming to requirements of Section 02086 - Adjusting Manholes, Inlets, and Valve Boxes to Grade.

E. Dimension for Type C and Type E manholes shall be as shown on Drawings.

3.06 INSPECTION AND TESTING

A. Perform post installation television inspection in accordance with Section 02531 – Gravity Sanitary Sewers. Hand held cameras may be used in storm sewers in lieu of requirements of Paragraph 3.09 of Section 02531 – Gravity Sanitary Sewers. Clearly stencil distance markings on each joint of pipe to indicate distance from starting manhole when using hand held cameras.

B. Mandrel Testing: Use a mandrel to test flexible pipe for deflection. Refer to Section 02533 – Acceptance Testing for Sanitary Sewers for the mandrel and test requirements.

3.07 BACKFILL AND SITE CLEANUP

A. Backfill trench after pipe installation is inspected and approved by Project Manager.

B. Backfill and compact soil in accordance with Section 02317 - Excavation and Backfill for Utilities.

C. Repair and replace removed or damaged pavement and sidewalks as specified in Section 02951 - Pavement Repair and Restoration.

D. In unpaved areas, grade surface as uniform slope to natural grade as indicated on Drawings. Provide minimum of 4 inches of topsoil and seed according to requirements of Section 02921 Hydro Mulch Seeding, or Section 02922 - Sodding, as required.

END OF SECTION

SECTION 02632

CAST-IN-PLACE INLETS, HEADWALLS AND WINGWALLS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Cast-in-place inlets for storm or sanitary sewers, including cast iron frame and plate or grate.

B. Cast-in-place headwalls including wingwalls for storm sewers.

C. Cast-in-place junction box with lid or grate top.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02090 – Frames, Grates, Rings, and Covers

D. Section 02317 – Excavation and Backfill for Utilities

E. Section 03315 – Concrete for Utility Construction

F. Section 04061 – Mortar

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for cast-in-place inlets is on unit price basis for each inlet installed.

2. Payment for cast-in-place headwalls including wingwalls is on unit price basis for each headwall including wingwall installed.

3. Payment for cast-in-place junction box with lid or grate top is on unit price basis for each junction box installed.

4. Payment for inlets and for culvert headwalls including wingwalls and junction boxes includes connection of lines and furnishing and installing frames, grates, rings, and covers.

5. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this section is included in total Stipulated Price.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit shop drawings for approval of design and construction details for cast-in-place units which differ from units shown on Drawings.

C. Submit manufacturers' data and details for frames, grates, rings, and covers.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Class A concrete with minimum compressive strength of 4000 psi conforming to requirements of Section 03315 - Concrete for Utility Construction, unless otherwise indicated on Drawings.

B. Reinforcing Steel: Conform to requirements of Section 03315 - Concrete for Utility Construction.

C. Mortar and Hydraulic Cement - Conform to requirements of Section 04061 - Mortar.

D. Miscellaneous metals: Cast-iron frames, grates, rings, and covers conforming to requirements of Section 02090 - Frames, Grates, Rings, and Covers.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify lines and grades are correct.

B. Verify compacted subgrade will support loads imposed by inlets.

3.02 INSTALLATION

A. Construct units complete in place to dimensions, lines and grades as shown on Drawings.

B. Excavate in accordance with requirements of Section 02317 - Excavation and Backfill for Utilities.

C. Construct box section of inlet of Class A concrete.

D. Forms required for both outside and inside faces of concrete inlet walls, however, when nature of material excavated for inlet can be hand trimmed to smooth vertical face, outside forms may be omitted with approval of Project Manager.

E. Place reinforcing steel to conform to details shown on Drawings. Provide positive means for holding steel cages in place during concrete placement. Welding of reinforcing steel is not permitted unless noted on Drawings. Maximum variation in reinforcement position is plus or minus 10 percent of wall thickness or plus or minus 1/2 inch, whichever is less. Regardless of variation, maintain minimum cover of concrete over reinforcement as shown on Drawings.

F. Chamfer exposed edges unless otherwise indicated on Drawings.

3.03 FINISHES

A. Cut off inlet leads neatly at inside face of inlet wall. Point up with mortar.

B. When box section of inlet complete, shape floor of inlet with mortar to conform to detailed Drawings.

C. Finish concrete surfaces in accordance with requirements of Section 03315 - Concrete for Utility Construction.

3.04 FIELD QUALITY CONTROL

A. Verify that inlets are free of leaks. Repair leaks in approved manner.

3.05 CONNECTIONS

A. Connect inlet leads to inlets.

B. Seal leads inside and outside with hydraulic cement.

3.06 BACKFILL

A. Backfill area of excavation surrounding each completed inlet according to requirements of Section 02317 - Excavation and Backfill for Utilities.

END OF SECTION

SECTION 02633

PRECAST CONCRETE INLETS, HEADWALLS, AND WINGWALLS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Precast concrete inlets for storm or sanitary sewers, including cast iron frame and plate or grate.

B. Precast concrete headwalls and wingwalls for storm sewers.

C. Precast junction box with lid or grate top.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02090 – Frames, Grates, Rings, and Covers

D. Section 02317 – Excavation and Backfill for Utilities

E. Section 04061 – Mortar

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for inlets is on unit price basis for each inlet installed.

2. Payment for headwalls and wingwalls is on unit price basis for each headwall and wingwall installed.

3. Payment for junction box with lid or grate top is on unit price basis for each junction box installed.

4. Payment for inlets, headwalls, wingwalls, and junction boxes includes connection of lines and furnishing and installing frames, grates, rings, and covers.

5. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 858 - Standard Specification for Underground Precast Concrete Utility Structures.

B. ASTM C 890 - Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.

C. ASTM C 1889 – Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Utility, Water, and Wastewater Structures Using AASHTO LRFD Design.

D. AASHTO HL-93 design live loading loads as referred to in AASHTO LRFD Bridge Design.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit shop drawings for approval of design and construction details for precast concrete inlets, junction box headwalls, and wingwalls. Precast units differing from standard designs shown on Drawings will be rejected unless shop drawing submittals are approved. Clearly show proposed substitution is equal or superior in every aspect to standard designs.

C. Submit manufacturers' data and details for frames, grates, rings, and covers.

1.06 STORAGE AND SHIPMENT

A. Store precast units on level blocking. Do not place loads until design strength is reached. Shipment of acceptable units may be made when 28-day strength requirements have been met.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Provide concrete for precast machine-made units meeting requirements of ASTM C 858 regarding reinforced concrete, cement, aggregate, mixture, and concrete test. Minimum 28-day compressive strength shall be 4,000 psi

B. Design Loading Criteria: Inlets walls, transition slabs, top sections, and inlet base slabs shall be designed, by manufacturer, to requirements of ASTM C 890, and/or ASTM C 1889 for depth as shown on Drawings and to resist following loads

1. AASHTO HL-93 design live loading loads as referred to in AASHTO LRFD Bridge Design Specifications applied to inlet cover and transmitted down to transition and base slabs.

2. Unit soil weight of 120 pcf located above portions of the inlet, including base slab projections.

3. Lateral soil pressure based on saturated soil conditions producing an at-rest equivalent fluid pressure of 100 pcf.

4. Internal liquid pressure based on unit weight of 63 pcf.

5. Dead load of inlet sections fully supported by transition and base slabs.

C. Reinforcing Steel: Place reinforcing steel to conform to details shown on Drawings and as follows:

1. Provide positive means for holding steel cages in place throughout production of concrete units. Maximum variation in reinforcement position is plus or minus 10 percent of wall thickness or plus or minus 1/2-inch, whichever is less. Regardless of variation, maintain minimum cover of concrete over reinforcement as shown on Drawings.

2. Welding of reinforcing steel is not permitted unless noted on Drawings.

D. Mortar and Hydraulic Cement: Conform to requirements of Section 04061 - Mortar.

E. Miscellaneous Metal: Cast-iron frames and plates conforming to requirements of Section 02090 - Frames, Grates, Rings, and Covers.

F. Third-Party Certification Requirement:

1. Precast concrete manufacturers supplying precast concrete products shall maintain active certification from an accepted third-party quality control program at the time of manufacture.

2. Accepted third-party quality control programs are the National Precast Concrete Association (NPCA) Plant Certification Program and the American Concrete Pipe Association (ACPA) Q-Cast Program.

3. Copies of certificates demonstrating compliance with the above third-party plant certification requirements shall be furnished upon the first delivery to the project. Certifications shall be resubmitted annually thereafter or upon request by the Project Manager.

2.02 SOURCE QUALITY CONTROL

A. Tolerances: Allowable casting tolerances for concrete units are plus or minus 1/4 inch from dimensions shown on Drawings. Concrete thickness in excess of that required will not constitute cause for rejection provided that excess thickness does not interfere with proper jointing operations.

B. Precast Unit Identification: Mark date of manufacture and name or trademark of manufacturer clearly on inside of inlet, headwall, or wingwall.

C. Rejection: Precast units rejected for non-conformity with these specifications and for following reasons:

1. Fractures or cracks passing through shell, except for single end crack that does not exceed depth of joint.

2. Surface defects indicating honeycombed or open texture.

3. Damaged or misshaped ends, where damage would prevent making satisfactory joint.

D. Replacement: Immediately remove rejected units from Work site and replace with acceptable units.

E. Repairs: Occasional imperfections resulting from manufacture or accidental damage may be repaired if, in opinion of Project Manager, repaired units conform to requirements of these specifications.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify lines and grades are correct.

B. Verify compacted subgrade will support loads imposed by inlets.

3.02 INSTALLATION

A. Install units complete in place to dimensions, lines, and grades as shown on Drawings.

B. Excavate in accordance with requirements of Section 02317 - Excavation and Backfill for Utilities.

C. Bed precast concrete units on foundations of firm, stable material shaped to conform to shape of unit bases.

D. Provide adequate means to lift and place concrete units.

3.03 FINISHES

A. Use hydraulic cement to seal joints, fill lifting holes and as otherwise required.

B. When box section of inlet has been completed, shape floor of inlet with mortar to conform to Drawing details.

C. Adjust cast iron inlet plate frames to line, grade, and slope shown on Drawings. Grout frame in place with mortar.

D. Install precast adjustment rings above tops of cones or flat-top sections as required to adjust finished elevation and to support inlet plate frame.

E. Place at least two precast concrete grade rings with thickness of 12 inches or less, under casting. Refer to standard details for additional requirements of precast concrete grade rings.

3.04 FIELD QUALITY CONTROL

A. Verify that inlets are free of leaks. Repair leaks in approved manner.

3.05 CONNECTIONS

A. Connect storm sewer leads to inlets as shown on Drawings. Seal connections inside and outside with hydraulic cement. Make connections watertight.

3.06 BACKFILL

A. Backfill area of excavation surrounding each completed inlet, headwall, or wingwall according to requirements of Section 02317 - Excavation and Backfill for Utilities.

END OF SECTION

SECTION 02642

CORRUGATED METAL PIPE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Corrugated metal pipe (CMP).

B. Corrugated metal pipe with smooth interior (CMPSI).

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02317 – Excavation and Backfill for Utilities

D. Section 02631 – Storm Sewers

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for corrugated metal pipe in open cut under this Section. Include payment in unit price for Section 02631 - Storm Sewers.

2. No payment will be made for corrugated metal pipe in non-open cut under this Section. Include payment in unit price for applicable tunneling section.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AASHTO LRFD Bridge Design Specifications.

B. AASHTO M 36 – Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains

C. AASHTO M 190 - Standard Specification for Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches.

D. AASHTO M 196 - Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains.

E. AASHTO M 197 - Standard Specification for Aluminum Alloy Sheet for Corrugated Aluminum Pipe.

F. AASHTO M 218 - Standard Specification for Steel Sheet, Zinc Coated (Galvanized) for Corrugated Steel Pipe.

G. AASHTO M 232 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

H. AASHTO M 245 - Corrugated Steel Pipe, Polymer Precoated, for Sewers and Drains.

I. AASHTO M 246 - Standard Specification for Steel Sheet, Metallic-Coated and Polymer Precoated for Corrugated Steel Pipe.

J. AASHTO M 274 - Standard Specification for Steel Sheet, Aluminum-Coated (Type 2) for Corrugated Steel Pipe.

K. ASTM B 633 - Standard Specification for Electro deposited Coatings of Zinc on Iron and Steel.

L. ASTM A 760 - Standard Specifications for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains.

M. ASTM A 798 – Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications

N. MIL-DTL-24441 – Military Specification.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit shop drawings and calculations with the following information:

1. Design dimensions and details for pipe and fittings indicating alignment, grade, and laying dimensions.

2. Fabrication details, details of fittings and flanges, details of specials, and proposed welding procedures.

3. Show station numbers for pipe and fittings corresponding to Drawings.

4. Submit detailed calculations per AASHTO LRFD Bridge Design Specifications. Designs are required for each pipe location and are to be signed and sealed by a licensed engineer.

1.06 QUALITY ASSURANCE

A. Provide manufacturer's affidavits that pipe was manufactured in compliance with standards referenced in this Section, and that coatings and linings were not applied or allowed to cure in freezing temperatures

PART 2 PRODUCTS

2.01 PIPE AND FITTINGS

A. Corrugated metal pipe may be galvanized steel, aluminized steel, aluminum or precoated galvanized steel as indicated on Drawings and conforming to following:

Galvanized Steel	AASHTO M 218
Aluminized Steel	AASHTO M 274
Aluminum	AASHTO M 197
Precoated Galvanized Steel	AASHTO M 246

1. Reference to gauge of metal is to U.S. Standard Gauge for uncoated sheets. Tables in AASHTO M 218 and AASHTO M 274 list thicknesses for coated sheets in inches. Tables in AASHTO M 197 list thicknesses in inches for clad aluminum sheets.

B. Coupling bands and other hardware for galvanized or aluminized steel pipe shall conform to requirements of AASHTO M 36 for steel pipe and AASHTO M 196 for aluminum pipe.

1. Coupling bands shall be not more than 3 nominal sheet thicknesses lighter than thickness of pipe to be connected and in no case lighter than 0.052 inch for steel or 0.048 inch for aluminum.

2. Coupling bands shall be made of same base metal and coating (metallic or otherwise) as pipe.

3. Minimum width of corrugated locking bands shall be as shown below for corrugations which correspond to end circumferential corrugations on pipes being joined:

   a. 10 1/2-inches wide for 2 2/3-inch by 1/2-inch corrugations.

   b. 12-inches wide for 3-inch by 1-inch corrugations.

4. Helical pipe without circumferential end corrugations will be permitted only when it is necessary to join new pipe to existing pipe which was installed with no circumferential end corrugations. In this event pipe furnished with helical corrugations at ends shall be field jointed with either helically corrugated bands or with bands with projections (dimples). Minimum width of helical corrugated bands shall conform to following:

   a. 12-inches wide for 1/2-inch deep helical end corrugations.

b. 14-inches wide for 1-inch deep helical end corrugations.

5. Bands with projections shall have circumferential rows of projections with one projection for each corrugation. Width of bands with projections shall be not less than following:

a. 12-inches wide for pipe diameters up to and including 72-inches. Bands shall have two circumferential rows of projections.

b. 16 1/4-inches wide for pipe diameters of 78-inches and greater. Bands shall have four circumferential rows of projections.

6. Bolts for coupling bands shall be 1/2-inch diameter. Bands 12-inches wide or less will have minimum of 2 bolts per end at each connection, and bands greater than 12-inches wide shall have minimum of 3 bolts at each connection.

7. Galvanized bolts may be hot dip galvanized in accordance with requirements of AASHTO M 232, mechanically galvanized to provide same requirements as AASHTO M 232, or electro galvanized per ASTM B 633, Type RS.

C. Coat bituminous coated pipe or pipe arch inside and out with bituminous coating which shall meet these performance requirements and requirements of AASHTO M 190.

1. Uniformly coat pipe inside and out to minimum thickness of 0.05-inch, measured on crests of corrugations.

2. Adhere bituminous coating to metal so that it will not chip, crack, or peel during handling and placement; and to protect pipe from corrosion and deterioration.

3. Where paved invert is shown on Drawings, pipe or pipe arch, in addition to fully-coated treatment described above, shall receive additional bituminous material, same as specified above, applied to bottom quarter of circumference to form smooth pavement. Maintain minimum thickness of 1/8-inch above crests of corrugations.

D. Furnish fittings and specials required for bends, end sections, branches, access manholes, and connections to other fittings. Design fittings and specials in accordance with Drawings and ASTM A 760. Fittings and specials are subject to same internal and external loads as straight pipe.

2.02 PIPE FABRICATION

A. Steel Pipe:

1. Galvanized or aluminized steel pipe shall be full circle or arch pipe conforming to AASHTO M 36, Type I, Type IA, or Type II, as indicated on Drawings.

2. Fabrication with circumferential corrugations, lap joint construction with riveted or spot- welded seams, helical corrugations with continuous helical lock seam, or ultra-high frequency resistance butt-welded seams is acceptable.

B. Aluminum Pipe:

1. Conform to requirements of AASHTO M 196, Type I, Type IA, circular pipe, or Type II, pipe arch as indicated on Drawings.

2. Fabrication with circumferential corrugations, lap joint construction with riveted or spot- welded seams, or helical corrugations with continuous helical lock seam.

3. Portions of aluminum pipe that will be in contact with concrete or metal other than aluminum shall be insulated from these materials with coating of bituminous material meeting requirements of AASHTO M 190. Extend coating minimum distance of one foot beyond area of contact.

C. Precoated Galvanized Steel Pipe:

1. Pipe shall be full circle or arch pipe conforming to AASHTO M 245, Type I, Type IA or Type II as indicated on Drawings.

2. Fabrication with circumferential corrugations, lap joint construction with riveted seams, or helical lock seams is acceptable.

3. Inside and outside coating shall be minimum of 10 mils.

PART 3 EXECUTION

3.01 PREPARATION

A. Repair damaged spelter coating by thoroughly wire brushing damaged area and removing all loose, cracked, or weld-burned spelter coating. Paint cleaned area with paint conforming to Military SpecificationsMIL-DTL-24441.

B. Repair damaged aluminized or polymer coating in accordance with manufacturer's recommendations.

3.02 EARTHWORK

A. Excavate in accordance with requirements of Section 02317 - Excavation and Backfill for Utilities, except where tunneling or jacking methods are shown on Drawings. When pipes are laid in trench, trench when completed and shaped to receive pipe, shall be of sufficient width to provide free working space for satisfactory bedding and jointing and thorough tamping of backfill and bedding material under and around pipe.

B. Bed pipe in accordance with Drawings. When requested by Project Manager, furnish simple template for each size and shape of pipe for use in checking shaping of bedding. Template shall consist of thin plate or board cut to match lower half of cross section.

C. Where rock in either ledge or boulder form exists below pipe, remove rock below grade and replace with suitable materials so slightly yielding compacted earth cushion is provided below pipe minimum of 12-inches thick.

D. Remove and replace where soil encountered at established grade is quicksand, muck or similar unstable materials in accordance with requirements of Section 02317 - Excavation and Backfill for Utilities. Do not allow cement stabilized materials for backfill to come into contact with uncoated aluminum or aluminized pipe surface.

E. After metal pipe structure has been completely assembled on proper line and grade and headwalls constructed when required by drawing details, place selected material from excavation or borrow along both sides of completed structures equally, in uniform layers not exceeding 6 inches in depth (loose measurement), wetted when required and thoroughly compacted between adjacent structures and between structure and sides of trench, or for distance each side of structure equal to diameter of pipe. Compact backfill material to same density requirements as specified for adjoining sections of embankment in accordance with specifications. Above three-fourths point of structure, place uniformly on each side of pipe in layers not to exceed 12-inches.

F. Only hand operated tamping equipment will be allowed within vertical planes 2-feet beyond horizontal projection of outside surface of structure for backfilling, until minimum cover of 12-inches is obtained. Remove and replace damaged pipe.

G. Do not permit heavy earth moving equipment to haul over structure until minimum of 4-feet of permanent or temporary compacted fill has been placed.

H. During backfilling, obtain uniform backfill material and uniform compacted density throughout length of structure to avoid unequal pressure. Provide proper foundation and bedding under the structure in accordance with ASTM A 798.

I. Prior to adding each new layer of loose backfill material, inspection will be made of inside periphery of structure for local or unequal deformation caused by improper construction methods. Evidence of deformation will be reason for corrective measures as may be directed by Project Manager.

3.03 PIPING INSTALLATION

A. Place pipes on prepared foundation starting at outlet end. Join sections firmly together, with side laps or circumferential joints pointing upstream and with longitudinal laps on sides.

B. Coat metal in joints not protected by galvanizing or aluminizing with approved asphaltum paint.

C. Provide proper equipment for hoisting and lowering sections of pipe into trench without damaging pipe or disturbing prepared foundation and sides of trench. Take up and re-lay pipe which is not in alignment or which shows undue settlement after laying, or is damaged.

D. Lay multiple installations of corrugated metal pipe and pipe arches with center lines of individual barrels parallel. Unless otherwise indicated on Drawings, maintain following clear distances between outer surfaces of adjacent pipes:

Diameter of Pipe	Clear Distance Between Pipes Full Circle and Pipe Arch	Pipe Arch Design No.
18"	1'-2"	2
24"	1'-5"	3
30"	1'-8"	4
36"	1'-11"	5
42"	2'-2"	6
48"	2'-5"	7
54"	2'-10"	8
60"-84"	3'-2"	9
90"-120"	3'-5"	10 & over

E. Where extensions are attached to existing structures, install proper connection between structure and existing as indicated on Drawings, coat connection with bituminous material when required.

F. When existing headwalls and aprons are indicated for reuse on Drawings, sever portion to be reused from existing culvert, and relocate to prepared position. Restore damaged headwalls, aprons or pipes attached to headwall to their original condition.

3.04 JOINTING

A. Use field joints to maintain pipe alignment during construction and prevent infiltration of side material.

B. Lap coupling bands equally on pipes being connected to form tightly-closed joint.

C. Use corrugated locking bands to field join pipes furnished with circumferential corrugations including pipe with helical corrugations having reformed circumferential corrugations on ends. Fit locking bands into minimum of one full circumferential corrugation of pipe ends being coupled.

END OF SECTION

SECTION 02643

PLATE CULVERT STRUCTURES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Structural plate culverts and special structural plate shapes.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 02317 – Excavation and Backfill for Utilities

C. Section 02320 – Utility Backfill Materials

D. Section 03315 – Concrete for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for structural plate pipes, pipe arches, arches, underpasses or box culverts is on linear foot basis for each structure, measured along flow lines between ends of structures. Separate payment will be made for each different required size, gage, or minimum thickness of required material.

2. For multiple structures, measured length will be sum of lengths of barrels as prescribed above.

3. Include cost of aluminum alloy inverts, toe walls, footings, closure plates, and stiffeners in unit price for structure.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AASHTO M 167 - Standard Specification for Corrugated Steel Structural Plate, Zinc Coated, for Field Bolted Pipe, Pipe Arches, and Arches

B. AASHTO M 190 - Standard Specification for Asphalt-Coated Corrugated Metal Culvert Pipe and Pipe Arches.

C. AASHTO M 219 - Standard Specification for Corrugated Aluminum Alloy Structural Plate for Field Bolted Pipe, Pipe Arches, and Arches.

D. AASHTO M 243 - Standard Specification for Field-Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe-Arches, and Arches.

E. ASTM A 153 - Standard Specification for Zinc Coating (Hot-dip) on Iron and Steel Hardware.

F. ASTM B 221 - Standard Specification for Aluminum and Aluminum - Alloy Extruded Bars, Rods, Wires, Profile, and Tubes.

G. ASTM B 695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.

H. Tex-728-I-Measurement of Dry Film Coating Thickness on Steel

I. MIL-DTL-24441 – Military Specification.

1.05 ACCEPTANCE

A. Furnish itemized list of number and size of plates in each shipment to be used for visual inspection by Project Manager. Inspection will be made of plates for deficiency in size, radius of curvature and evidence of poor workmanship. Inspection may include sampling for chemical analysis and determination of weight of splutter coating. Plates failing to meet requirements of this Section will be rejected.

B. Project Manager may elect to inspect materials in rolling mill or in fabrication shop. Project Manager will have free access to mill or shop for inspection.

C. Repair damaged areas of splutter coating. Repair may be accomplished by painting with paint conforming to Military Specification MIL-DTL-24441 when approved in advance by Project Manager.

D. The following defects are causes for rejection:

1. Uneven laps.

2. Elliptical shaping (unless specified).

3. Variation from straight center line.

4. Ragged edges.

5. Loose, unevenly lined or spaced bolts.

6. Illegible brand.

7. Bruised, scaled, or broken splutter coating.

8. Dents or bends in metal.

PART 2 PRODUCTS

2.01 METAL PIPE AND ARCH MATERIALS

A. Conform plates and fasteners used for construction of structural plate pipes, pipe arches, arches, underpasses, box culverts and special shapes to AASHTO M 167 for galvanized corrugated steel structures, and to AASHTO M 219 for aluminum alloy structures.

B. Steel fasteners shall be mechanically galvanized or hot-dip galvanized and shall conform to ASTM A 153, Class C or D, or ASTM B 695, Class 40. Determine weight of galvanized coating according to Test Method Tex-728-I.

C. Steel plates shall consist of structural units of corrugated galvanized metal. Furnish single plates in standard sizes to permit structure length increments of 2 feet. Plates shall have approximately 2 inch lip beyond each end and crest. Length of given structure shall be approximately 4 inches longer than nominal length, except when skewed or beveled.

D. Aluminum plate shall consist of structural units of corrugated aluminum alloy. For aluminum alloy structures, furnish cut plates on structure ends to permit structure length increments of one foot. Conform aluminum alloy inverts, toe walls, footings and closure plates to material requirements for aluminum structural plate. Extruded aluminum transverse stiffeners shall conform to ASTM B 221, Alloy 6061-T6.

E. Comply headwalls with material requirements shown on Drawings.

2.02 STRUCTURE AND MATERIAL DESIGNATION

A. The types of structures are described on Drawings as follows:

1. Structural Plate Pipe (Galvanized Steel)

2. Structural Plate Pipe (Aluminum)

3. Structural Plate Pipe Arch (Galvanized Steel)

4. Structural Plate Pipe Arch (Aluminum)

5. Structural Plate Arch (Galvanized Steel)

6. Structural Plate Arch (Aluminum)

7. Structural Plate Underpass (Galvanized Steel)

8. Structural Plate Underpass (Aluminum)

9. Structural Plate Box Culvert (Galvanized Steel)

10. Structural Plate Box Culvert (Aluminum)

B. Either galvanized steel or aluminum may be used when no material is designated on Drawings.

2.03 PLATE JOINTS

A. Form plates to provide bolted lap joints. Punch bolt holes so plates having like dimensions, curvature, and same number of bolts per foot of seam are interchangeable.

B. Curve each plate to proper radius so cross-sectional dimensions of finished structure will be as indicated on Drawings.

C. Stagger joints so not more than three plates are jointed at any one point. Unless otherwise specified, place bolt holes along edges of plates forming longitudinal seams in finished structure as follows:

1. Stagger in rows 2-inches apart, with one row in valley and one in crest of corrugations with not less than 4 bolts per foot for galvanized steel structures.

2. Stagger in rows 1 ¾-inches apart, with 2 bolts in each valley and on each crest and not less than 16 bolts per 3 feet for aluminum alloy structures.

D. Provide for bolt spacing of not more than 12 inches for bolt holes along edges of plates that will form circumferential seams in finished structure.

E. Keep minimum distance from center of hole to edge of plate to not less than 1 3/4 times diameter of bolt.

F. Diameter of bolt holes in longitudinal seams not to exceed diameter of bolt by more than 1/8 inch.

G. Cut plates for forming skewed or sloped ends to give angle of skew or slope specified.

H. Repair burned edges to eliminate oxide and burrs. Maintain legible identification numerals on each plate to designate proper position in finished structure.

2.04 CONCRETE

A. Conform to Section 03315 - Concrete for Utility Construction. Unless otherwise shown on Drawings, use Class A concrete for footings and headwalls. Use Class B concrete for slope protection and for invert paving. Place reinforcement as shown on Drawings.

2.05 REINFORCING STEEL

A. Conform to requirements of Section 03315 - Concrete for Utility Construction.

PART 3 EXECUTION

3.01 PROTECTIVE COATINGS, LININGS AND PAVINGS

A. When required, protect structural plate structures with bituminous coating, bituminous lining or have invert paved with bituminous material. Remove moisture, dirt, oil, unbonded or incompatible paint, grease, alkalies, or other foreign matter from surface to be coated before applying coating material.

B. Apply bituminous coatings to inside and outside of structures to minimum thickness of 0.05-inch as provided in AASHTO M 190, Type A.

C. Apply protective coating to coupling bands for coated structures. Use coatings in accordance with AASHTO M 190. Coupling bands may be single-dipped with coating thickness requirement waived.

D. Apply bituminous linings, when required, over bituminous coatings, to inside bottom portion of structure as provided in AASHTO M 190, Type C.

E. When lining and paving are not required, asphalt mastic coating may be substituted for bituminous coating on corrugated steel or aluminum structures on outside surface of structure. Inside surface need not be coated.

F. Use asphalt mastic coating conforming to requirements of AASHTO M 243, except asbestos fibers will not be used. Perform this process at fabrication plant. Apply asphalt mastic material uniformly to outside surface with minimum thickness of 0.05-inch. Pinholes, blisters, cracks or lack of bond are cause for rejection.

G. When protective coatings are applied to structures, clearly identify thickness of metal on inner surface of each section with paint or other approved means. Repair damaged protective coatings, linings, and invert paving. Use bituminous material conforming to AASHTO M 190 or other approved materials to repair damaged asphalt mastic coatings.

H. Coat portion of nuts and bolts projecting outside pipe after installation. Portion of nuts and bolts projecting inside structure need not be coated.

I. When asphalt mastic is used for protective coating, surface at joints of structure need not be coated prior to assembly. Thoroughly seal joints after assembly with asphalt mastic on outside of structure.

3.02 CONSTRUCTION METHODS

A. Excavate in accordance with Section 02317 - Excavation and Backfill for Utilities. Make trenches for pipes, pipe arches, underpasses or box culverts of sufficient width to provide free working space for erection and thorough tamping of backfill and bedding material under and around structure. When quality of native soil is less than proposed backfill material, extend excavation to each side of barrel, minimum horizontal distance of half span or two-thirds of total rise, whichever is greater.

B. Bed foundations for structural plate structures with metal inverts in foundation of sandy earth material as specified in Section 02320 - Utility Backfill Materials, accurately shaped to fit lower part of pipe for at least ten percent of its overall height. Length of bedding arch need not exceed width of bottom plate. Uniformly seat corrugations on minimum 3-inch thick bed of sandy material. For culverts, place bedding to full width of invert.

1. Where rock, in ledge or boulder formation, exists below pipe, remove rock below grade and replace with compacted earth cushion having minimum thickness of 12 inches.

2. Where soil encountered at established grade is quicksand, muck, or similar unstable material, remove and replace material in accordance with Section 02317 - Excavation and Backfill for Utilities. When required, use special bedding as shown on Drawings.

C. Form foundations for structural plate structures with reinforced concrete footings to lines and grades shown on Drawings or as established by Project Manager.

1. Set anchors or slots for box culverts to line and grade when placing concrete for each substructure unit. Conform to Section 03315 - Concrete for Utility Construction for placing substructure units.

2. Place footings entirely in rock, shale or similarly hard material, or on firm soil or compacted soil cushion. When part of founding area is rock, undercut it and replace with minimum 12-inch thick compacted soil cushion. When thin layer of soil is partially covering rock within bearing area and when practical to do so, soil may be removed and footings placed directly on rock in accordance with details shown on Drawings.

D. Erection: Install structural plate structures in accordance with Drawings.

1. Coat steel in joints not protected by galvanizing with suitable bituminous coating.

2. Handle pipes and plates carefully to avoid damage to protective coating. Repair damaged coatings.

3. Use anchor bolts with 3/4-inch diameter by 6-inch minimum length on not more than 19-inch centers for anchoring plates to headwalls or other concrete end treatment.

4. Do not place plates for arch structures until substructure has cured for minimum of 3 days.

5. When plates are in position, tighten nuts and bolts progressively and uniformly, beginning at one end of structure. Tighten nuts second time to torque of not less than 150 ft-lbs nor more than 300 ft-lbs for steel bolts and not less than 100 ft-lbs nor more than 150 ft-lbs for aluminum bolts. When impact wrench is used, check with long-handled, structural, socket, or torque wrench to ensure that they are properly tightened. Replace service bolts used in drawing plates together with standard high strength bolts.

E. Use acceptable shape control devices for monitoring horizontal and vertical shape of structures. Maintain shape within two percent of design span or rise during erection and backfilling.

F. Backfilling: Perform backfilling and embankment construction around pipe in accordance with Section 02317 - Excavation and Backfill for Utilities. Conduct backfill operations to ensure inside dimensions remain within tolerances specified in shape control.

END OF SECTION

SECTION 02662

PIPING, VALVES, FITTINGS, AND ACCESSORIES FOR WATER STORAGE TANKS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pipe, fittings and accessories.

1.02 REALTED SECIONS

A. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. No separate measurement and payment for work performed under this Item.

B. The Contractor shall include the cost for this work in the contract bid price for work of which this is a component part.

1.04 REFERENCES

A. The Standards applicable to this Item include, but are not limited to, the following:

1. ANSI/AWWA C110/A21.10 - American National Standard for Ductile-Iron and Gray- Iron Fittings, 3 in. Through 48 in., for Water (latest edition).

2. ANSI/AWWA C111/A21.11 - American National Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings (latest edition).

3. ANSI/AWWA C150/A21.50 - American National Standard for the Thickness Design of Ductile-Iron Pipe (latest edition).

4. ANSI/AWWA C151/A21.51 - American National Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water (latest edition).

5. ANSI/AWWA C200 - AWWA Standard for Steel Water Pipe 6-In. and Larger (latest edition).

6. ANSI/AWWA C206 - AWWA Standard for Field Welding of Steel Water Pipe (latest edition).

7. ANSI/AWWA C207 - AWWA Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 in. through 144 in. (latest edition).

8. ANSI/AWWA C208 - AWWA Standard for Dimensions for Fabricated Steel Water Pipe Fittings (latest edition).

9. ANSI/AWWA C209 - AWWA Standard for Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines (latest edition).

10. ANSI/AWWA C210 - AWWA Standard for Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings (latest edition).

11. ANSI/AWWA C213 - AWWA Standard for Fusion-Bonded Epoxy Coatings for the Interior and Exterior of Steel Water Pipelines.

12. ANSI/AWWA C214 - AWWA Standard for Tape Coatings for Steel Water Pipe (latest edition).

13. ANSI/AWWA C500 - AWWA Standard for Metal-Seated Gate Valves for Water Supply Service (latest edition).

14. ANSI/AWWA C504 - AWWA Standard for Rubber-Seated Butterfly Valves (latest edition).

15. ANSI/AWWA C508 - AWWA Standard for Swing-Check Valves for Waterworks Service, 2 in. through 24 in. (latest edition).

16. ASTM A48 - Standard Specification for Gray Iron Castings.

17. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

18. ASTM D2241 Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR-Series) (latest edition).

19. ASTM D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.

1.05 SUBMITTALS

A. Submit complete product description including dimension drawings, specifications and materials list for all piping, fittings, joints, valves and accessories.

B. Operation and maintenance manual shall be submitted for valves in accordance with contract document requirements.

C. Submit valve data in accordance with Section 01330 – Submittal Procedures.

D. Submit procedures for hydrostatic testing.

1.06 PRODUCT HANDLING

A. Delivery and Storage:

1. Piping and valves shall be shipped and stored in such a manner which will protect them from damage.

2. All containers or pallets should be clearly tagged in accordance with contract documents.

3. All material shall be stored above ground on timbers or other suitable cribbing, and in a position that will facilitate drainage of rain water, or be completely covered.

1.07 DESIGN REQUIREMENTS

A. All pipe, fittings and valves to be in accordance with the latest edition of the applicable AWWA Standard and approved by the Texas Department of Health for use in potable water system.

PART 2 PRODUCTS

2.01 PIPING

A. Steel Pipe:

1. All new yard piping 4-inches and above shall be steel pipe in accordance with AWWA Standards C200-latest edition, C206-latest edition, C207-latest edition and C208-latest edition.

2. Above ground piping shall be welded, with flanged joints and fittings.

3. Underground buried piping shall be welded joints unless otherwise noted on the drawings.

4. The interior of all new pipe and fittings (above and below ground) is to be coated with the same coating system as the tank interior.

5. New exterior above ground piping to receive the same coating system as specified for tank exterior.

6. External Coating Systems for Buried Steel Pipe

a. Steel pipe shall be supplied with tape coatings as specified herein. The Contractor shall obtain from the manufacturer(s) and furnish to the Engineer an affidavit that the coating complies with the applicable requirements of this section and that the coating was not applied and allowed to cure in freezing temperatures.

b. Tape Coating. Provide an 80-mil shop-applied tape coating system in accordance with AWWA C214, latest edition, except as modified herein. Components of this system shall include a primer, one 20-mil layer of inner-layer tape for corrosion protection and two 30- mil layers of outer-layer tape for mechanical protection. Inner and outer tape widths shall be 18 inches. Tape coating system shall be Polyken YG-III, Tek-Rap Yard-Rap, or equal. Pipe shall be provided with shop coatings cut back from the joint ends to facilitate joining and welding of the pipe. The successive tape layers shall be tapered by 1-inch staggers to facilitate field wrapping of the joints. These cutbacks shall be such that a gap of approximately 4 to 4-1/2 inches will result to facilitate welding when the bell and spigot are engaged.

B. PVC Pipe:

1. All pipe smaller than 4-inches in diameter shall be polyvinyl chloride (PVC), Schedule 40, in accordance with ASTM D2241, with solvent welded joints per manufacturer’s recommendation and ASTM D2855.

2.02 FLEXIBLE COUPLINGS

A. Dresser style 38, Rockwell 411, Romac 400 or approved equal.

B. Pipe end to be clean and smooth.

C. Space between pipe ends shall not be less than 1/4" or more than 1", unless otherwise noted on the drawings.

D. Buried couplings shall be coated a minimum of 12 mils (DFT) fusion bonded epoxy resin in accordance with AWWA C213-latest edition. Type 316 stainless steel rods, nuts, bolts and washers shall be used.

2.03 FLAP VALVES

A. Description:

1. Valve shall swing open under direct pressure to release fluid, and close when direct pressure is relieved.

2. Back pressure shall hold the gate against its seat.

B. Iron body, bronzed mounted, with bronze hinge pin, flap ring and seat ring.

C. Waterman Model PF25 spigot end, or equal.

D. All valves to be installed where shown on the drawings and in accordance with the manufacturer's recommendations.

2.04 GATE VALVES

A. Gate valves, 3-inch and larger, shall be flanged, iron body, bronze mounted, with double disc gates having parallel seats, with the make, size, working pressure and "AWWA" cast on the valve bodies.

B. Valves are to meet or exceed the requirements of AWWA C500-latest edition.

C. Stem movement shall be outside screw and yoke (OS&Y) with handwheels for all above ground valves unless shown otherwise on drawings.

D. Buried valves to be non-rising stem (NRS). Buried valves shall be provided with a cast iron valve box and valve key of sufficient length to extend three feet above ground.

E. Valve handwheel rotation shall be counter-clockwise to open.

F. Handwheel yoke shall be aligned to 45 degrees from horizontal.

2.05 BUTTERFLY VALVES

A. Description:

1. Rubber seated butterfly valves shall be furnished and installed as shown on drawings, as specified herein, and shall meet or exceed the requirements of AWWA C504-latest edition.

B. Type:

1. Valve shall be short body type designed for a differential pressure of 150 psi (Class 150B).

2. Above ground valves to be flanged. Buried valves to be push-on or flanged.

C. Body: Cast Iron, ASTM A126 Class B or ASTM A48 Class 40.

D. Seats: Buna-N or neoprene, and may be applied to disc or body. Seats shall be mechanically secured and may not rely solely on adhesive properties of epoxy or similar bonding agent to attach seat to body. Seats on disc shall be mechanically retained by stainless steel (18-8) retaining ring held in place by stainless steel (18-8) cap screws that pass through rubber seat for added retention. When seat is on disc, seat shall be retained in position by shoulders located on both disc and stainless steel retaining ring. Mating surfaces for seats: Type 316 stainless steel, secured to disc by mechanical means. Sprayed-on or plated mating surfaces will not be allowed. Seat must be replaceable in field for valves greater than 30 inches in diameter. Valves with segmented retaining rings will not be accepted.

E. Disc: Cast iron or ductile iron fastened to shaft with stainless steel pins or bolts. For 30-inch and larger, disc to shaft connection to be with stainless steel tapered pins secured with nuts.

F. Shaft: Stainless steel, AISI Type 304 or 316.

G. Bushings: Self-lubricating bronze, Grade A, D or E; nylon; or reinforced Teflon.

H. Shaft Seals: Upper seal to consist of self-adjusting split "V" type packing or a stuffing box with pulldown packing. Packing material to be Buna-N, TFE impregnated Teflon or graphite asbestos. Seals to be replaceable without removing valve shaft.

I. End Cover: Cast iron, gasketed or with Buna-N O-ring.

J. Fastenings: 18-8 stainless steel, everdur or bronze.

K. Cover Plate Cap Screws for Buried Service: Stainless steel, AISI Type 316.

L. Operators:

1. Furnish handwheel operators to conform with AWWA C504-latest edition, including Appendix A.

2. Handwheel rotation to be counterclockwise to open.

3. Provide readily visible position indicator.

4. Manual operators to be single reduction, self-locking, worm gear or traveling nut type with side-mounted handwheel.

5. Include bolted-on spur or bevel gear assembly where necessary to develop the maximum valve seating or unseating torque with an applied single point force at the handwheel rim of 80 pounds or less.

6. Handwheel diameter not to exceed nominal valve diameter and in no case be larger than 30 inches.

7. Manual operators to be Series MDT by Pratt or T-Series by Limitorque.

8. For buried valves, include extension stem, 2-inch square operating nut, and cast iron valve box and key of sufficient length to extend three feet above ground.

9. Gear to be grease packed, totally enclosed for buried service.

10. Handwheel yoke shall be aligned to 45 degrees from horizontal.

M. All butterfly valves shall comply with the requirements of AWWA C504-latest edition: Section 1.5, Data to Be Furnished By Manufacturer or Fabricator.

2.06 BALL VALVES

A. Ball valves for chlorine solution lines shall be manufactured of PVC Type 1, Grade 1 molding compound with teflon ball seals and viton stem and body seals, true union design, Chemtrol or approved equal.

2.07 CHECK VALVES

A. Swing Check Valves

1. Swing check valves 4-inches through 14-inches having a system pressure 30 psi or less, shall be air cushioned with side mount lever and weight. The valve shaft shall extend through both sides of the body with minimum shaft diameters equal to APCO Series 6000. The cushion shall be totally enclosed, swivel mounted at the bottom, and equipped with a micrometer air control valve and air breather filters. Valves shall be similar to APCO Series 6000, or approved equal.

2. Swing check valves 10-inches through 14-inches having a system pressure greater than 30 psi shall be cushioned with side mount lever and weight. Valves shall be similar to APCO Series 6100, or approved equal.

3. Swing check valves 16-inches and larger regardless of system operating pressure shall be cushioned with side mount lever and weight. Valves shall be similar to APCO Series 6100, or approved equal.

B. Check valves of special design utilizing controlled closing of the disc, such as APCO Series 6000B (Bottom-Buffer) and Golden Anderson Fig. #25-DXH or approved equal shall be used when specifically indicated on the Drawings. These valves are special valves used to control the surge pressure in the force main upon multiple pump shutdown during a power failure. Other surge control check valves utilizing ball or cone valve and power cylinder operator may also be used as approved by the City Engineer.

C. All check valves shall have 300 series stainless steel hinge shafts, stainless steel body seats and stainless steel resilient seat retainer rings.

D. APCO Series 600 silent check valves (or approved equal) are acceptable for use in elevated storage tanks.

2.08 FREEZE PROTECTION

A. Any valves or appurtenances requiring freeze protection shall be encased in aluminum roll jacketing as manufactured by R P R Products, Inc., or approved equal.

2.09 ALTITUDE VALVES

A. Altitude valves for elevated storage tanks shall be for two-way flow. Valves shall be manufactured by Cla-Val. All associated standard hardware shall be included in valve replacement or new installation (Main Valve, Altitude Control, Valve Position Indicator, Bell Reducer, Check Valve, CK2 Cock, and CV Flow Control). Optional Features to be included are Flow Clean Strainer and CK2 Cock (Isolation Valve).

PART 3 EXECUTION

3.01 PIPING INSTALLATION

A. General:

1. Where indicated on the Plans piping connections between dissimilar metals, e.g., ductile iron or cast iron and steel, etc., shall be provided with dielectric insulating kits consisting of dielectric gaskets, bolt sleeves, and washers to prevent any galvanic action between the dissimilar metals.

2. All pipe installation shall be in accordance with the manufacturer's recommendations.

3. Watertight pipe and joints shall be provided.

4. Pipe shall be placed to the lines and grades shown on the drawings.

5. In order to make connections to existing piping it may be necessary to operate existing yard piping valves and to shut down certain portions of the plant and pumping facilities. All such operational activities shall be performed by Owner personnel only.

B. Manway Flanges and Flanged Joints:

1. Prior to installation of bolts, accurately center and align flanged joints to prevent mechanical prestressing of flanges, pipe and equipment. Align bolt holes to straddle the vertical, horizontal or north-south center line. Do not exceed 3/64 inch per foot inclination of the flange face from the true alignment.

2. For flange joints 30 inches in diameter and greater at butterfly valve flanges provide Pyrox G-10 with nitrile seal, Type "E" LineBacker gasket as manufactured by Pipeline Seal and Insulator, Inc., or approved equal conforming to ANSI 21.11 mechanical joint gaskets. For flanged joints less than 30 inches in diameter, provide a phenolic PSI, Type "E" gasket by Pipe Seal and Insulator, Inc.

3. Use full-face gaskets for all other flanged joints. Provide cloth inserted rubber gasket material, 1/8-inch thick in accordance with AWWA C207-latest edition. Gaskets shall be factory cut to proper dimensions.

4. Use ANSI nuts and bolts, galvanized or black to match flange material. Use cadmium- plated steel nuts and bolts underground. Tighten bolts progressively to prevent unbalanced stress. Draw bolts tight to ensure proper seating of gaskets.

5. The Contractor shall pay particular attention to procedures used in tightening and torquing flanged joints. Improper methods may result in leakage and necessitate corrective measures. The Contractor should follow recommended industry standards and guidelines as set forth by the various fabricators and manufacturers.

3.02 FIELD HYDROSTATIC TEST

A. All new water lines shall be field hydrostatically tested at 100 psi. Conduct hydrostatic tests in the presence of the Engineer and in an approved manner.

B. Each valved section of pipe shall be slowly filled with water and the specified test pressure shall be applied by means of a pump connected to the pipe in a manner approved by the Engineer.

C. The average water velocity when filling the pipeline should be less than 1 fps and shall not, under any circumstance, exceed 2 feet per second.

D. The Contractor shall furnish, install and operate, at Contractor's expense, the necessary connections, pump, and gauges.

E. Before applying the specified pressure test, all air shall be expelled from the pipe.

F. Joint Leakage:

1. All joints showing visible leaks shall be repaired.

2. The Contractor shall check at valves and fittings to ensure that no leakage may be occurring that could affect or invalidate the test.

3. Any cracked or defective pipes, fittings or valves discovered in consequence of this pressure test shall be removed and replaced by the Contractor with sound material and the test shall be repeated until satisfactory to the Engineer.

G. Allowable Leakage:

1. There should be no leakage for flanged joint steel pipe during the hydrostatic tests.

H. Length of Test:

1. The duration of the hydrostatic test shall be a minimum 4 hours at the specified pressure.

2. If a large quantity of water is required to increase the pressure during testing, entrapped air, leakage at joints, or a broken pipe can be suspected.

3. Tests should be discontinued until the source of trouble is identified and corrected.

I. Each section of pipe shall be chlorinated as specified prior to hydrostatic testing.

J. It shall be the responsibility of the Contractor to furnish all required temporary blinds or other closures required to facilitate the chlorination and pressure testing.

K. The Contractor shall submit a plan and procedure for pressure testing for Engineer approval prior to initiating such testing. The plan shall include a diagram of the section (s) of pipe to be tested, isolation procedure, schematic of test set-up, and a Step-by-Step work plan.

END OF SECTION

SECTION 02711

HOT MIX ASPHALT BASE COURSE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Foundation course of compacted mixture of coarse and fine aggregates, and asphalt binder.

1.02 REALTED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 02315 – Roadway Excavation

E. Section 02321 – Cement Stabilized Sand

F. Section 02330 – Embankment

G. Section 02336 – Lime Stabilized Subgrade

H. Section 02337 – Lime/Fly Ash Stabilized Subgrade

I. Section 02338 – Portland Cement Stabilized Subgrade

J. Section 02713 – Recycled Crushed Concrete Base Course

K. Section 02714 – Flexible Base Course for Temporary Driveways

L. Section 02741 – Asphaltic Concrete Pavement

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for hot mix asphalt base is on a per ton basis.

2. Payment for hot mix asphalt base for transitions and base repairs is on a per ton basis.

3. No separate payment will be made for hot mix asphaltic base for temporary driveway, temporary detour pavement, temporary roadway shoulders, etc. Include payment in unit price for respective driveway (Section 02714 – Flexible Base Course for Temporary Driveways) or temporary pavement (Section 02741 – Asphaltic Concrete Pavement) section.

4. Measurement:

   a. Match actual pavement area placed or replaced but no greater than maximum pavement replacement limits and thickness designated or shown on Drawings.

   b. Include installed hot mix asphalt base course material that extends one foot beyond outside edge of pavement to be replaced, except where proposed pavement section shares common edge with existing pavement section.

   c. Actual quantity for payment purpose as measured and calculated in this section shall not exceed the maximum volume-weight conversion rate of 105 pounds per square yard area per inch thickness.

5. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. AASHTO T201 - Standard Specification for Kinematic Viscosity of Asphalts (Bitumens).

B. AASHTO T202 - Standard Specification for Viscosity of Asphalt by Vacuum Capillary Viscometer.

C. ASTM C 33 - Standard Specifications for Concrete Aggregate.

D. ASTM C 131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

E. ASTM C 136 - Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

F. ASTM D 4402 - Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using Rotational Viscometer.

G. TxDOT Tex-106-E - Calculating the Plasticity Index of Soils.

H. TxDOT Tex-126-E - Molding, Testing, and Evaluating Bituminous Black Base Material.

I. TxDOT Tex-200-F- Sieve Analysis of Fine and Coarse Aggregates.

J. TxDOT Tex-203-F - Sand Equivalent Test.

K. TxDOT Tex-204-F - Design of Bituminous Mixtures.

L. TxDOT Tex-207-F - Determining Density of Compacted Bituminous Mixtures.

M. TxDOT Tex-208-F - Test for Stabilometer Value of Bituminous Mixtures.

N. TxDOT Tex-227-F - Theoretical Maximum Specific Gravity of Bituminous Mixtures.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certificates that asphalt materials and aggregates meet requirements of Paragraph 2.01, Materials.

C. Submit proposed mix and test data for each type of base course in Work.

D. Submit manufacturer's description and characteristics of mixing plant for approval.

E. Submit manufacturer's description and characteristics of spreading and finishing machine for approval.

PART 2 PRODUCTS

2.01 MATERIALS

A. Coarse Aggregate:

1. Use crushed gravel or crushed stone, or combination retained on No. 10 sieve, uniform in quality throughout and free from dirt, organic, or other injurious material occurring either free or as coating on aggregate. Conform aggregate o ASTM C 33 except for gradation. Furnish rock or gravel with Los Angeles abrasion loss not to exceed 40 percent by weight when tested in accordance with ASTM C 131.

2. Reclaimed asphalt pavement (RAP) or reclaimed Portland cement concrete pavement (RPCCP) are permitted as aggregates for hot mix asphalt base course if combined aggregate criteria, gradation, and mixture properties are met.

B. Fine Aggregate: Sand or stone screenings, or combination thereof, passing No. 10 sieve. Conform aggregate to ASTM C 33 except for gradation. Use sand composed of sound, durable stone particles free from loams or other deleterious foreign matter. Furnish screenings of same or similar material as specified for coarse aggregate. Plasticity index of that part of fine aggregate passing No. 40 sieve shall be not more than 6 when tested by TxDOT Tex-106-E. Sand equivalent shall have minimum value of 45 when tested by TxDOT Tex-203-F.

C. Composite Aggregate: Conform to following limits when graded in accordance with ASTM C 136. Provide either coarse or fine aggregate where designated on the Drawings.

GRADATION OF COMPOSITE AGGREGATE Percent Passing by Weight or Volume		
Sieve Size	Type A Coarse	Type B Fine Base
1 1/2"	98.0-100.0	-
1 1/4"	-	-
1"	78.0-94.0	98.0-100.0
3/4"	64.0-85.0	84.0-98.0
1/2”	50.0-70.0	-
3/8"	-	60.0 to 80.0
#4	30.0-50.0	40.0 to 60.0
#8	22.0-36.0	29.0-43.0
#30	8.0-23.0	13.0-28.0
# 50	3.0-19.0	6.0-20.0
#200	2.0-7.0	2.0-7.0
VMA % Minimum	12.0	13.0
*2 to 8 when Test Method Tex-200-F, Part II (Washed Sieve Analysis) is used.		

D. Asphalt Binder: Moisture-free homogeneous material meeting following requirements:

SPECIFICATION	PG 64 – 22
Average 7-day Maximum Pavement Design Temperature, degrees Ca	<64
Minimum Pavement Design Temperature, degrees Ca	>-22
Original Binder	
Flash Point Temperature, T48, Minimum degrees C	230
Viscosity, ASTM D 4402, b Maximum 3 Pa.s (3000cP), Test Temperature, degrees C	135
Dynamic Shear, TP5; cG*/sine[], Minimum, 1.00kPaTest Temperature @ 10rad/sec, degrees C	64

Rolling Thin Film Oven (T240) or Thin Film Oven (T179) Residue	
Mass Loss, Maximum, %	- 1.00
Dynamic Shear, TP5; G*/sine[], Minimum, 2.20 kPa Test Temperature @ 10rad/sec, degrees C	64
Pressure Aging Vessel Residue (PPI)	
PAV Aging Temperature, degrees C d	100
Dynamic Shear, TP5; G*/sine[], Maximum, 5000 kPa Test Temperature @ 10rad/sec, degrees C	25
Physical Hardening e	Report
Creep Stiffness, TP1; f S, Maximum, 300 Mpa; m-value, Minimum, 0.300 Test Temperature @ 60 sec, degrees C	-12
Direct Tension, TP3; f Failure Strain, Minimum, 1.0%; Test Temperature @ 1.0 mm/min, degrees C	-12

Notes:

a Pavement temperature can be estimated from air temperatures using algorithm contained in TxDOT testing procedures.

b The requirement may be waived at discretion of Project Manager if supplier warrants that asphalt binder can be adequately pumped and mixed at temperatures that meet applicable safety standards.

c For quality control of unmodified asphalt cement production, measurement of viscosity of original asphalt cement may be substituted for dynamic shear measurements of G*/sine [ ] at test temperature where asphalt is Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary of rotational viscometry (AASHTO T 201 or T202).

d The PAV aging temperature is based on simulated climatic conditions and is one of three temperatures: 90 C, 100 C, or 110 C. The PAV aging temperature is 100 C for PG64 and PG70.

e Physical Hardening - TP 1 is performed on a set of asphalt beams according to Section 13.1, except conditioning time is extended to 24 hours plus of minus 10 minutes at 10 C above minimum performance temperature. The 24-hour stiffness and m-value are reported for information purposes only.

f If creep stiffness is below 300 MPa, the direct tension test is not required. If creep stiffness is between 300 and 600 MPa the direct tension failure strain requirement can be used in lieu of creep stiffness requirement. The m-value requirement must be satisfied in both cases.

E. Reclaimed asphalt pavement (RAP) may be used at a rate no greater than 20 percent.

2.02 EQUIPMENT

A. Mixing Plant: Weight-batching or drum mix plant with capacity for producing continuous mixtures meeting specifications. With exception of a drum mix plant, the plant shall have satisfactory conveyors, power units, aggregate handling equipment, hot aggregate screens and bins, and dust collectors.

B. Provide equipment to supply materials adequately in accordance with rated capacity of plant and produce finished material within specified tolerances. Following equipment is essential:

1. Cold aggregate bins and proportioning device
2. Dryer
3. Screens
4. Aggregate weight box and batching scales
5. Mixer
6. Asphalt storage and heating devices
7. Asphalt measuring devices
8. Truck scales

C. Bins: Separate aggregate into minimum of four bins to produce consistently uniform grading and asphalt content in completed mix. One cold feet bin per stockpile is required.

2.03 MIXES

A. Employ certified testing laboratory to prepare design mixes.

1. Test in accordance with TxDOT Tex-126-E, TxDOT Tex-204-F, TxDOT Tex-208-F, and TxDOT Tex-227-F.
2. Verify mixture design properties for plant-produced mixture. Demonstrate that asphalt plant is capable of producing mixture meeting design volumetric and stability requirements before placement begins.

B. Density, Stability, and Air Voids Requirements. Select asphalt binder content for base courses to result in 3 to 5 percent air voids in laboratory molded specimens, while meeting minimum VMA requirement for selected mixture classification.

Percent Density		Percent	HVEEM Stability Percent	Percent Asphalt Content	
Min	Max.	Optimum	Not Less Than	Min.	Max.
94.5	97.5	96	35	3.5	7

PART 3 EXECUTION

3.01 PREPARATION

A. Complete backfill of new utilities below future grade.

B. Verify lines and grades are correct.

C. Prepare subgrade in accordance with requirements of Section 02330 - Embankment and Section 02315 - Roadway Excavation or Section 02336 - Lime Stabilized Subgrade and Section 02337 - Lime/Fly-Ash Stabilized Subgrade, and Section 02338 - Portland Cement Stabilized Subgrade. Subgrade preparation may also refer to Section 02321 - Cement Stabilized Sand or Section 02713 - Recycled Crushed Concrete Base Course.

D. Correct subgrade deviations in excess of plus or minus 1/4 inch in cross section, or in 16 foot length by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling.

3.02 PLACEMENT

A. Place base when surface temperature taken in shade and away from artificial heat is above 40 degrees F and rising. Do not place asphalt base when temperature of surface to receive base course is below 50 degrees F and falling.

B. Haul prepared and heated asphalt base mixture to project in tight vehicles previously cleaned of foreign material. Mixture shall be at temperature between 250 degrees F and 325 degrees F when laid.

C. Place hot mix asphalt base course in compacted lifts no greater than 4 inches thick, unless permitted in writing by Engineer.

D. Place courses as nearly continuously as possible. Place material with approved mechanical spreading and finishing machine of screeding or tamping type. Spread lifts to attain smooth course of uniform density to section, line, and grades as indicated on Drawings.

E. In areas with limited space where use of paver or front-end loader is impractical, spread by hand and compact asphalt by mechanical means. Carefully place materials to avoid segregation of mix; do not broadcast material. Remove lumps that do not break down readily.

3.03 JOINTS

A. Transverse Joints. Pass roller over unprotected ends of freshly laid mixture only when mixture has cooled. When work is resumed, cut back placed material to produce slightly beveled edge for full thickness of course. Remove old material which has been cut away and lay new mix against fresh cut.

B. Existing pavement. When new asphalt is laid against existing asphalt pavement, saw cut existing asphalt to full depth creating vertical face. Clean joint and apply tack coat before placement.

3.04 COMPACTION

A. Construct test strip to identify correct type, number, and sequence of rollers necessary to obtain specified in-place density or air-voids. Prepare test strip at least 500 feet in length, comparable to placement and compaction conditions for Project.

B. Begin rolling while pavement is still hot and as soon as it will bear roller without undue displacement or hair line cracking. Keep wheels properly moistened with water to prevent adhesion of surface mixture. Do not use excessive water; do not use petroleum by-products.

C. Compact surface thoroughly and uniformly with power-driven equipment capable of obtaining required compaction. Obtain subsequent compression by starting at side and rolling longitudinally toward center of pavement, overlapping on successive trips by at least one-half width of rear wheels. Make alternate trips slightly different in length. Continue rolling until no further compression can be obtained and rolling marks are eliminated. Complete rolling before mat temperature drops below 175 degrees F.

D. Along walls, curbs, headers, similar structures, and in locations not accessible to rollers, compact mixture thoroughly with lightly oiled tamps.

E. Compact base course to a minimum density of 91 percent (TxDOT Tex-227-F).

3.05 TOLERANCES

A. Pavement Repairs.

1. Furnish templates for checking surface of finished sections. Maximum deflection of templates, when supported at center, shall not exceed 1/4 inch.

2. Completed surface, when tested with 10 foot straight edge laid parallel to center line of pavement, shall show no deviation in excess of 1/4 inch in 10 feet. Correct surface not meeting this requirement.

3.06 FIELD QUALITY CONTROL

A. Perform testing under provisions of Section 01454 - Testing Laboratory Services.For in-place depth and density, take minimum of one core at random locations for each 1000 feet of single lane pavement. On a 2-lane pavement, take samples at random every 500 feet from alternating lanes. Take cores for parking lots every 500 square yards of base to determine in-place depth and density. If cul-de sac or streets are less than 500 feet, minimum of 2 cores (one per lane) will be procured. On small projects, take a minimum of two cores for each day's placement. For first days placement and prior to coring, minimum of 5 nuclear gauge readings will be performed at each core location to establish correlation between nuclear gauge (wet density reading) and core (bulk density). This process will continue for each day's placement until engineer determines that a good bias has been established for that nuclear gauge.

B. Determine in-place density in accordance with TxDOT Tex-207-F and Tex-227-F from cores or sections of asphaltic base located near each core. Other methods of determining in-place density, which correlate satisfactorily with results obtained from roadway specimens, may be used when approved by Project Manager.

C. Request, at option, three additional cores within a 5-foot radius of core indicating nonconforming in-place depth at no additional cost to City. In-place depth at these locations shall be average depth of four cores.

D. Fill cores and density test sections with new compacted asphalt base or cold patch material.

3.07 NONCONFORMING PAVEMENT

A. Re-compact and retest nonconforming street sections not meeting surface test requirements. Patch asphalt pavement sections in accordance with procedures established by Asphalt Institute. Retesting is at no cost to the City.

B. Remove and replace areas of asphalt base found deficient in thickness by more than 10 percent. Remove and replace areas of asphalt base found deficient in density. Use new asphalt base of thickness shown on Drawings.

C. Replace or correct nonconforming pavement sections at no additional cost to City.

3.08 PROTECTION

A. Do not open base to traffic until 12 hours after completion of rolling, or as shown on Drawings.

B. Maintain asphalt base in good condition until completion of Work.

C. Repair defects immediately by replacing base to full depth.

END OF SECTION

SECTION 02712

CEMENT STABILIZED BASE COURSE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Foundation course of cement stabilized crushed stone.

B. Foundation course of cement stabilized bank run gravel.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 02315 – Roadway Excavation

E. Section 02330 – Embankment

F. Section 02742 – Prime Coat

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for cement stabilized base course is on square yard basis. Separate pay items are used for each different required thickness of base course.

2. Payment for asphaltic seal cure is by gallon.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

4. Refer to Paragraph 3.09, Unit Price Adjustment.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 131 - Standard Test Method for Resistance to Degradation of Small-Size Course Aggregate by Abrasion and Impact in Los Angeles Machine.

B. ASTM C 150 - Standard Specification for Portland Cement.

C. ASTM D 698 - Standard Test Method for Laboratory Compaction Characteristics of Soils Using Standard Effort (12,400 ft-lbf/ft3 (600kN kN-m/m3).

D. ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.

E. ASTM D 1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))

F. ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

G. ASTM D 6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

H. TxDOT Tex-101-E - Preparing Soil and Flexible Base Materials for Testing.

I. TxDOT Tex-110-E - Particle Size Analysis of Soils.

J. TxDOT Tex-120-E - Soil-Cement Testing.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit samples of crushed stone, gravel, and soil binder for testing.

C. Submit manufacturer's description and characteristics for pug mill and associated equipment, spreading machine, and compaction equipment for approval.

1.06 TESTS

A. Perform testing under provisions of Section 01454 - Testing Laboratory Services.

B. Perform tests and analysis of aggregate and binder materials in accordance with ASTM D 1557 and ASTM D 4318.

1.07 DELIVERY, STORAGE AND HANDLING

A. Make stockpiles from layers of processed aggregate to eliminate segregation of materials. Load material by making successive vertical cuts through entire depth of stockpile.

B. Store cement in weatherproof enclosures. Protect from ground dampness.

PART 2 PRODUCTS

2.01 CEMENT

A. ASTM C 150 Type I; bulk or sacked.

2.02 WATER

A. Clean, clear; and free from oil, acids, alkali, or vegetable matter.

2.03 AGGREGATE

A. Crushed Stone: Material retained on No. 40 Sieve meeting following requirements:

1. Durable particles of crusher-run broken limestone, sandstone, or granite obtained from approved source.

2. Los Angeles abrasion test percent of wear not to exceed 40 when tested in accordance with ASTM C 131.

B. Gravel: Durable particles of bank run gravel or processed material.

C. Soil Binder: Material passing No. 40 Sieve meeting following requirements when tested in accordance with ASTM D 4318:

1. Maximum Liquid limit: 35.

2. Maximum Plasticity index: 10.

D. Mixed aggregate and soil binder shall meet the following requirements:

1. Grading in accordance with TxDOT Tex-101-E and Tex-110-E within the following limits:

Sieve	Percent Retained			
	Crushed Stone 0 to 10	Processed G. 1 0 to 5	Gravel G. 2 -	Bank run Gravel 0 to 5
1 3/4 inch				
1/2 inch	-	-	0	-
No. 4	45 to 75	30 to 75	15 to 35	30 to 75
No. 40	55 to 80	60 to 85	55 to 85	65 to 85

2. Obtain prior permission from Project Manager for use of additives to meet above requirements.

2.04 ASPHALT SEAL CURE

A. Cutback Asphalt: MC30 conforming to requirements of Section 02742 - Prime Coat.

B. Emulsified Petroleum Resin: EPR-1 Prime conforming to requirements of Section 02742 - Prime Coat.

2.05 MATERIAL MIX

A. Design mix for minimum average compressive strength of 200 psi at 48 hours using TxDOT Tex-120-E unconfined compressive strength testing procedures. Provide minimum cement content of 1 1/2 sacks, weighing 94 pounds each, per ton of mix.

B. Increase cement content when average compressive strength of tests on field samples fall below 200 psi. Refer to Part 3 concerning field samples and tests.

C. Mix in stationary pug mill equipped with feeding and metering devices for adding specified quantities of base material, cement, and water into mixer. Dry mix base material and cement sufficiently to prevent cement balls from forming when water is added.

D. Resulting mixture shall be homogeneous and uniform in appearance.

2.06 SOURCE QUALITY CONTROL

A. Perform testing under provisions of Section 01454 - Testing Laboratory Services.

B. Perform testing for unconfined compressive strength by TxDOT Test Method Tex-120-E as follows:

1. Mold three samples each day or for each 300 tons of production.

2. Compressive strength shall be average of three tests for each production lot.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify compacted subgrade is ready to support imposed loads.

B. Verify lines and grades are correct.

3.02 PREPARATION

A. Complete backfill of new utilities below future grade.

B. Prepare subgrade in accordance with requirements of Section 02330 - Embankment and Section 02315 - Roadway Excavation.

C. Correct subgrade deviations in excess of plus or minus 1/4 inch in cross section or in 16 foot length by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling.

D. Prepare sufficient subgrade in advance of base course for efficient operations.

3.03 PLACEMENT

A. Do not mix and place cement stabilized base when temperature is below 40 degrees F and falling. Place base when temperature taken in shade and away from artificial heat is above 35 degrees F and rising.

B. Place material on prepared subgrade in uniform layers to produce thickness indicated on Drawings. Depth of layers shall not exceed 6 inches.

C. Spread with approved spreading machine. Conduct spreading so as to eliminate planes of weakness or pockets of non-uniformly graded material resulting from hauling and dumping operations.

D. Provide construction joints between new material and stabilized base that has been in place 4 hours or longer. Joints shall be approximately vertical. Form joint with temporary header or make vertical cut of previous base immediately before placing subsequent base.

E. Use only one longitudinal joint at center line under main lanes and shoulder unless shown otherwise on Drawings. Do not use longitudinal joints under frontage roads and ramps unless indicated on Drawings.

F. Place base so that projecting reinforcing steel from curbs remain at approximate center of base. Secure firm bond between reinforcement and base.

3.04 COMPACTION

A. Start compaction as soon as possible but not more than 60 minutes from start of moist mixing. Compact loose mixture with approved tamping rollers until entire depth is uniformly compacted. Do not allow stabilized base to mix with underlying material.

B. Correct irregularities or weak spots immediately by replacing material and recompacting.

C. Apply water to maintain moisture between optimum and 2 percent above optimum moisture as determined by ASTM D 698. Mix in with spiked tooth harrow or equal. Reshape surface and lightly scarify to loosen imprints made by equipment.

D. Remove and reconstruct sections where average moisture content exceeds ranges specified at time of final compaction.

E. Finish by blading surface to final grade after compacting final course. Seal with approved pneumatic tired rollers which are sufficiently light to prevent surface hair line cracking. Rework and recompact at areas where hair line cracking develops.

F. Compact to minimum density of 95 percent of maximum dry density at moisture content of treated material between optimum and 2 percent above optimum as determined by ASTM D 1557, unless otherwise indicated on Drawings.

G. Maintain surface to required lines and grades throughout operation.

3.05 CURING

A. Moist cure for minimum of 7 days before adding pavement courses. Restrict traffic on base to local property access. Keep subgrade surface damp by sprinkling.

B. If indicated on Drawings, cover base surface with curing membrane as soon as finishing operation is complete. Apply with approved self-propelled pressure distributor at following rates, or as indicated on Drawings:

1. MC30: 0.1 gallon per square yard.

2. EPR-1 Prime: 0.15 gallon per square yard.

C. Do not use cutback asphalt during period of April 16 to September 15.

3.06 TOLERANCES

A. Smooth and conform completed surface to typical section and established lines and grades.

B. Top surface of base course: Plus or minus 1 1/4 inch in cross section, or in 16 foot length.

3.07 FIELD QUALITY CONTROL

A. Perform testing under provisions of Section 01454 - Testing Laboratory Services.

B. Take minimum of one core at random locations per 1000 linear feet per lane of roadway or 500 square yards of base to determine in-place depth.

C. Request additional cores in vicinity of cores indicating nonconforming in-place depths at no extra cost to City. When average of tests fall below required depth, place additional material and compact at no additional cost to City.

D. Perform compaction testing in accordance with ASTM D 698 or ASTM D 6938 at randomly selected locations. Remove and replace areas that do not conform to compaction requirements at no additional cost to City.

E. Fill cores and density test sections with new compacted cement stabilized base.

3.08 NONCONFORMING BASE COURSE

A. Remove and replace areas of base course found deficient in thickness by more than 10 percent, or that fail compressive strength tests, with cement-stabilized base of thickness shown on Drawings.

B. Replace nonconforming base course sections at no additional cost to City.

3.09 UNIT PRICE ADJUSTMENT

A. Make unit price adjustments for in-place depth determined by cores as follows:

1. Adjusted unit price shall be ratio of average thickness as determined by cores to thickness bid upon, times unit price.

2. Apply adjustment to lower limit of 90 percent and upper limit of 100 percent of unit price.

3.10 PROTECTION

A. Maintain stabilized base in good condition until completion of Work. Repair defects immediately by replacing base to full depth.

B. Protect asphalt membrane, when used, from being picked up by traffic. Membrane may remain in place when proposed surface courses or other base courses are to be applied.

END OF SECTION

SECTION 02713

RECYCLED CRUSHED CONCRETE BASE COURSE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Recycled crushed concrete base (RCCB) course.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01452 – Inspection Services

D. Section 01454 – Testing Laboratory Services

E. Section 02315 – Roadway Excavation

F. Section 02330 – Embankment

G. Section 02336 – Lime Stabilized Subgrade

H. Section 02337 – Lime/Fly Ash Stabilized Subgrade

I. Section 02338 – Portland Cement Stabilized Subgrade

J. Section 02742 – Prime Coat

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for RCCB is on per ton basis furnished and compacted in place.

2. Payment for RCCB for transitions and base repairs, if required, is on a per ton basis.

3. No separate payment will be made for RCCB for temporary driveway, temporary detour pavement, temporary road shoulders and etc. Include payment in unit price for related work.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 150 - Standard Specification for Portland Cement.

B. TxDOT Tex-101-E - Preparing Soil and Flexible Base Materials for Testing.

C. TxDOT Tex-106-E - Calculating the Plasticity Index of Soils.

D. TxDOT Tex-110-E - Determining Particle Size Analysis of Soils.

E. TxDOT Tex-113-E - Laboratory Compaction Characteristics and Moisture-Density Relationship of Base Materials.

F. TxDOT Tex-115-E - Field Method for Determining In-place Density of Soils and Base Materials.

G. TxDOT Tex-120-E - Soil-Cement Testing.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit representative samples of crushed concrete for testing.

C. Submit weight tickets, certified by supplier, for each delivery of recycled crushed concrete, gravel, and soil binder.

D. Submit manufacturer's description and characteristics for pug mill and associated equipment, mixer trucks, spreading and compaction equipment for approval.

1.06 DELIVERY, STORAGE AND HANDLING

A. Provide materials from stockpiles that are protected during storage from contaminates detrimental to concrete base.

B. Load material from same area of stockpile to maintain uniformity of each successive delivery to Project site.

C. Store cement in weatherproof enclosures. Protect from ground dampness.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Provide RCCB with following performance:

1. Minimum 7 percent cement.

2. Minimum compressive strength: 650 psi at 14 days following TxDOT Tex-120-E.

3. Prepare concrete product in on-site or off-site pug mill, or in on-site or off-site portable concrete mixer.

B. Preliminary Design: Prepare preliminary mix with minimum cement to crushed concrete ratios of 5 percent by dry mass of materials.

1. Designate source of concrete for crushing. Follow Section 01454 - Testing Laboratory Services for tests of concrete from source.

2. Results of laboratory and compression tests will be used by Project Manager to select final mix design.

2.02 PORTLAND CEMENT

A. ASTM C 150 Type I, II, or III; bulk or sacked.

2.03 WATER

A. Potable.

2.04 AGGREGATE

A. Recycled Crushed Concrete: Material retained on No. 40 Sieve, and durable coarse particles of crusher-run reclaimed cured Portland cement concrete, obtained from approved source. Organic material is prohibited. The crushed concrete shall be substantially free of foreign matter including but not limited to asphalt, base, and dirt.

B. Soil Binder (classified below): Meeting following requirements when tested following TxDOT Tex-106-E:

1. Maximum liquid limit: 35

2. Maximum plasticity index: 10

C. Mixed Aggregate and Soil Binder: Grading following TxDOT Tex-101-E and Tex-110-E within following limits:

Sieve	Percent Crushed Concrete Retained
1-3/4 inch	0 to 10
No. 4	45 to 75
No. 40	55 to 80; classified as Soil Binder

1. Bank sand may be added to mix at pug mill.

2.05 ASPHALTIC SEAL CURE

A. Acquire written approval from Project Manager before curing and before proceeding with curing.

B. Use following as option to curing by sprinkling:

1. Cut-back asphalt: MC30 following Section 02742 - Prime Coat.

2. Emulsified petroleum resin: EPR-1 Prime following Section 02742 - Prime Coat.

2.06 MATERIAL MIX

A. Design mix for minimum compressive strength of 650 psi at 14 days following TxDOT Tex-120-E unconfined compressive strength.

B. Cement Ratio: Follow Paragraph 2.01A. Increase cement content in two percent steps up to 9 percent maximum when compressive strength of design mix samples fail TxDOT Tex-120E test.

2.07 MIXING EQUIPMENT

A. Mix following Paragraph 2.01A, with metering devices adding specified quantities of crushed concrete, cement, and water into mixer. Dry mix crushed concrete and cement prior to adding water. Produce homogeneous and uniformly mixed product.

2.08 SOURCE QUALITY CONTROL

A. Test following Section 01454 -Testing Laboratory Services.

B. When directed by Project Manager, test for unconfined compressive strength following Test Method TxDOT Tex-120-E as follows:

1. Mold minimum of three samples each day or for each 500 tons of production or one for each day.

2. Compressive strength: average of 3 specimens for each sample lot.

PART 3 EXECUTION

3.01 EXAMINATION

A. Follow Section 01452 - Inspection Services.

B. Verify buried utility work is complete.

C. Verify lime treatment of base is complete.

D. Verify subgrade is ready to support imposed loads. Verify flatwork, foundations, projecting reinforcement and similar Work interfacing with base is in place.

E. Verify lines and grades are correct.

3.02 PREPARATION

A. Complete backfill of new utilities below future grade.

B. Prepare subgrade in accordance with requirements of Section 02330 - Embankment and Section 02315 - Roadway Excavation, or Section 02336 - Lime Stabilized Subgrade and Section 02337 - Lime/Fly Ash Stabilized Subgrade and Section 02338 - Portland Cement Stabilized Subgrade.

C. Correct subgrade deviations in excess of plus or minus 1/4 inch in cross section, or in 16 foot length by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling.

D. Prepare sufficient subgrade in advance of base course for efficient operations.

E. Have sufficient products and equipment on hand to expeditiously apply base.

3.03 MIXING

A. Maintain moisture content of between optimum and 5 percent above optimum.

3.04 PLACEMENT

A. Place mixture with approved spreading equipment. Spread to eliminate planes of weakness or pockets of nonuniformly graded material resulting from hauling and dumping operations.

B. Provide approximately vertical construction joints between fresh base and base-in-place 4 hours or longer. Form joint with temporary header or make vertical cut of in-place base immediately before placing fresh base.

C. Make cold joints at center line of head-to-head parking stalls.

D. Place base so that projecting reinforcing steel from curbs remain at approximate center of base. Provide proper bond between reinforcement and base.

E. Transverse and longitudinal joints shall be vertical.

F. Unless noted otherwise, place recycled crushed concrete base in courses not to exceed 8 inches in depth. All courses shall be placed on same working day unless approved by Project Manager. Construction joints between new base and base previously placed shall be wetted and coated with dry cement prior to addition of new base.

G. Complete finishing operations within period of 6 hours after cement is added to base materials.

3.05 COMPACTION

A. Start compaction maximum 3 hours after start of mixing. Compact loose mixture with approved tamping rollers until entire depth is uniformly compacted. Do not allow base to mix with underlying material.

1. Do not rework uncompacted material that has set up for more than 30 minutes.

2. Complete placement and compaction work within 6 hours from start of moist mixing.

B. Correct irregularities or weak spots immediately by replacing material and recompacting.

C. Apply water to maintain moisture between optimum and 5 percent above optimum moisture.

D. Remove and reconstruct sections where average moisture content exceeds ranges specified at time of final compaction.

E. Finish by blading surface to final grade after compacting final course. Seal with approved pneumatic tired rollers or flat wheel rollers which are sufficiently light to prevent surface hair line cracking.

F. Compact to minimum density of 95 percent of dry density, following TxDOT Tex - 113-E, at moisture content of treated material between optimum and 5 percent above optimum.

G. Test roadway base course compaction in accordance with TxDOT Tex-115-E.

H. Maintain surface to required lines and grades throughout operation.

3.06 CURING

A. Moist cure for minimum of 72 hours before adding pavement courses.

B. Use sprinkling or, at option, apply following curing membrane as soon as initial set begins, using approved light-weight self-propelled pressure distributor:

1. MC30: 0.1 gallon per square yard.

2. EPR-1 Prime: 0.15 gallon of asphalt residual per square yard.

C. Do not use cut-back asphalt during period of April 16 through September 15.

3.07 TOLERANCES

A. Completed Surface: Smooth and conform to typical section and established lines and grades.

B. Top Surface of Base Course: Plus or minus 1/4 inch in cross section or in 16 foot length.

3.08 FIELD QUALITY CONTROL

A. Test following Section 01454 - Testing Laboratory Services.

B. Perform compaction tests following TxDOT Tex-113-E at randomly selected locations. Remove and replace areas failing compaction requirements at no additional cost to City.

C. Test and analyze aggregate and binder products following TxDOT Tex-110-E.

3.09 PROTECTION

A. Maintain base in proper condition until surface is placed. Surface must be placed within 14 days after final mixing and compaction unless otherwise approved by Project Manager. Repair unacceptable base course immediately by replacing base to full depth.

B. Curing membrane may remain in place at areas where surface courses or other base courses are applied.

C. Prevent construction traffic on base for minimum 3 days. Light vehicles, used to maintain proper cure, are permitted on base after initial set or as permitted by Project Manager.

END OF SECTION

SECTION 02714

FLEXIBLE BASE COURSE FOR TEMPORARY DRIVEWAYS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Foundation course of crushed concrete or stone.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 02315 – Roadway Excavation

E. Section 02336 – Lime Stabilized Subgrade

F. Section 02337 – Lime/Fly Ash Stabilized Subgrade

1.03 MEASUREMENT AND PAYMENT

A. UNIT PRICES

1. Measurement for flexible base course payment is on each driveway basis. To maintain access or temporary driveway, separate measurement will be made for each different type of driveway (residential, commercial, or custom properties) or as identified on the Drawings.

2. Payment limits for temporary driveways are based upon the width of the driveway access (not to exceed 12-feet for residential, 24-feet for commercial, or custom dimensioned properties) and the length from permanent or temporary roadway to the remaining permanent driveway or street right-of-way, as necessary to maintain access to properties.

3. No separate payment will be made for flexible base course for temporary roads, detour pavements, and shoulder under this Section unless it is included as an extra unit bid and as approved for payment by the project manager. Flexible base course for temporary driveways or access if included under the extra unit bid item is on a cubic yard basis.

4. Temporary driveways will be paid only once per driveway location shown to be replaced on the Drawing and payment shall be made based upon actual installation.

5. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 REFERENCES

A. ASTM C 131 – Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

B. ASTM D 1556 - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method.

C. ASTM D 698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12.44 ft-lbf/ft3).

D. ASTM D 4318 - Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

E. ATMD D 6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

F. TxDOT Tex-101-E - Preparing Soil and Flexible Base Materials for Testing.

G. TxDOT Tex-110-E - Particle Size Analysis of Soils.

1.05 SUBMITTALS

A. Submittals shall conform to requirements of Section 01330 - Submittals Procedures.

B. Submit samples of flexible base course and soil binder for testing.

1.06 TESTS

A. Tests and analysis of soil materials will be performed in accordance with ASTM C 131, ASTM D 698, ASTM D 4318, Tex-101-E, and Tex-110-E under provisions of Section 01454 - Testing Laboratory Services.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Provide materials from stockpiles that are protected during storage from contaminates that would be detrimental to the flexible base course.

B. Load materials from same area of stockpile to maintain uniformity of each successive delivery to the project site.

PART 2 PRODUCTS

2.01 MATERIALS

A. Crushed Stone or Concrete: Material retained on the No. 40 sieve meeting the following requirements:

1. Durable particles of crusher-run broken limestone, crushed concrete, crushed sandstone, or granite obtained from an approved source.

B. Soil Binder: Material passing the No. 40 sieve meeting the following requirements when tested in accordance with ASTM D 4318:

1. Maximum Liquid Limit: 40

2. Maximum Plasticity Index: 12

3. Maximum Lineal Shrinkage: 7 (when calculated from volumetric shrinkage at liquid limit).

C. Mixed Materials shall meet the following requirements:

1. Minimum compressive strength of 35 psi at 0 psi lateral pressure and 175 psi at 15 psi lateral pressure using triaxial testing procedures.

2. Grading in accordance with Tex-101-E and Tex-110-E within the following limits:

Sieve	Percent Retained
1-3/4 inch	0 to 10
No. 4	45 to 75
No. 40	60 to 85

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify compacted subgrade is ready to support imposed loads.

B. Verify lines and grades are correct.

3.02 PREPARATION

A. Complete backfill of new utilities below future grade.

B. Prepare subgrade in accordance with requirements of Section 02315 - Roadway Excavation or Sections 02336 - Lime Stabilized Subgrade and 02337 - Lime/Fly-ash Stabilized Subgrade.

C. Correct subgrade deviations in excess of plus or minus 1/2 inch in cross section, or in 16 foot length by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling.

D. Prepare sufficient subgrade in advance of base course operations.

3.03 PLACEMENT

A. Spread and shape in lifts to compacted thickness not to exceed 6 inches in depth. Complete spreading, shaping, and compacting on same day material is deposited.

B. Place base so that projecting reinforcing steel from curbs remain at approximate center of base. Secure a firm bond between reinforcement and base.

C. Start rolling operations as soon as possible after placement. Use sheepfoot, steel, or pneumatic rollers as approved. Roll longitudinally with subgrade starting from sides. Overlap successive strips by one-half width of each rear wheel.

D. Maintain moisture between optimum and 3 percent above optimum moisture.

E. Compact to 95 percent of Proctor density in accordance with ASTM D 698, unless otherwise indicated on the Drawings.

F. Finish to grade and compact lift before placing successive lift.

G. Maintain shape by grading throughout operation.

H. Provide total thickness indicated on Drawings.

3.04 TOLERANCES

A. Completed surface shall be smooth and conform to typical section and established lines and grades.

3.05 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. Compaction Testing will be performed in accordance with ASTM D 698 or ASTM D 6938 at a random location near each depth determination core. Rework and recompact areas that do not conform to compaction requirements.

3.06 PROTECTION

A. Sprinkle to prevent excessive loss of moisture.

B. Restrict construction traffic on finished base to equipment required to complete the work.

END OF SECTION

SECTION 02741

ASPHALTIC CONCRETE PAVEMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Surface course of compacted mixture of coarse and fine aggregates and asphaltic binder.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 02711 – Hot Mix Asphalt Base Course

E. Section 02712 – Cement Stabilized Base Course

F. Section 02713 - Recycled Crushed Concrete Base Course

G. Section 02743 - Tack Coat

H. Section 02767 - Thermoplastic Pavement Markings

I. Section 02951 – Pavement Repair and Restoration

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for hot-mix asp halt concrete pavement is on a per ton basis. Separate pay items are used for each different required thickness of pavement.

2. Payment for hot-mix asphalt concrete pavement includes payment for associated work performed in accordance with Section 02743 - Tack Coat.

3. Payment for pavement repair or pavement replacement for utility projects is on a square yard basis and includes surface and base materials in accordance with Section 02951 - Pavement Repairs and Restoration.

4. Payment for temporary detour pavement or temporary roadway and shoulder is on a square yard basis and includes surface and base materials, associated grading, maintenance and removal as well as restoration of ditches.

5. Payment for speed humps is on linear foot basis, and includes milling of existing pavement, tack coat, and placement and compaction of asphalt. Measurement of speed hump is along length of 12 foot wide speed hump, measured transverse to centerline of road. Separate payment is made for thermoplastic markings applied to speed hump.

6. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 33 - Standard Specification for Concrete Aggregates.

B. ASTM C 131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

C. ASTM D 4022 - Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer.

D. TxDOT Tex-106-E - Calculating the Plasticity Index of Soils

E. TxDOT Tex-126-E - Molding, Testing, and Evaluating Bituminous Black Base Material.

F. TxDOT Tex-200-F - Sieve Analysis of Fine and Course Aggregates.

G. TxDOT Tex-203-F - Sand Equivalent Test.

H. TxDOT Tex-204-F - Design of Bituminous Mixtures.

I. TxDOT Tex 206-F - Compacting Test Specimens of Bituminous Mixtures.

J. TxDOT Tex-207-F - Determining Density of Compacted Bituminous Mixtures.

K. TxDOT Tex-208-F - Test for Stabilometer Value of Bituminous Mixtures.

L. TxDOT Tex-217-F - Determining Deleterious Material and Decantation Test for Coarse Aggregates.

M. TxDOT Tex-227-F - Theoretical Maximum Specific Gravity of Bituminous Mixtures.

N. TxDOT Tex-530-C - Effect of Water on Bituminous Paving Mixtures.

O. TxDOT Tex-531-C - Prediction of Moisture Induced Damage to Bituminous Paving Materials Using Molded Specimens.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certificates that asphalt materials and aggregates meet requirements of Paragraph 2.01, Materials.

C. Submit proposed design mix and test data for surface course.

D. Submit manufacturer's description and characteristics of spreading and finishing machine for approval.

PART 2 PRODUCTS

2.01 MATERIALS

A. Coarse Aggregate:

1. Use gravel, crushed stone, or combination thereof, that is retained on No. 10 sieve, uniform in quality throughout and free from dirt, organic or other injurious matter occurring either free or as coating on aggregate. Use aggregate conforming to ASTM C 33 except for gradation. Furnish rock or gravel with Los Angeles abrasion loss not to exceed 40 percent by weight when tested in accordance with ASTM C 131.

2. Aggregate by weight shall not contain more than 1.0 percent by weight of fine dust, clay- like particles, or silt when tested in accordance with Tex-217-F, Part II.

B. Fine Aggregate: Sand, stone screenings or combination of both passing No. 10 sieve. Use aggregate conforming to ASTM C 33 except for gradation. Use sand composed of sound, durable stone particles free from loams or other injurious foreign matter. Furnish screenings of same or similar material as specified for coarse aggregate. Plasticity index of that part of fine aggregate passing No. 40 sieve shall be not more than 6 when tested by TxDOT Tex-106-E. Sand equivalent shall have minimum value of 45 when tested by TxDOT Tex-203-F.

C. Composite Aggregate: Conform to following limits when graded in accordance with TxDOT Tex-200-F. Use type specified on Drawings:

GRADATION OF COMPOSITE AGGREGATE		
	PERCENT PASSING	
SIEVE SIZE	Course Surface (TxDOT Type C)	Fine Surface (TxDOT Type D)
-	-	-
3/4 “	95 to 100	-
1/2"	-	98.0-100.0
3/8"	70.0-85.0	85.0-100.0
#4	43 to 63	50.0 to 70.0
#8	32.0-44.0	35.0-46.0
#30	14.0-28.0	15.0-29.0
# 50	7.0-21.0	7.0-20.0
#200	2.0-7.0	2.0-7.0
VMA % minimum	14.0	15.0
* 2 to 8 when Test Method Tex-200-F, Part II (Washed Sieve Analysis) is used.		

D. Asphalt Binder: Moisture-free homogeneous material which will not foam when heated to 347 F, meeting the following requirements.

PERFORMANCE GRADED BINDER	
CRITERIA / TEST	PERFORMANCE GRADE (PG64-22)
Average 7-day Maximum Pavement Design Temperature, C	< 64
Minimum Pavement Design Temperature, C	> -22
ORIGINAL BINDER	
Flash Point Temperature, T48; Minimum C	230
Viscosity, ASTM D 4402; Maximum, 3Pa*s (3000 cP) Test Temperature, C	135
Dynamic Shear, TP5; G*/sin[ ], Minimum, 1.00 kPa Test Temperature @ 10 rad/sec., C	64
ROLLING THIN FILM OVEN (T240) OR THIN FILM OVEN (T179) RESIDUE	
Mass Loss, Maximum , %	1.00
Dynamic Shear, TP5; G*/sin [ ], Minimum, 2.20 kPa Test Temperature @ 10 rad/sec., C	64
PRESSURE AGING VESSEL RESIDUE (PP1)	
PAV Aging Temperature, C	100
Dynamic Shear, TP5; G*/sin [ ], Minimum, 5000 kPa Test Temperature @ 10 rad/sec., C	25
Physical hardening	Report
Creep Stiffness, TP1; S, Maximum, 300 Mpa -value, Minimum, 0.300 Test Temperature @ 60 sec., C	-12
Direct Tension, TP3; Failure Strain, Minimum, 1.0% Test Temperature @ 1.0 mm/min, C	-12

E. Anti-stripping Agent:

1. Evaluate mixture of aggregate, asphalt, and additives proposed for use for moisture susceptibility and requirement for anti-stripping agents. To substantiate mix design, produce and test trial mixtures using proposed project materials and equipment prior to placement. Test for susceptibility to moisture and trial mixture may be waived by Project Manager when similar designs using same material have previously proven satisfactory.

2. Liquid Anti-stripping Agent. Use anti-stripping agent with uniform liquid with no evidence of crystallization, settling, or separation of components. Submit sample of anti- stripping agent proposed for use and manufacturer's product data, including recommended dosage range, handling and storage, and application instructions.

F. Pavement markings for speed humps: Conform to requirements of Section 02767 - Thermoplastic Pavement Markings.

2.02 EQUIPMENT

A. Mixing Plant: Weight-batching or drum mix plant with capacity for producing continuous mixtures meeting specifications. With exception of a drum mix plant, plant shall have satisfactory conveyors, power units, aggregate handling equipment, hot aggregate screens and bins, and dust collectors.

B. Provide equipment to supply materials adequately in accordance with rated capacity of plant and produce finished material within specified tolerances. Following equipment is essential:

1. Cold aggregate bins and proportioning device

2. Dryer

3. Screens

4. Aggregate weight box and batching scales

5. Mixer

6. Asphalt storage and heating devices

7. Asphalt measuring devices

8. Truck scales

C. Bins: Separate aggregate into minimum of four bins to produce consistently uniform grading and asphalt content in completed mix. Provide one cold feed bin per stockpile.

2.03 MIXES

A. Employ certified testing laboratory to prepare design mixes. Test in accordance with TxDOT Tex-126-E or Tex-204-F, Tex-206-F, Tex-208-F, Tex-530-C and Tex-531-C.

B. Density, Stability and Air Void Requirements:

Percent Density		Percent	HVEEM Stability Percent
Min	Max	Optimum	Not Less Than
94.5	97.5	96	35

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify compacted base course is ready to support imposed loads.

B. Verify lines and grades are correct.

3.02 PREPARATION

A. Tack Coat: Conform to requirements of Section 02743 - Tack Coat. Where mixture will adhere to surface on which it is to be placed without use of tack coat, tack coat may be eliminated when approved by Project Manager.

B. Prepare subgrade in accordance with requirements of Section 02711 - Hot Mix Asphalt Base Course, Section 02712 - Cement Stabilized Base Course, or Section 02713 - Recycled Crushed Concrete Base Course.

C. Prepare subgrade in advance of asphalt concrete paving operation.

D. Perform pavement repair and resurfacing as indicated in Section 02951 - Pavement Repair and Restoration.

E. Do not use cutback asphalt.

F. Milling of pavement for speed humps: Mill pavement (concrete or asphalt) to depth of one inch and width between 18 and 24 inches around entire perimeter of proposed hump, as shown in detail for speed hump design.

3.03 PLACEMENT

A. Do not place asphalt pavement less than 2 inches thick when surface temperature taken in shade and away from artificial heat is below 50 F and falling. Asphalt may be placed when temperature is above 40 F and rising.

B. Haul prepared and heated asphaltic concrete mixture to project in tight vehicles previously cleaned of foreign material. Mixture temperature shall be between 250 F and 325 F when laid.

C. Spread material into place with approved mechanical spreading and finishing machine of screening or tamping type.

D. Surface Course Material: Surface course 2 inches or less in thickness may be spread in one lift. Spread lifts in such a manner that, when compacted, finished course will be smooth, of uniform density, and will be to section, line and grade as shown. Place construction joints on surface courses to coincide with lane lines or as directed by Project Manager.

E. Joints: Pass roller over unprotected ends of freshly laid mixture only when mixture has cooled. When work is resumed, cut back laid material to produce slightly beveled edge for full thickness of course. Remove old material which has been cut away and lay new mix against fresh cut.

F. When new asphalt is laid against existing or old asphalt, saw cut existing or old asphalt to full depth to provide straight smooth joint.

G. In smaller restricted areas where use of paver is impractical spread material by hand. Compact asphalt by mechanical means. Carefully place materials to avoid segregation of mix. Do not broadcast material. Remove lumps that do not break down readily.

3.04 COMPACTION

A. Construct test strip to identify correct type, number, and sequence of rollers necessary to obtain specified in-place density or air-voids when directed by the Project Manager. Prepare test strip at least 1,000 feet in length, comparable to placement and compaction conditions for Project.

B. Begin rolling while pavement is still hot and as soon as it will bear roller without shoving, displacement or hair cracking. Keep wheels properly moistened with water to prevent adhesion of surface mixture. Do not use excessive water or petroleum by-products.

C. Compact surface thoroughly and uniformly, first with power-driven, 3-wheel, or tandem rollers weighing a minimum of 8 tons. Obtain subsequent compression by starting at side and rolling longitudinally toward center of pavement, overlapping on successive trips by at least one-half width of rear wheels. Make alternate trips slightly different in length.

D. Continue rolling until no further compression can be obtained and rolling marks are eliminated. Complete rolling before mat temperature drops below 185 F.

E. Use tandem roller for final rolling. Double coverage with approved pneumatic roller on asphaltic concrete surface is acceptable after flat wheel and tandem rolling has been completed.

F. Along walls, curbs, headers and similar structures, and in locations not accessible to rollers, compact mixture thoroughly with lightly oiled tamps.

G. Compact binder course and surface course to a minimum density of 91 percent of maximum possible density of voidless mixture composed of same materials in like proportions.

3.05 TOLERANCES

A. Furnish templates for checking surface in finished sections. Maximum deflection of templates, when supported at center, shall not exceed 1/8 inch.

B. Completed surface, when tested with 10-foot straightedge laid parallel to center line of pavement, shall show no deviation in excess of 1/8 inch in 10 feet. Correct surface not meeting this requirement.

C. Dimensions of speed humps shall conform to details for speed hump design and speed hump height tolerances.

3.06 QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. For in-place depth and density, take minimum of one core at random locations for each 1000 feet of single lane pavement. On a 2-lane pavement, take samples at random every 500 feet from alternating lanes. Take cores for parking lots every 500 square yards of base to determine in-place depth and density. If cul-de sac or streets are less than 500 feet, minimum of 2 cores (one per lane) will be procured. On small projects, take a minimum of two cores for each day's placement. For first days placement and prior to coring, minimum of 5 nuclear gauge readings will be performed at each core location to establish correlation between nuclear gauge (wet density reading) and core (bulk density). This process will continue for each day's placement until engineer determines that a good bias has been established for that nuclear gauge.

C. Determine in-place density in accordance with TxDOT Tex-207-F and Tex-227-F from cores or sections. Other methods of determining in-place density, which correlate satisfactorily with results obtained from roadway specimens, may be used when approved by Project Manager. Average densities for each street placed in a single day to determine compliance.

D. Contractor may request three additional cores in vicinity of cores indicating nonconforming in-place depths or density at no additional cost to City. In-place depth and density at these locations shall be average of four cores.

E. Fill cores and density test sections with new compacted asphaltic concrete.

F. Speed humps: Measure dimensions of completed speed hump, before applying pavement markings, at locations shown on Speed Hump Height Measurement Worksheet. Complete one worksheet for each speed hump, and send completed worksheets to City of Houston, Houston Public Works, Traffic Management and Maintenance Branch, P.O. Box 1562, Houston, Texas, 77251-1562.

3.07 NONCONFORMING PAVEMENT

A. Recompact and retest nonconforming street sections not meeting surface test requirements or having unacceptable surface texture. Patch asphalt pavement sections in accordance with procedures established by Asphalt Institute. Retesting is at no cost to the City.

B. Remove and replace areas of asphalt surface found deficient in thickness by more than 10 percent. Use new asphaltic surface of thickness shown on Drawings. Remove and replace areas of asphalt surface found deficient in average density.

C. Replace speed humps which do not conform to requirements of details, or which are rejected by Project Manager.

3.08 PROTECTION

A. Do not open pavement to traffic until completion of rolling and temperature has cooled to set asphaltic concrete surface, or as shown on Drawings.

B. Maintain asphalt pavement in good condition until completion of Work.

C. Repair defects immediately by replacing asphalt pavement to full depth.

3.09 PAVEMENT MARKINGS FOR SPEED HUMPS

A. Apply pavement markings to speed humps in conformance with dimensions shown on detail for speed hump design.

END OF SECTION

SECTION 02742

PRIME COAT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Prime coat for asphalt concrete paving

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for prime coat under this Section. Include payment in unit price for material being primed.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit product data for proposed prime coat.

C. Submit report of recent calibration of distributor.

PART 2 PRODUCTS

2.01 CUTBACK ASPHALT

A. Provide moisture-free homogeneous material which will not foam when heated to 347 degrees F and which meets following requirements:

B. Asphalt material for prime coat shall be MC-30 or MC-70 and shall meet following requirements:

PROPERTIES	TYPE - GRADE			
	MC-30		MC-70	
	MIN.	MAX.	MIN.	MAX.
Water, Percent	---	0.2	---	0.2
Flash Point, T.O.C., °F	100	---	100	---
Kinematic Viscosity at 140°F, cst	30	60	70	140

1. Distillate shall be as follows, expressed as percent by volume of total distillate to 680 degrees F:

TEMPERATURE	TYPE-GRADE			
	MC-30		MC-70	
	MIN.	MAX.	MIN.	MAX.
to 437°F	---	25	---	20
to 500°F	40	70	20	60
to 600°F	75	93	65	90
Residue from 680°F Distillation, Volume, Percent	50	---	55	---

2. Tests on Distillation Residue:

TEST	TYPE-GRADE			
	MC-30		MC-70	
	MIN.	MAX.	MIN.	MAX.
Penetration at 77°F, 100g, 5 sec.	120	250	120	250
Ductility at 77°F, 5 cm/min. cms	100*	---	100*	---
Solubility in Trichloroethylene, %	99	---	99	---
Spot Test	All Negative			

* If penetration of residue is more than 200 and ductility at 77 degrees F is less than 100 cm, material will be acceptable when its ductility at 60 degrees F is more than 100.

2.02 EMULSIFIED PETROLEUM RESIN

A. EPR-1 Prime: Slow curing emulsion of petroleum resin and asphalt cement conforming to following requirements:

PROPERTIES	MIN.	MAX.
Fural Viscosity at 77°F, Sec	14	40
Residue by Evaporation, % by Weight	60	-
Sieve Test, %	-	0.1
Particle Charge Test	Positive	
Tests on Distillation Residue:		
Flash Point, COC (F)	400	-
Kinematic Viscosity @ 140 F (cst)	190	350

B. For use, EPR-1 may be diluted with water up to maximum three parts water to one part EPR-1 in order to achieve desired concentration of residual resin/asphalt to facilitate application.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify base is ready to support imposed loads.

B. Verify lines and grades are correct.

3.02 PREPARATION

A. Thoroughly clean base course surface of loose material by brooming prior to application of tack coat.

B. Prepare sufficient base in advance of paving for efficient operations.

3.03 APPLICATION, BASIC

A. Apply prime coat with approved type of self-propelled pressure distributor. Distribute prime coat evenly and smoothly under pressure necessary for proper distribution.

B. Keep storage tanks, piping, retorts, booster tanks, and distributors used in handling asphalt materials clean and in good operating condition. Conduct operations so asphalt material does not become contaminated.

C. If yield of asphaltic material appears to be in error, recalibrate distributor prior to continuing Work.

D. Maintain surface until Work is accepted by City.

3.04 APPLICATION, CUTBACK ASPHALT

A. Do not use cutback asphalt during period of April 16 through September 15.

B. Do not place prime coat when air temperature is below 60 degrees F and falling. Materials may be placed when air temperature taken in shade and away from artificial heat is above 50 degrees F and rising.

C. Distribute at rate of 0.25 to 0.35 gallons per square yard.

D. Equipment shall accurately determine temperature of asphaltic material in heating equipment and in distributor, for determining rate of application, and for obtaining uniformity at junction of two distributor loads. Maintain in accurate working order, including recording thermometer at storage heating unit.

E. Base temperature of application on temperature-viscosity relationship that will permit application of asphalt with viscosity of 100 to 125 centistokes. Maintain asphalt within 15 degrees F of temperature required to meet viscosity. Selected temperature shall be within following range.

Prime Coat Type	Minimum (°F)	Maximum (°F)
MC-30	70	150
MC-70	125	175

F. Do not allow temperature of MC-30 to exceed 175 degrees F.

G. Do not allow temperature of MC-70 to exceed 200 degrees F.

3.05 APPLICATION, EMULSIFIED PETROLEUM RESIN

A. Do not place prime coat when air temperature is below 36 degrees F and falling.

B. Distribute at rate of 0.15 to 0.25 gallons per square yard.

3.06 PROTECTION

A. Prevent traffic or placement of subsequent courses over freshly applied prime coat until authorized by Project Manager.

END OF SECTION

SECTION 02743

TACK COAT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Tack coat for asphalt concrete paving.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for tack coat under this Section. Include payment in unit price for asphaltic pavements.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM D 244 - Standard Test Methods and Practices for Emulsified Asphalts.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit product data for proposed tack coat.

C. Submit report of recent calibration of distributor.

PART 2 PRODUCTS

2.01 EMULSION

A. Provide homogeneous material which shows no separation of asphalt after mixing and meets viscosity requirements within 30 days after delivery.

B. Emulsion material for tack coat.

1. Emulsified asphalt: SS-1 or SS-1h meeting following criteria:

PROPERTIES	SS-1		SS-1h	
	MIN.	MAX.	MIN.	MAX.
Furol Viscosity at 77°F, sec.	20	100	20	100
Residue by Distillation, %	60	--	60	--
Oil Portion of Distillate, %	--	1/2	--	1/2
Sieve Test, %	--	0.10	--	0.10
Miscibility (Standard Test)	Passing			
Cement Mixing, %	--	2.0	--	2.0
Storage Stability, 1 Day, %	--	1	--	1
Test on Residue: Penetration at 77°F, 100g, 5 sec. Solubility in Trichloroethylene, % Ductility at 77°F, 5 cm/min., cms	 120 97.5 100	 160 -- --	 70 97.5 80	 100 -- --

2. Polymer Modified Emulsion, SS-1P, for use where thin overlays (less than or equal 2 inches) are placed on collector or arterial streets and for speed humps, especially over existing Portland cement concrete pavement.

PROPERTIES	SS-1P	
	MIN.	MAX.
Furol Viscosity at 77°F, sec.	30	100
Residue by Distillation, %	60	--
Oil Portion of Distillate, %	--	1/2
Sieve Test, %	--	0.10
Miscibility (Standard Test)	Passing	
Cement Mixing, %	--	2.0
Storage Stability, 1 Day, %	--	1
Test on Residue: Penetration at 77°F, 100g, 5 sec.; Solubility in Trichloroethylene, %Ductility at 77°F, 5 cm/min., cms; Viscosity at 140°F, poises	100 97 50 1300	140 -- -- --

3. For emulsions used for tack coats during period of April 16 through September 15, volatile organic compound solvents (VOC) shall not exceed 12 percent by weight when tested in accordance with ASTM D 244.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify compacted base is ready to support imposed loads.

B. Verify lines and grades are correct.

3.02 PREPARATION

A. Thoroughly clean base course or concrete surface of loose material by brooming prior to tack coat application.

3.03 APPLICATION

A. Apply tack coat uniformly by use of approved distributor at rate not to exceed 0.05 gallons per square yard of surface depending on texture of underlying surface. Select an application rate that will provide appropriate asphalt residual.

B. Paint contact surfaces of curbs, structures, and joints with thin uniform coat of tack coat.

3.04 PROTECTION

A. Prevent traffic or placement of subsequent courses over freshly applied tack coat until authorized by Project Manager.

END OF SECTION

SECTION 02751

CONCRETE PAVING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Portland cement concrete paving.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 02751 – Concrete Paving

E. Section 02752 – Concrete Pavement Joints

F. Section 02753 – Concrete Pavement Curing

G. Section 02951 – Pavement Repair and Restoration

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for concrete paving is on square yard basis. Separate pay items are used for each different required thickness of pavement.

2. Payment for concrete paving, high early strength, is on square yard basis.

3. Payment for pavement repair or pavement replacement for utility projects is on a square yard basis and includes base materials in accordance with Section 02951 – Pavement Repair and Restoration.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

5. Refer to Paragraph 3.15, Unit Price Adjustment.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.

B. ASTM A615 - Standard Specification for Deformed and Carbon-Steel Bars for Concrete Reinforcement.

C. ASTM C 31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.

D. ASTM C 33 - Standard Specifications for Concrete Aggregates.

E. ASTM C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

F. ASTM C 40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.

G. ASTM C 42 - Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

H. ASTM C 78 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third Point Loading).

I. ASTM C 94 - Standard Specification for Ready-Mixed Concrete.

J. ASTM C 131 - Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

K. ASTM C 136 - Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

L. ASTM C 138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

M. ASTM C 143 - Standard Test Method for Slump of Hydraulic Cement Concrete.

N. ASTM C 150 - Standard Specification for Portland Cement.

O. ASTM C 174 - Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores.

P. ASTM C 231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

Q. ASTM C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.

R. ASTM C 494 - Standard Specification for Chemical Admixtures for Concrete.

S. ASTM C 618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for use in Concrete.

T. TxDOT Tex-203-F - Sand Equivalent Test.

U. TxDOT Tex-406-A - Material Finer than 75 □□m (No. 200) Sieve In Mineral Aggregates (Decantation Test for Cement Aggregates).

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit proposed mix design and test data for each type and strength of concrete in Work. Include proportions and actual flexural strength obtained from design mixes at required test ages.

C. Submit for approval manufacturer's description and characteristics for mixing equipment, and for traveling form paver, when proposed for use.

D. Submit manufacturer's certificates giving properties of reinforcing steel. Include certificate of compliance with ASTM A 1064. Provide specimens for testing when required by Project Manager.

1.06 HANDLING AND STORAGE

A. Do not mix different classes of aggregate without written permission of Project Manager.

B. Class of aggregate being used may be changed before or during Work with written permission of Project Manager. Comply new class with specifications.

C. Reject segregated aggregate. Before using aggregate whose particles are separated by size, mix them uniformly to grading requirements.

D. Reject aggregates mixed with dirt, weeds, or foreign matter.

E. Do not dump or store aggregate in roadbed.

PART 2 PRODUCTS

2.01 MATERIALS

A. Portland Cement:

1. Sample and test cement to verify compliance with Standards of ASTM C 150, Type I or Type III.

2. Bulk cement which meets referenced standards may be used when method of handling is approved by Project Manager. When using bulk cement, provide satisfactory weighing devices.

3. Fly ash which meets standards of ASTM C 618 may be used as mineral fill when method of handling is approved by Project Manager.

B. Water: Conform to requirements for water in ASTM C 94.

C. Coarse Aggregate: Crushed stone, gravel, or combination thereof, which is clean, hard, and durable, conforms to requirements of ASTM C 33, and has abrasion loss not more than 45 percent by weight when subjected to Los Angeles Abrasion Test (ASTM C 131).

1. Maximum percentage by weight of deleterious substances shall not exceed following values:

Item	Percent by Weight of Total Sample Maximum
Clay lumps and friable particles	3.0
Material finer than 75-µm (No. 200) sieve:	
Concrete subject to abrasion	3.0*
All Other concrete	5.0*
Coal and lignite:	
Where surface appearance of concrete is of importance	0.5
All other concrete	1.0

* In case of manufactured sand, when material finer than 75-µm (No. 200) sieve consists of dust of fracture, essentially free from clay or shale, these limits may be increased to 5 and 7 percent, respectively.

2. Conform coarse aggregate (size 1 1/2-inch to No. 4 sieve) to requirements of ASTM C33. Use gradation within following limits when graded in accordance with ASTM C 136:

Sieve Designation (Square Openings)	Percentage by Weight
Retained on 1 3/4" sieve	0
Retained on 1 1/2"sieve	0 to 5
Retained on 3/4" sieve	30 to 65
Retained on 3/8" sieve	70 to 90
Retained on No. 4 sieve	95 to 100
Loss by Decantation Test *Method Tex-406-A	1.0 maximum

* In case of aggregates made primarily from crushing of stone, when material finer than 200 sieve is dust of fracture essentially free from clay or shale as established by Part III of TxDOT Tex-406-A, percent may be increased to 1.5.

D. Fine Aggregate: Sand, manufactured sand, or combination thereof, composed of clean, hard, durable, uncoated grains, free from loams or other injurious foreign matter. Conform fine aggregate for concrete to requirements of ASTM C 33. Use gradation within following limits when graded in accordance with ASTM C 136:

Sieve Designation (Square Openings)	Percentage by Weight
Retained on 3/8" sieve	0
Retained on No. 4 sieve	0 to 5
Retained on No. 8 sieve	0 to 20
Retained on No. 16 sieve	15 to 50
Retained on No. 30 sieve	35 to 75
Retained on No. 50 sieve	65 to 90
Retained on No. 100 sieve	90 to 100
Retained on No. 200 sieve	97 to 100

1. When subjected to color test for organic impurities (ASTM C 40), fine aggregate shall not show color darker than standard color. Fine aggregate shall be subjected to Sand Equivalent Test (Tex-203-F). Sand equivalent value shall not be less than 80, unless higher value is shown on Drawings.

E. Mineral Filler: Type “C” or Type “F” fly ash of acceptable quality and meeting requirements of ASTM C 618 may be used as mineral admixture in concrete mixture. When fly ash mineral filler is used, store and inspect in accordance with ASTM C 618. Do not use fly ash in amounts to exceed 25 percent by weight of cementatious material in mix design. Cement content may be reduced when strength requirements can be met. Note: When fly ash is used, term "cement" is defined as cement plus fly ash.

F. Air Entraining Agent: Furnish air entraining agent conforming to requirements of ASTM C 260.

G. Water Reducer: Water reducing admixture conforming to requirements of ASTM C 494 may be used when required to improve workability of concrete. Amount and type of admixture is subject to approval by Project Manager.

H. Reinforcing Steel:

1. Provide new billet steel manufactured by open hearth process and conforming to ASTM A 615, Grade 60. Store steel to protect it from mechanical injury and rust. At time of placement, steel shall be free from dirt, scale, rust, paint, oil, or other injurious materials.

2. Cold bend reinforcing steel to shapes shown. Once steel has been bent, it may not be rebent.

3. Provide wire fabric conforming to ASTM A 1064. Use fabric in which longitudinal and transverse wires have been electrically welded at points of intersection. Welds shall have sufficient strength not to be broken during handling or placing. Conform welding and fabrication of fabric sheets to ASTM A 1064.

2.02 EQUIPMENT

A. Conform Equipment to requirements of ASTM C94.

2.03 MIXING

A. Flexural strength shall be as specified using test specimens prepared in accordance with ASTM C 31 and tested in accordance with ASTM C78 (using simple beam with third-point loading). Compressive strength shall be as specified using test specimens prepared in accordance with ASTM C 31 and tested in accordance with ASTM C 39. Determine and measure batch quantity of each ingredient, including water for batch designs and all concrete produced for Work. Mix shall conform to these specifications and other requirements indicated on Drawings.

B. Mix design to produce concrete which will have flexural strength of 500 psi at 7 days and 600 psi at 28 days. Minimum compressive strength shall be 3,000 pounds per square inches for 7 days and 4,000 pounds per square inches at 28 days when tested in accordance with ASTM C39. Slump of concrete shall be at least 2-inches but no more than 5-inches, when tested in accordance with ASTM C143.

1. Concrete pavement, including curb, curb and gutter, and saw-tooth curb, shall contain at least 5 1/2 sacks (94 pounds per sack) of cement per cubic yard, with not more than 6.5 gallons of water, net, per sack of cement (water-cement ratio maximum 0.57). Determine cement content in accordance with ASTM C 138. Addition of mineral filler may be used to improve workability or plasticity of concrete to limits specified.

2. Coarse dry aggregate shall not exceed 85 percent of loose volume of concrete.

3. Add air-entraining admixture to ensure uniform distribution of agent throughout batch. Base air content of freshly mixed air-entrained concrete upon trial mixes with materials to be used in Work, adjusted to produce concrete of required plasticity and workability. Percentage of air entrainment in mix shall be 4 1/2 percent plus or minus 1 1/2 percent. Determine air content by testing in accordance with ASTM C 231.

4. Use retardant when temperature exceeds 90 degrees F. Proportion as recommended by manufacturer. Use same brand as used for air-entraining agent. Add and batch material using same methods as used for air-entraining agent.

C. Use high early strength concrete pavement to limits shown on Drawings. Design to meet following:

1. Concrete Mix: Flexural strength greater than or equal to 500 psi at 72 hours.

2. Cement: Minimum of 7 sacks of cement per cubic yard of concrete.

3. Water-Cement Ratio maximum of 0.45. Slump of concrete shall a maximum of 5-inches, when tested in accordance with ASTM C 143.

4. Other requirements for proportioning, mixing, execution, testing, etc., shall be in accordance with this Section 02751 - Concrete Paving.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify compacted base is ready to support imposed loads and meets compaction requirements.

B. Verify lines and grades are correct.

3.02 PREPARATION

A. Properly prepare, shape and compact each section of subgrade before placing forms, reinforcing steel or concrete. After forms have been set to proper grade and alignment, use subgrade planer to shape subgrade to its final cross section. Check contour of subgrade with template.

B. Remove subgrade that will not support loaded form. Replace and compact subgrade to required density.

3.03 EQUIPMENT

A. Alternate equipment and methods, other than those required by this Section, may be used provided equal or better results will be obtained. Maintain equipment for preparing subgrade and for finishing and compacting concrete in good working order.

B. Subgrade Planer and Template:

1. Use subgrade planer with adjustable cutting blades to trim subgrade to exact section shown on Drawings. Select planer mounted on visible rollers which ride on forms. Planer frame must have sufficient weight so that it will remain on form, and have strength and rigidity that, under tests made by changing support from wheels to center, planer will not develop deflection of more than 1/8-inch. Tractors used to pull planer shall not produce ruts or indentations in subgrade. When slip form method of paving is used, operate subgrade planer on prepared track grade or have it controlled by electronic sensor system operated from string line to establish horizontal alignment and elevation of subbase.

2. Provide template for checking contour of subgrade. Template shall be long enough to rest upon side forms and have strength and rigidity that, when supported at center, maximum deflection shall not exceed 1/8-inch. Fit template with accurately adjustable rods projecting downward at 1-foot intervals. Adjust these rods to gauge cross sections of slab bottom when template is resting on side forms.

C. Machine Finisher: Provide power-driven, transverse finishing machine designed and operated to strike off and consolidate concrete. Machine shall have two screeds accurately adjusted to crown of pavement and with frame equipped to ride on forms. Use finishing machine with rubber tires when it operates on concrete pavement.

D. Hand Finishing:

1. Provide mechanical strike and tamping template 2-feet longer than width of pavement to be finished. Shape template to pavement section.

2. Provide two bridges to ride on forms and span pavement for finishing expansion and dummy joints. Provide floats and necessary edging and finishing tools.

E. Burlap Drag or transverse broom for Finishing Slab: Furnish four plies of 10-ounce burlap material fastened to bridge to form continuous strip of burlap full width of pavement. Maintain contact 3-foot width of burlap material with pavement surface. Keep burlap drags clean and free of encrusted mortar.

F. Vibrators: Furnish mechanically-operated, synchronized vibrators mounted on tamping bar which rides on forms and hand-manipulated mechanical vibrators. Furnish vibrators with frequency of vibration to provide maximum consolidation of concrete without segregation.

G. Traveling Form Paver: Approved traveling form paver may be used in lieu of construction methods employing forms, consolidating, finishing and floating equipment. Meet requirements of this specification for subgrade, pavement tolerances, pavement depth, alignments, consolidation, finishing and workmanship. When traveling form paver does not provide concrete paving that meets compaction, finish, and tolerance requirements of this Specification, immediately discontinue its use and use conventional methods.

1. Equip traveling paver with longitudinal transangular finishing float adjustable to crown and grade. Use float long enough to extend across pavement to side forms or edge of slab.

2. Ensure that continuous deposit of concrete can be made at paver to minimize starting and stopping. Use conventional means of paving locations inaccessible to traveling paver, or having horizontal or vertical curvature that traveling paver cannot negotiate.

3. Where Drawings require tie bars for adjacent paving, securely tie and support bars to prevent displacement. Tie bars may be installed with approved mechanical bar inserter mounted on traveling-form paver. Replace pavement in which tie bars assume final position other than that shown on Drawings.

3.04 FORMS

A. Side Forms: Use metal forms of approved shape and section. Preferred depth of form is equal to required edge thickness of pavement. Forms with depths greater or less than required edge thickness of pavement will be permitted, provided difference between form depth and edge thickness when not greater than 1-inch, and further provided that forms of depth less than pavement edge are brought to required edge thickness by securely attaching wood or metal strips to bottom of form, or by grouting under form. Bottom flange of form shall be same size as thickness of pavement. Aluminum forms are not allowed. Forms shall be approved by Project Manager. Length of form sections shall be not less than 10-feet and each section shall provide for staking in position with not less than 3 pins. Flexible or curved forms of wood or metal of proper radius shall be used for curves of 200-foot radius or less. Forms shall have ample strength and shall be provided with adequate devices for secure setting so that when in-place they will withstand, without visible springing or settlement, impact and vibration of finishing machine. In no case shall base width be less than 8-inches for form 8-inches or more in height. Forms shall be free from warp, bends or kinks and shall be sufficiently true to provide straight edge on concrete. Top of each form section, when tested with straight edge, shall conform to requirements specified for surface of completed pavement. Provide sufficient forms for satisfactory placement of concrete. For short radius curves, forms less than 10-feet in length or curved forms may be used. For curb returns at street intersections and driveways, wood forms of good grade and quality may be used.

B. Form Setting:

1. Rest forms directly on subgrade. Do not shim with pebbles or dirt. Accurately set forms to required grade and alignment and, during entire operation of placing, compacting and finishing of concrete, do not deviate from this grade and alignment more than 1/8-inch in 10-feet of length. Do not remove forms for at least 8 hours after completion of finishing operations. Provide supply of forms that will be adequate for orderly and continuous placing of concrete. Set forms and check grade for at least 300-feet ahead of mixer or as approved by Project Manager.

2. Adjacent slabs may be used instead of forms, provided that concrete is well protected from possible damage by finishing equipment. Do not use adjacent slabs for forms until concrete has aged at least 7 days.

3. Prior to form setting, grade subgrade appropriately so that when the forms are set, and the concrete is poured, finished, and cured, there is positive drainage, free of sitting water / ponding in the gutter ("gutter ponds") or on the pavement area of new panels. This requirement may not be capable of being met at the construction joint between an existing pavement panel and a new individual pavement panel that is properly installed to match the existing panel. However, this requirement shall be met between two new panels and within the area of new panels.

3.05 REINFORCING STEEL AND JOINT ASSEMBLIES

A. Place reinforcing steel and joint assemblies and position securely as indicated on Drawings. Wire reinforcing bars securely together at intersections and splices. Bars and coatings shall be free of rust, dirt or other foreign matter when concrete is placed. Secure reinforcing steel to chairs.

B. Position pavement joint assemblies at required locations and elevations, and rigidly secure in position. Install dowel bars in joint assemblies, each parallel to pavement surface and to center line of pavement, as shown.

C. Cut header boards, joint filler, and other material used for forming joints to receive each dowel bar.

D. Secure in required position to prevent displacement during placing and finishing of concrete.

E. Drill dowels into existing pavement, secure with epoxy, and provide paving headers as required to provide rigid pavement sections.

F. Use sufficient number of chairs for steel reinforcement bars to maintain position of bars within allowable tolerances. Place reinforcement as shown on Drawings. In plane of steel parallel to nearest surface of concrete, bars shall not vary from plan placement by more than 1/12 of spacing between bars. In plane of steel perpendicular to nearest surface of concrete, bars shall not vary from plan placement by more than 1/4-inch.

3.06 FIBROUS REINFORCING

A. Do not use fibrous reinforcing to replace structural, load-bearing, or moment-reinforcing steel.

3.07 PLACEMENT

A. Place concrete when air temperature taken in shade and away from artificial heat is above 35 degrees F and rising. Do not place concrete when temperature is below 40 degrees F and falling.

B. Place concrete within 90 minutes after initial water had been added. Remove and dispose of concrete not placed within this period.

C. Concrete slump during placement shall be 1 to 5-inches, except when using traveling-form paver, slump shall be maximum of 2-inches.

D. Deposit concrete continuously in successive batches. Distribute concrete in manner that will require as little rehandling as possible. Where hand spreading is necessary, distribute concrete with shovels or by other approved methods. Use only concrete rakes in handling concrete. At placement interruption of more than 30 minutes, place transverse construction joint at stopping point. Remove and replace sections less than 10-feet long.

E. Take special care in placing and spading concrete against forms and at longitudinal and transverse joints to prevent honeycombing. Voids in edge of finished pavement will be cause for rejection.

3.08 COMPACTION

A. Consolidate concrete using mechanical vibrators as specified herein. Extend vibratory unit across pavement, not quite touching side forms. Space individual vibrators at close enough intervals to vibrate and consolidate entire width of pavement uniformly. Mount mechanical vibrators to avoid contact with forms, reinforcement, transverse or longitudinal joints.

B. Furnish enough hand-manipulated mechanical vibrators for proper consolidation of concrete along forms, at joints and in areas not covered by mechanically controlled vibrators.

3.09 FINISHING

A. Finish concrete pavement with power-driven transverse finishing machines or by hand finishing methods.

1. Hand finish with mechanical strike and tamping template in same width as pavement to be finished. Shape template to pavement section shown on Drawings. Move strike template forward in direction of placement, maintaining slight excess of material in front of cutting edge. Make minimum of two trips over each area. Screed pavement surface to required section. Work screed with combined transverse and longitudinal motion in direction work is progressing. Maintain screed in contact with forms. Use longitudinal float to level surface.

B. On narrow strips and transitions, finish concrete pavement by hand. Thoroughly work concrete around reinforcement and embedded fixtures. Strike off concrete with strike-off screed. Move strike-off screed forward with combined transverse and longitudinal motion in direction work is progressing, maintaining screed in contact with forms, and maintaining slight excess of materials in front of cutting edge. Tamp concrete with tamping template. Use longitudinal float to level surface.

C. After completion of straightedge operation, make first pass of burlap drag or transverse broom as soon as construction operations permit and before water sheen has disappeared from surface. Follow with as many passes as required to produce desired texture depth. Permit no unnecessary delays between passes. Keep drag wet, clean and free from encrusted mortar during use.

3.10 JOINTS AND JOINT SEALING

A. Conform to requirements of Section 02752 - Concrete Pavement Joints.

3.11 CONCRETE CURING

A. Conform to requirements of Section 02753 - Concrete Pavement Curing.

3.12 TOLERANCES

A. Test entire surface before initial set and correct irregularities or undulations. Bring surface within requirements of following test and then finish. Place 10-foot straightedge parallel to center of roadway to bridge depressions and touch high spots. Do not permit ordinates measured from face of straight edge to surface of pavement to exceed 1/16-inch per foot from nearest point of contact. Maximum ordinate with 10-foot straightedge shall not exceed 1/8-inch. Grind spots in excess of required tolerances to meet surface test requirements. Restore texture by grooving concrete to meet surface finishing specifications.

3.13 FIELD QUALITY CONTROL

A. Perform testing under provisions of Section 01454 - Testing Laboratory Services.

B. Compressive Strength Test Specimens: Make four test specimens for compressive strength test in accordance with ASTM C 31 for each 150 cubic yards or less of pavement that is placed in one day. Test two specimens at 7 days or at number of hours as directed by the Project Manager for high early strength concrete. Test remaining two specimens at 28 days. Test specimens in accordance with ASTM C 39. Minimum compressive strength shall be 3000 pounds per square inch for first two specimens and 3500 pounds per square inch at 28 days.

C. When compressive test indicates failure, make yield test in accordance with ASTM C 138 for cement content per cubic yard of concrete. When cement content is found to be less than that specified per cubic yard, increase batch weights until amount of cement per cubic yard of concrete conforms to requirements.

D. Minimum of one 4-inch core will be taken at random locations per 375-feet per 12-feet lane or 500 square yards of pavement to measure in-place depth. Measure depth in accordance with ASTM C 174. Each core may be tested for 28 day compressive strength according to methods of ASTM C 42. 28 day compressive strength of each core tested shall be a minimum of 3000 pounds per square inch.

E. Request, at option, three additional cores in vicinity of cores indicating nonconforming in- place depths at no cost to City. In-place depth at these locations shall be average depth of four cores.

F. Fill cores and density test sections with new concrete paving or non-shrink grout.

3.14 NONCONFORMING PAVEMENT

A. Remove and replace areas of pavement found deficient in thickness by more than 10 percent, or that fail compressive strength tests, with concrete of thickness shown on Drawings.

B. When measurement of any core is less than specified thickness by more than 10 percent, actual thickness of pavement in this area will be determined by taking additional cores at 10-foot intervals parallel to centerline in each direction from deficient core until, in each direction, core is taken which is not deficient by more than 10 percent. Exploratory cores for deficient thickness will not be used in averages for adjusted unit price. Exploratory cores are to be used only to determine length of pavement in unit that is to be removed and replaced. Replace nonconforming pavement sections at no additional cost to City.

C. Remove and replace new pavement panels that do not have positive drainage and are not free of sitting water / ponding in the gutter ("gutter ponds") or on the pavement area of new panels. This requirement does not apply at the construction joint between existing pavement and a new individual panel that is properly installed to match the existing panel. However, this requirement applies between two new panels and within the area of new panels.

3.15 UNIT PRICE ADJUSTMENT

A. Unit price adjustments shall be made for in-place depth determined by cores as follows:

1. Adjusted Unit Price shall be ratio of average thickness as determined by cores to thickness bid upon, times unit price.

2. Apply adjustment to lower limit of 90 percent and upper limit of 100 percent of unit price.

3. Average depth below 90 percent but greater than 80 percent may be accepted by Project Manager at adjusted Unit Price of:

a. Unit Price Bid - [2 x (1-ratio) x Unit Price Bid]

b. Ratio equals average core thickness divided by thickness bid upon

c. 0.9 ratio pays 80 percent of unit price and 0.8 ratio pays 60 percent of unit price.

4. Average depth below 80 percent will be rejected by Project Manager.

3.16 PAVEMENT MARKINGS

A. Restore pavement markings to match those existing in accordance with City of Houston standard specifications and details and Project Manager's requirements.

3.17 PROTECTION

A. Barricade pavement section to prevent use until concrete has attained minimum design strength. Cure barricade pavement section for minimum 72 hours before use. Do not open pavement to traffic until concrete is at least 10 days old. Pavement may be open to traffic earlier provided Contractor pays for testing and additional specimen once 7 day specified strength is obtained. Pavement may be opened when high early strength concrete is used meeting specified 72 hour strength.

B. High early strength concrete may be used to provide access at driveways, street intersections, esplanades and other locations approved by Project Manager.

C. On those sections of pavement to be opened to traffic, seal joints, clean pavement, and place earth against pavement edges before permitting use by traffic. Opening of pavement to traffic shall not relieve responsibility for Work.

D. Maintain concrete paving in good condition until completion of Work.

E. Repair defects by replacing concrete to full depth.

END OF SECTION

SECTION 02752

CONCRETE PAVEMENT JOINTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Joints for concrete paving; concrete sidewalks, concrete driveways, curbs, and curb and gutters.

B. Saw-cutting existing concrete or asphalt pavements for new joints.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for street pavement expansion joints, with or without load transfer, is on linear foot basis.

2. Payment for horizontal dowels is on a unit price basis for each horizontal dowel.

3. No separate payment will be made for formed or sawed street pavement contraction joints and longitudinal weakened plane joints. Include payment in unit price for Concrete Paving.

4. No separate payment will be made for joints for Curb, Curb and Gutter, Saw-tooth Curb, Concrete Sidewalks, and Concrete Driveways. Include payment in unit price for Curb and Gutter, Concrete Sidewalks, and Concrete Driveways.

5. Payment will be made for Preformed Expansion Joints on a linear foot basis only when field conditions require that sidewalk be moved adjacent to existing concrete structure (i.e., street, back of curb, etc.).

6. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement. ASTM D 994 - Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).

B. ASTM D 1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).

C. ASTM D 6690 - Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

D. TxDOT Tex-525-C - Tests for Asphalt and Concrete Joint Sealers

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit product data for joint sealing compound and proposed sealing equipment for approval.

C. Submit samples of dowel cup, metal supports, and deformed metal strip for approval. Submit manufacturer's recommendation for placing sealant(s).

PART 2 PRODUCTS

2.01 BOARD EXPANSION JOINT MATERIAL

A. Filler board of selected stock. Use wood of density and type as follows:

1. Construction heart cypress weighing no more than 40 pounds per cubic foot, after being oven dried to constant weight.

2. Construction heart redwood weighing no more than 30 pounds per cubic foot, after being oven dried to constant weight.

2.02 PREFORMED EXPANSION JOINT MATERIAL

A. Bituminous fiber and bituminous mastic composition material conforming to ASTM D 994 and ASTM D 1751.

2.03 JOINT SEALING COMPOUND

A. Conform joint sealants to one of sealant classes described in this section.

B. Conform hot-poured rubber-asphalt compound to ASTM D 6690.

C. Two-component Synthetic Polymer.

1. Curing is to be by polymerization and not by evaporation of solvent or fluxing of harder particles.

2. Cure sufficiently at average temperature of 25 ± 1 C (77 ± 2 F) so as not to pick up under wheels of traffic in maximum three hours.

3. Performance requirements, when tested in accordance with TxDOT Tex-525-C, shall meet above curing times and requirements as follows:

Cold-Extruded and Cold-Pourable (Self-Leveling) Specifications	
Property	Requirement
Penetration, 25°C (77°F) 150 g Cone, 5 s, 0.1 mm (in.), maximum	130
Bond and Extension 50%, -29°C (-20°F), 3 cycles*: • Dry Concrete Block • Steel blocks (Primed, if recommended by manufacturer) • Steel blocks shall be used when armor joints are specified	 Pass Pass
Flow at 70°C (158°F)	None
Water content % by mass, maximum	5.0
Resilience: • Original sample, % min. (cured) • Oven-aged at 70°C (158°F), % min.	 50 50
Cold-extruded material only - Cold Flow (10 minutes)	None

* After bond and extension test, there shall be no evidence of cracking, separation or other opening that is over 3 millimeters (1/8-inch) deep in sealer or between sealer and test blocks.

4. Provide cold-extruded type for vertical or sloping joints.

5. Provide self-leveling type for horizontal joints.

D. Self-Leveling, Low Modulus Silicone or Polyurethane Sealant for Asphaltic Concrete and Portland Cement Concrete Joints. This shall be a single component self-leveling silicone or polyurethane material that is compatible with both asphalt and concrete pavements. The sealer shall not require a primer for bond; a backer rod shall be required which is compatible with the sealant; no reaction shall occur between rod and sealant.

1. When tested in accordance with TxDOT Tex-525-C, self-leveling sealant shall meet following requirements:

Self-Leveling, Low Modulus Silicone or Polyurethane Sealant	
Property	Requirements
Tack Free Time, 25 ± 1°C (77 ± 2°F), minutes	120 maximum
Nonvolatile content, % by mass	93 minimum
Tensile Strength and 24 Hour Extension Test: * Initial, 10-day cure, 25 ± 1°C (77 ± 2°F), kPa (psi) * After Water Immersion, kPa (psi) * After Heat Aging, kPa (psi) * After Cycling, -29°C (-20°F), 50%, 3 cycles, kPa (psi) * 24 Hour Extension	 * 21 to 69 (3 to 10) * 21 to 69 (3 to 10) * 21 to 69 (3 to 10) * 21 to 69 (3 to 10) * Pass (All Specimens) After 24 hours, there shall be no evidence of cracking, separation or other opening that is over 3 mm (1/8 in.) deep at any point in the sealer or between the sealer and test blocks.

2.04 LOAD TRANSMISSION DEVICES

A. Smooth, steel dowel bars conforming to ASTM A 615, Grade 60. When indicated on Drawings, encase one end of dowel bar in approved cap having inside diameter 1/16-inch greater than diameter of dowel bar.

B. Deformed steel tie bars conforming to ASTM A 615, Grade 60.

2.05 SUPPORTS FOR REINFORCING STEEL AND JOINT ASSEMBLY

A. Employ supports of approved shape and size that will secure reinforcing steel and joint assembly in correct position during placing and finishing of concrete. Space supports as directed by Project Manager.

PART 3 EXECUTION

3.01 PLACEMENT

A. When new Work is adjacent to existing concrete, place joints at same location as existing joints in adjacent pavement.

B. If limit of removal of existing concrete or asphalt pavement does not fall on existing joint, saw cut existing pavement minimum of 2-inches deep to provide straight, smooth joint surface without chipping, spalling or cracks.

3.02 CONSTRUCTION JOINTS

A. Place transverse construction joint wherever concrete placement must be stopped for more than 30 minutes. Place longitudinal construction joints at interior edges of pavement lanes using No. 6 deformed tie bars, 30-inches long and spaced 18-inches on centers.

3.03 EXPANSION JOINTS

A. Place 3/4-inch expansion joints at radius points of curb returns for cross street intersections, or as located in adjacent pavement but no further than 80 feet apart. Use no boards shorter than 6 feet. When pavement is 24 feet or narrower, use not more than 2 lengths of board. Secure pieces to form straight joint. Shape board filler accurately to cross section of concrete slab. Use load transmission devices of type and size shown on Drawings unless otherwise specified or shown as "No Load Transfer Device." Seal with joint sealing compound.

3.04 CONTRACTION JOINTS

A. Place contraction joints at same locations as in adjacent pavement or at spaces indicated on Drawings. Place smoothed, painted and oiled dowels accurately and normal to joint. Seal groove with joint sealing compound.

3.05 LONGITUDINAL WEAKENED PLANE JOINTS

A. Place longitudinal weakened plane joints at spaces indicated on Drawings. If more than 15 feet in width is poured, longitudinal joint must be saw cut. Seal groove with joint sealing compound.

3.06 SAWED JOINTS

A. Use sawed joints as alternate to contraction and weakened plane joints. Use circular cutter capable of cutting straight line groove minimum of 1/4-inch wide. Maintain depth of one quarter of pavement thickness. Commence sawing as soon as concrete has hardened sufficiently to permit cutting without chipping, spalling or tearing and prior to initiation of cracks. Once sawing has commenced, continue until completed. Make saw cut with one pass. Complete sawing within 24 hours of concrete placement. Saw joints at required spacing consecutively in sequence of concrete placement.

B. Concrete Saw: Provide sawing equipment adequate in power to complete sawing to required dimensions and within required time. Maintain ample supply of saw blades at work site during sawing operations. Maintain sawing equipment on job during concrete placement.

3.07 TRANSVERSE WEAKENED PLANE JOINTS

A. Saw cut transverse contraction joints every 20-feet (nominally) in the pavement, but no greater than 20-feet between saw cuts. The spacing of the saw cuts shall be at regular intervals between expansion joints. The width of the saw cuts shall be a minimum of ¼-inch wide, and the depth of the saw cuts shall be one-quarter of the pavement thickness. Commence saw cutting as soon as concrete has hardened sufficiently to allow saw cutting without damage to the pavement (affecting finish, chipping, spalling, tearing, etc.) and within 24 hours after concrete placement, but prior to initiation of cracks. Once sawing has commenced on a cut, continue until the cut is completed. Make each saw cut with one pass. Make saw cuts at required spacing consecutively in sequence of concrete placement. Seal the saw cuts (grooves) with joint sealing compound. The goal of the transverse saw cutting is to create weakened joints that will prevent random, non-linear, surface contraction cracking.

B. The dimension D/3 (but no less than 3-inches) on City of Houston Standard Drawing Number 02751-01 is measured from the bottom of the concrete slab.

C. Equipment requirements shall be in accordance with paragraph 3.06.B.

3.08 JOINTS FOR CURB, CURB AND GUTTER

A. Place 3/4-inch preformed expansion joints through curb and gutters at locations of expansion and contraction joints in pavement, at end of radius returns at street intersections and driveways, and at curb inlets. Maximum spacing shall be 120-foot centers.

3.09 JOINTS FOR CONCRETE SIDEWALKS

A. Provide 3/4-inch expansion joints conforming to ASTM A 1751 along and across sidewalk at back of curbs, at intersections with driveways, steps, and walls; and across walk at intervals not to exceed 36 feet. Provide expansion joint material conforming to ASTM D 994 for small radius curves and around fire hydrants and utility poles. Extend expansion joint material full depth of slab.

3.10 JOINTS FOR CONCRETE DRIVEWAYS

A. Provide 3/4-inch expansion joints conforming to ASTM D 1751 across driveway in line with street face of sidewalks, at existing concrete driveways, and along intersections with sidewalks and other structures. Extend expansion joint material full depth of slab.

3.11 JOINT SEALING

A. Seal joints only when surface and joints are dry, ambient temperature is above 50 degrees F and less than 85 degrees F and weather is not foggy or rainy.

B. Use joint sealing equipment in like new working condition throughout joint sealing operation, and be approved by Project Manager. Use concrete grooving machine or power-operated wire brush and other equipment such as plow, brooms, brushes, blowers or hydro or abrasive cleaning as required to produce satisfactory joints.

C. Clean joints of loose scale, dirt, dust and curing compound. The term joint includes wide joint spaces, expansion joints, dummy groove joints or cracks, either preformed or natural. Remove loose material from concrete surfaces adjacent to joints.

D. Fill joints neatly with joint sealer to depth shown. Pour sufficient joint sealer into joints so that, upon completion, surface of sealer within joint will be 1/4-inch above level of adjacent surface or at elevation as directed.

3.12 PROTECTION

A. Maintain joints in good condition until completion of Work.

B. Replace damaged joints material with new material as required by this Section.

END OF SECTION

SECTION 02753

CONCRETE PAVEMENT CURING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Curing of Portland cement concrete paving.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for concrete curing under this Section. Include payment in unit price for Concrete Paving, Concrete Sidewalks, Concrete Driveways, Curbs, and Curb and Gutters.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 156 - Standard Test Method for Water Loss [from a Mortar Specimen] Through Liquid Membrane-Forming Curing Compounds for Concrete.

B. ASTM C 171 - Standard Specifications for Sheet Materials for Curing Concrete.

C. ASTM C 309 - Standard Specifications for Liquid Membrane-Forming Compounds for Curing Concrete.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit manufacturer's product data for cover materials and liquid membrane-forming compounds.

PART 2 PRODUCTS

2.01 COVER MATERIALS FOR CURING

A. Conform curing materials to one of the following:

1. Polyethylene Film: Opaque pigmented white film conforming to requirements of ASTM C 171.

2. Waterproofed Paper: Paper conforming to requirements of ASTM C 171.

3. Cotton Mats: Single layer of cotton filler completely enclosed in cover of cotton cloth. Mats shall contain not less than 3/4 of a pound of uniformly distributed cotton filler per square yard of mat. Cotton cloth used for covering materials shall weigh not less than 6 ounces per square yard. Stitch mats so that mat will contact surface of pavement at all points when saturated with water.

2.02 LIQUID MEMBRANE-FORMING COMPOUNDS

A. Conform liquid membrane-forming compounds to ASTM C 309. Membrane shall restrict loss of water to not more than 0.55 kg/m2 in 72 hours using test method ASTM C 156.

PART 3 EXECUTION

3.01 CURING REQUIREMENT

A. Cure concrete pavement by protecting against loss of moisture for period of not less than 72 hours immediately upon completion of finishing operations. Do not use membrane curing for concrete pavement to be overlaid by asphalt concrete.

B. Failure to provide sufficient cover material shall be cause for immediate suspension of concreting operations.

3.02 POLYETHYLENE FILM CURING

A. Immediately after finishing surface, and after concrete has taken its initial set, apply water in form of fine spray. Cover surface with polyethylene film so film will remain in direct contact with surface during specified curing period.

B. Cover entire surface and both edges of pavement slab. Overlap joints in film sheets minimum of 12 inches. Immediately repair tears or holes occurring during curing period by placing acceptable moisture-proof patches or replacing.

3.03 WATERPROOFED PAPER CURING

A. Immediately after finishing surface, and after concrete has taken its initial set, apply water in form of fine spray. Cover surface with waterproofed paper so paper will remain in direct contact with surface during specified curing period.

B. Prepare waterproofed paper to form blankets of sufficient width to cover entire surface and both edges of pavement slab, and not be more than 60 feet in length. Overlap joints in blankets caused by joining paper sheets not less than 5 inches and securely seal with asphalt cement having melting point of approximately 180 degrees F. Place blankets to secure overlap of at least 12 inches. Immediately repair tears or holes appearing in paper during curing period by cementing patches over defects.

3.04 COTTON MAT CURING

A. Immediately after finishing surface, and after concrete has taken its initial set, completely cover surface with cotton mats, thoroughly saturated before application, maintaining contact with surface of pavement equally at all points.

B. Keep mats on pavement for specified curing period. Keep mats saturated so that, when lightly compressed, water will drip freely from them. Keep banked earth or cotton mat covering edges saturated.

3.05 LIQUID MEMBRANE-FORMING COMPOUNDS

A. Immediately after free surface moisture, and after concrete has dispersed, apply liquid membrane-forming compound in accordance with manufacturer's instructions.

B. Moisten concrete by water fogging prior to application of membrane when surface has become dry.

C. Seal concrete surface with single coat at rate of coverage recommended by manufacturer and directed by Project Manager, but not less than one gallon per 200 square feet of surface area.

3.06 TESTING MEMBRANE

A. Treated areas will be visually inspected for areas of lighter color of dry concrete as compared to dump concrete. Test suspected areas by placing few drops of water on surface. Membrane passes test when water stands in rounded beads or small pools which can be blown along surface of concrete without wetting surface.

B. Reapply membrane compound immediately at no cost to City when membrane fails above test.

END OF SECTION

SECTION 02754

CONCRETE DRIVEWAYS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Portland cement concrete driveways.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 02336 – Lime Stabilized Subgrade

C. Section 02337 – Lime/Fly Ash Stabilized Subgrade

D. Section 02338 – Portland Cement Stabilized Subgrade

E. Section 02751 – Concrete Paving

F. Section 02752 – Concrete Pavement Joints

G. Section 02753 – Concrete Pavement Curing

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for concrete driveways is on square foot basis, including excavation.

2. No payment will be made for work in areas where driveway has been removed or replaced for Contractor's convenience.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Conform to material and proportion requirements for concrete of Section 02751 - Concrete Paving.

B. Reinforcing Steel: Conform to material requirements for reinforcing steel of Section 02751 - Concrete Paving.

C. Preformed Expansion Joint Material: Conform to material requirements for preformed expansion joint material of Section 02752 - Concrete Pavement Joints.

D. Expansion Joint Filler: Conform to material requirements for expansion joint material of Section 02752 - Concrete Pavement Joints.

E. Subgrade Materials: Conform to subgrade material requirements of Section 02336 - Lime Stabilized Subgrade, Section 02337 - Lime/Fly-Ash Stabilized Subgrade, or Section 02338 - Portland Cement Stabilized Subgrade.

PART 3 EXECUTION

3.01 PREPARATION

A. Prepare subgrade in accordance with applicable portions of Section 02336 - Lime Stabilized Subgrade, Section 02337 - Lime/Fly-Ash Stabilized Subgrade, and Section 02338 - Portland Cement Stabilized Subgrade.

3.02 PLACEMENT

A. Place and finish concrete in accordance with applicable portions of Section 02751 - Concrete Paving.

3.03 JOINTS

A. Install joints in concrete driveway in accordance with Section 02752 - Concrete Pavement Joints.

3.04 CONCRETE CURING

A. Cure concrete driveway in accordance with Section 02753 - Concrete Pavement Curing.

3.05 PROTECTION

A. Conform to applicable requirements of Section 02753 - Concrete Pavement Curing.

END OF SECTION

SECTION 02761

COLORED CONCRETE FOR MEDIANS AND SIDEWALKS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Colored concrete for medians and sidewalks.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02751 – Concrete Paving

D. Section 02772 – Concrete Medians and Directional Islands

E. Section 02775 – Concrete Sidewalks

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for coloring agent under this Section. Include payment in unit price bid for concrete sidewalks, and concrete medians and directional islands.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit product data for proposed coloring agent.

PART 2 PRODUCTS

2.01 MATERIALS

A. Coloring Agent: Provide dry-shake color hardener consisting of quartz-silica mixture of finely-graded, non-metallic aggregates, plasticizer and cement binder for producing color as shown on Drawings.

B. Concrete: Conform to material and proportion requirements of Section 02751 - Concrete Paving.

PART 3 EXECUTION

3.01 CONCRETE MEDIANS

A. Install concrete medians in accordance with requirements of PART 3 of Section 02772 - Concrete Medians and Directional Islands with addition of procedure for application of coloring agent as required by Paragraph 3.03, Coloring Agent.

3.02 CONCRETE SIDEWALKS

A. Install concrete sidewalks in accordance with requirements of PART 3 of Section 02775 - Concrete Sidewalks with addition of procedure for application of coloring agent as required by Paragraph 3.03, Coloring Agent.

3.03 COLORING AGENT

A. Apply coloring agent on newly finished concrete surface as soon as job conditions permit, but in no event later than 2 hours after concrete is placed, at rate recommended by manufacturer and approved by Project Manager.

B. Apply color hardener uniformly to surface by dry-shake method when no excess moisture shows at surface of concrete substrate, but while concrete is still plastic throughout. Do not sprinkle or otherwise add water to surface during application or finishing. Necessary moisture for color hardener shall come from concrete substrate in order to develop proper bond and assure adequate density for color-hardened surface.

C. First shake shall consume two-thirds of material. Withhold one-third for second shake and final touch-up. After first shake, float surface thoroughly by mechanical or hand methods. Do not trowel surface between first and second shakes.

D. Apply second shake evenly, then float and trowel surface. Retain small quantity of material from second shake for touching up nonuniform or weak-toned areas. Minimize hard troweling and use consistent finishing practices to ensure uniformity of color.

END OF SECTION

SECTION 02762

BLAST CLEANING OF PAVEMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Removal of existing pavement markings.

B. Preparation of pavement surfaces for new pavement markings.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for blast cleaning of roadway lanes is on linear foot basis for each width, measured in place.

2. Payment for blast cleaning of symbols and legends is on square foot basis, measured in place.

3. Payment for removal of raised pavement markings, all types, is on a lump sum basis.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit description and characteristics of proposed blasting medium and equipment for approval.

PART 2 PRODUCTS

2.01 MATERIALS

A. Blasting Media: Quality commercial product capable of producing specified surface cleanliness without deposition of deleterious materials on cleaned pavement surface. Do not use high silica content sand that may result in high levels of free crystalline silica dust particles as blasting agent.

2.02 EQUIPMENT

A. Equipment shall be power driven and of sufficient capacity to remove pavement markings. Equipment shall utilize moisture and oil traps of sufficient capacity to remove contaminants from air and prevent deposition of moisture, oil, or other contaminants on pavement surface.

PART 3 EXECUTION

3.01 REMOVAL OF EXISTING MARKINGS

A. Remove pavement markings where necessary to prevent driver confusion, or where indicated on Drawings. Included are areas where it will be necessary for drivers to cross existing markings which they would not normally cross. Remove or obliterate markings. Do not damage pavement surface.

3.02 CLEANING FOR PLACEMENT OF MARKERS

A. Remove old pavement markings, loose material, and other contaminants deleterious to adhesion of new pavement markings to be placed. On Portland cement concrete pavement, minimize over blasting to prevent damage to pavement surface. Small particles of tightly adhering existing pavement markings may remain when complete removal will result in pavement surface damage.

B. Follow manufacturer's written instructions for proper cleaning of pavement surfaces to receive pavement marking.

END OF SECTION

SECTION 02764

RAISED PAVEMENT MARKERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Raised pavement markers which include reflectorized and non-reflectorized traffic buttons, pavement markers and jiggle bars all of which are capable of being attached to a roadway surface by an adhesive.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 02762 - Blast Cleaning of Pavement

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Payment will be based on the number of satisfactorily installed pavement markers.

2. Unit price bid for each item shall be full compensation for materials, application of raised pavement markings, equipment, labor, tools, and incidentals necessary to complete Work in accordance with the plans and specifications.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). When Contract is Stipulated Price Contract, payment for Work in the Section is included in total Stipulated Price.

1.04 REFERENCES

A. TxDOT DMS-4200, Pavement Markers (Reflectorized)

B. TxDOT DMS-4300, Traffic Buttons

PART 2 PRODUCTS

2.01 MATERIALS

A. Raised Pavement Markers shall conform to the requirements of TxDOT DMS-4200, Pavement Markers (Reflectorized).

B. Traffic Buttons shall conform to the requirements of TxDOT DMS-4300, Traffic Buttons.

C. Testing. The Engineer reserves the right to perform any or all tests required by this item as a check on the tests reported by the manufacturer. Upon request, the Contractor shall furnish, free of charge, samples of the material of the size and in the amount determined by the Engineer for test purposes. In case of any variance, the Engineer's tests will govern.

PART 3 EXECUTION

3.01 EQUIPMENT

A. Provide the necessary equipment to conduct the work specified herein.

3.02 CONSTRUCTION

A. The Contractor shall establish guides to mark the lateral location of pavement markings as shown on the plans or as directed by the Engineer. The Engineer shall approve locations of these markings and may authorize necessary adjustments from the plans.

B. The reflective faces of all Type II markers shall be positioned so that the direction of reflection of one (1) face shall be directly opposite to the direction of reflection of the other face.

C. Raised Pavement markers Type I-C shall have clear reflector face towards traffic. Raised pavement markers Type II C-R, shall have the clear face toward the normal traffic flow and the red face toward wrong-way traffic.

D. Unless otherwise shown on the plans or specified by the Engineer, all raised pavement markers placed in broken lines shall be placed in line with and midway between the stripes. The first and last raised pavement marker in a no-passing line shall be a reflective marker. Buttons used to simulate a 10 feet skip lane lines shall be spaced at 40 inches.

E. The pavement markers not placed in accordance with the plans or as directed by the Engineer shall be removed by the Contractor at the Contractor's expense.

F. Removal of existing pavement markers or residual adhesive from a missing pavement marker prior to placement of new or replacement marker(s) shall be in conformance with Section 02762 - Blast Cleaning of Pavement. The portion of the highway surface to which the raised pavement marker is attached by the adhesive shall be clean and free of dirt, grease, oil, and moisture at the time of installation. Surface preparation for installation of raised pavement markers will not be paid for directly, but shall be considered subsidiary to this item. Unsound pavement or other materials that would adversely affect the bond of the adhesive shall not be an acceptable surface.

G. The hot epoxy adhesive shall be applied so that 100 percent of the bonding area of the raised pavement marker will be in contact and shall be of sufficient thickness so that excess adhesive shall be forced out around the perimeter of the raised pavement marker but without impairing the functional capability of the reflectivity of the pavement marker. When the project is complete, the raised pavement marker shall be firmly bonded to the pavement; lines formed by the raised pavement markers shall be true, and the entire installation shall present a neat appearance.

H. Where required by the Engineer, pavement markings outside the limits of this project will be removed or adjusted to provide for a proper tie into this project. The old markings shall be removed or defaced in such a manner that they do not give the appearance of traffic pavement markings.

END OF SECTION

SECTION 02765

PREFORMED PAVEMENT MARKINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnish and install preformed pavement markings, a long-term tape and sheeting pavement marking material to be used for permanent type longitudinal or transverse lines and word/symbol legends.

1.02 REALATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 02762 - Blast Cleaning of Pavement

C. Section 02767 – Thermoplastic Pavement Markings

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Payment for preformed pavement markings is on a linear foot basis.

2. Payment for words and symbols is for each word or symbol.

3. Unit price bid for each item shall be full compensation for materials, application of pavement markings, equipment, labor, tools, and incidentals necessary to complete Work in accordance with the plans and specifications.

4. Refer to Section 01270 – Measurement and Payment for unit price measures

B. Stipulated Price (Lump Sum). When Contract is Stipulated Price Contract, payment for work in the Section is included in total Stipulated Price.

1.04 REFERENCES

A. TxDOT DMS-8240, Permanent Prefabricated Pavement Markings

PART 2 PRODUCTS

2.01 MATERIALS

A. All materials shall conform to the requirements of TxDOT DMS-8240 Permanent Prefabricated Pavement Markings as shown on the plans. Type A, B, or C prefabricated markings shall be indicated on the plans based upon the traffic conditions of the roadway and the placement method indicated.

PART 3 EXECUTION

3.01 EQUIPMENT

A. Provide the necessary equipment to conduct the work specified herein.

3.02 CONSTRUCTION

A. General: All markings shall be located as shown in the plans. The contractor shall install the preformed plastic pavement markings to newly paved hot-mix asphaltic concrete pavements by the in-laid method unless the temperature of the pavement has reached or fallen below the minimum allowable pavement temperature shown in Table 1.

Table 1
Acceptable Pavement Temperatures for Application of Pavement Markings

Hot Mix Asphalt Type Upon Which the Performed Pavement Marking is to be Applied	Surface Temperature Range for Inlaid Method, °F	Minimum Allowable Pavement Temperature for Inlaid Method, °F	Surface Temperature Range for Cold Laid Method, ° F
Open-Graded Friction Course (OGFC)	160 °F to 180 °F	160 °F	60 °F to 120 °F
Stone Matrix Asphalt (SMA)			
Dense Graded Hot Mixed Asphalt w/PG 76- or 82-XX Asphalt Cement			
Dense Graded Hot Mixed Asphalt w/PG 70-, 64-, or 58-XX Asphalt Cement	120 °F to 155 °F	120 °F	

1. All material shall be placed according to the manufacturer's instructions, and in accordance with the surface condition, moisture and temperature requirements listed below:

B. Inlaid Preformed Pavement Markings.

1. This installation procedure shall apply to streets with newly paved asphaltic concrete surfaces that have attained the temperature ranges shown in Table 1 from initial placement. If at any time after initial placement the pavement cools to below the minimum allowable temperature as shown in Table 1, the markings shall be installed as Thermoplastic Pavement Markings per Section 02767 – Thermoplastic Pavement Markings requirements. For portland cement concrete streets, see Cold-Laid Preformed Pavement Markings (next section) below.

2. The Contractor shall place and inlay all pavement markings on the newly placed asphaltic concrete pavement prior to the final rolling of the asphalt.

3. The preformed pavement markings shall be applied after the newly placed asphaltic concrete pavement has been adequately compacted and within the temperature range specified in Table 1. The Contractor will be required to install temporary pavement markings at no additional cost to the City if the cold-laid method is used. Preformed pavement line markings shall be installed with a mechanical applicator which shall be capable of placing pavement lines in a neat, accurate and uniform manner. The mechanical applicator shall be equipped with a film cut-off device. Word legends and arrows shall be installed by hand and result in neat, accurate and uniform words and arrows. The preformed pavement markings shall be inlaid into the asphaltic concrete surface by means of a mechanical roller. The roller shall be of sufficient weight capacity to inlay the pavement marking to a minimum depth of 65% of the material thickness, and to not more than 80% of the material thickness while the temperature range of the pavement surface is within the ranges specified in Table 1. In the event the inlaid markings are distorted or discolored to the point that cleaning does not restore its initial appearance by the contractor's operations, fail to provide a uniform appearance, or are installed improperly, such markings shall be removed and replaced in the finished surface of the pavement as Thermoplastic Pavement Markings per Section 02767 - Thermoplastic Pavement Markings requirements at no additional expense to the City.

C. Cold-Laid Preformed Pavement Markings.

1. This installation procedure applies to all Portland cement concrete pavements, existing asphaltic concrete pavement, and newly placed asphaltic concrete that at any time has fallen below the minimum allowable temperature specified in Table 1 after initial placement.

2. Pavement on which pavement markings are to be placed shall be cleaned and prepared prior to placement of markings. Cleaning shall be in conformance with Section 02762 - Blast Cleaning of Pavement such that contaminants, loose materials, and conditions deleterious to proper adhesion are removed. When blast cleaning is required, it shall be done to the extent that a sound pavement surface is exposed. Surfaces shall be further prepared after cleaning by sealing or priming, as recommended by the manufacturer. Pavement to which materials to be applied shall be completely dry. Materials shall not be applied until concrete pavement has appeared to be dry for a minimum of four hours and until asphaltic concrete pavement has appeared to be dry for a minimum of two hours.

3. Pavement and ambient air temperature requirements recommended by the manufacturer shall be observed. If no temperature requirements are established by the manufacturer, material shall not be placed if the surface temperature is outside the acceptable range shown in Table 1 (see column 4 of this table).

END OF SECTION

SECTION 02767

THERMOPLASTIC PAVEMENT MARKINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This item includes the application of thermoplastic pavement markings, in conformance with the minimum optical and physical properties required for a thermoplastic road marking compound described herein, in a molten state, onto a pavement surface.

1.02 RELATED SECTIONS

A. Section 01270 – Measure and Payment

B. Section 02762 - Blast Cleaning of Pavement

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Payment for thermoplastic pavement markings is on a linear foot basis.

2. Payment for words and symbols is for each word or symbol.

3. Payment for green colored pavement markings is on a square foot basis.

4. Payment for railroad crossing markings, to include stop line and two transverse lines, is for each crossing marked. For multi-lane approaches to railroad crossings, the solid 8-inch lines will be measured in linear feet, complete in place.

5. Unit price bid for each item shall be full compensation for materials, application of pavement markings, equipment, labor, tools, and incidentals necessary to complete Work in accordance with the plans and specifications.

6. Refer to Section 01270 – Measure and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). When Contract is Stipulated Price Contract, payment for work in the Section is included in total Stipulated Price.

1.04 REFERENCES

A. FHWA memorandum dated 4/15/2011: "Interim Approval for Optimal Use of Green Colored Pavement for Bike Lanes (IA-14)"

B. TxDOT DMS-8220 “Hot Applied Thermoplastic”.

C. Texas Manual on Uniform Traffic Control Devices.

1.05 QUALITY ASSURANCE

A. Acceptance.

1. Sampling Procedure. Random samples may be taken at the job site at the discretion of the City Traffic Engineer for quality assurance. The City reserves the right to conduct the tests deemed necessary to identify component materials and verify results of specific tests indicated in conjunction with the specification requirements.

2. The sample(s) shall be labeled as to the shipment number, lot number, date, quantity, and any other pertinent information. At least three randomly selected bags shall be obtained from each lot. A 10 pound) sample from the three bags shall be submitted for testing and acceptance. The lot size shall be approximately 44,000 pounds unless the total order is less than this amount.

B. Notification.

1. The contractor shall notify the Construction Inspector 72 hours prior to the placement of the thermoplastic markings to enable the inspector to be present during the application operation. At the time of notification, the Contractor shall indicate the manufacturer and the lot numbers of the thermoplastic that will be used.

2. A check should be made by the contractor to ensure that the approved lot numbers appear on the material package. Failure to do so is cause for rejection.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packaging.

1. Containers. The thermoplastic material shall be delivered in 50 pound containers or bags of sufficient strength to permit normal handling during shipment and handling on the job without loss of material.

2. Labeling. Each container shall be clearly marked to indicate the color of the material, the process batch number and/or manufacturer's formulation number, the manufacturer's name and address and the date of manufacture.

1.07 WARRANTY

A. Warranty or Guarantee. If the normal trade practice for manufacturers is to furnish warranties or guarantees for the materials and equipment specified herein, the Contractor shall turn the guarantees and warranties over to the Engineer for potential dealing with the manufacturers. The extent of such warranties or guarantees will not be a factor in selecting the successful bidder.

PART 2 PRODUCTS

2.01 MATERIALS

A. All materials shall conform to the requirements of TxDOT DMS-8220 "Hot Applied Thermoplastic." Thermoplastic materials shall be stored in a dry environment to minimize the amount of moisture retained during storage.

B. Materials used for green colored pavement (bicycle green) shall be manufactured with appropriate pigment to ensure that the resulting colors comply with the Light Green color as specified in the FHWA memorandum dated 4/15/2011: "Interim Approval for Optimal Use of Green Colored Pavement for Bike Lanes (IA-14)". Green colored pavement to be defined as transverse markings.

2.02 SOURCE QUALITY CONTROL

A. Manufacturer's Responsibility.

1. Sampling and Testing. The manufacturer shall submit test results from an approved independent laboratory. All material samples shall be obtained 20 days in advance of the pavement marking operations. The cost of testing shall be included in the price of thermoplastic material. The approved independent laboratory's test results shall be submitted to the City Traffic Engineer in the form of a certified test report.

2. Bill of Lading. The manufacturer shall furnish the Material and Tests Laboratory with copies of Bills of Lading for all materials inspected. Bill of lading shall indicate the consignee and the destination, date of shipment, lot numbers, quantity, type of material, and location of source.

3. Material Acceptance. Final acceptance of a particular lot of thermoplastic will be based on the following.

   a. Compliance with the specification for material composition requirements verified by approved independent laboratory with tests results.

   b. Compliance with the specification for the physical properties required and verified by an approved independent laboratory with test results.

   c. Manufacturer's test results for each lot thermoplastic have been received.

   d. Identification requirements are satisfactory.

PART 3 EXECUTION

3.01 EQUIPMENT

A. Provide the necessary equipment to conduct the work specified herein. All equipment shall be maintained in good working order such that neat and clean thermoplastic markings are applied at the proper thicknesses and glass beads are placed at the correct rate. Equipment that is deemed deficient by the Engineer shall be replaced immediately.

3.02 CONSTRUCTION

A. The appearance of the finished markings shall have a uniform surface, crisp edges with a minimum over-spray, clean cut-off, meet straightness requirements and conform to the design drawings and/or engineer instructions.

B. The contractor shall provide the Engineer with certification from the marking manufacturer that contractor has been adequately trained and certified to apply the manufacturer's material. This certification shall be considered current if the certification date provided by the manufacturer is within two years of the date of marking application.

C. All striping and pavement markings shall be placed in accordance with the requirements of this specification, the detailed plans, and the current edition of the Texas Manual on Uniform Traffic Control Devices (TMUTCD). The Contractor shall provide all other engineering services necessary for pre-marking of all proposed stripe within the limits of the designated work.

D. Unless authorized otherwise in writing by the Engineer, striping shall be accomplished during daylight hours. Approved lighting arrangements will be required for night time operations when allowed. The Contractor may be required to place markings over existing markings, as determined by the Engineer. The Contractor shall adjust the operation of the thermoplastic screed shoe to match the previous lengths of stripes and skips, when necessary.

E. Failure of the striping material to adhere to the pavement surface during the life of the contract shall be prima facie evidence that the materials, even though complying with these specifications, or the application thereof, was inconsistent with the intent of the requirements for the work under the latest City specifications and shall be cause for ordering corrective action or replacement of the marking without additional cost to the City.

F. Unless otherwise approved by the Engineer, permanent pavement markings on newly constructed pavements surfaced with asphaltic concrete or bituminous seals shall not be applied for a minimum of 14 days or a maximum 35 days. Temporary pavement marking shall be provided during the 14 to 35-day period.

G. Surface Preparation.

1. Moisture. All surfaces shall be inspected for moisture content prior to application of thermoplastic. Approximately two square feet of a clear plastic or tar paper shall be laid on the road surface and held in place for 15 to 20 minutes. The underside of the plastic or tar paper shall then be inspected for a buildup of condensed moisture from the road surface. Pavement is considered dry if there is no condensation on the underside of the plastic or tarpaper. In the event of moisture, this test shall be repeated until there is no moisture on the underside of the plastic or tar paper.

2. Cleaning. All surfaces shall be clean and dry, before thermoplastic can be applied. Loose dirt and debris shall be removed by thoroughly blowing compressed air over the area to be striped. If the thermoplastic is to be applied over existing paint lines, the paint line shall be swept with a mechanical sweeper or wire brush to remove poorly adhered paint and dirt that would interfere with the proper bonding or the thermoplastic. Additional cleaning through the use of compressed air may be required to remove embedded dirt and debris after sweeping. Latence and curing compound shall be removed from all new Portland cement concrete surfaces in accordance with Section 02762, "Blast Cleaning of Pavement."

3. Layout. The pavement markings shall be placed in proper alignment with guidelines established on the roadway. Deviation from the alignment established shall not exceed 2 inches and, in addition, the deviation in alignment of the marking being placed shall not exceed 1 inch per 200 feet of roadway nor shall any deviation be abrupt.

    a. No striping material shall be applied over a guide cord; only longitudinal joints, existing stripes, primer, or other approved type guides will be permitted. In the absence of a longitudinal joint or existing stripe, the Contractor shall mark the points necessary for the placing of the proposed stripe. Edge striping shall be adjusted as necessary so that the edge stripe will be parallel to the centerline and shall not be placed off the edge of the pavement.

    b. Longitudinal markings shall be offset at least 2-inches from construction joints of Portland cement concrete surfaces and joints and shoulder breaks of asphalt surfaces.

4. Primer Sealer. Primer sealer shall be used on all Portland cement concrete surfaces. A primer sealer shall be used on asphalt surfaces that are over two years old and/or on asphalt surfaces that are worn or oxidized to a condition where 50 percent or more of the wearing surface is exposed aggregate. Existing pavement markings may act as the primer sealer if, after cleaning, more than 70 percent of the existing pavement marking is still properly bonded to the asphalt surface.

5. Primer Sealer Application. When required as described, the primer-sealer shall be applied to the road surface in a continuous film at a minimum thickness of 3 to 5 mils. Before the Thermoplastic is applied, the primer-sealer shall be allowed to dry to a tacky state. The thermoplastic shall be applied within 4 hours after the primer application.

H. Temperature Requirements.

1. Ambient Conditions. The ambient air and road surface shall be 55°F and rising before application of thermoplastic can begin.

2. Material Requirements. Unless otherwise specified by the material manufacturer, the thermoplastic compound shall be heated from 400°F to 450°F and shall be a minimum of 400°F as it makes contact with road surface during application. An infrared temperature gun shall be used to determine the temperature of the thermoplastic as it is being applied to the road surface.

I. Drop-on Glass Sphere Application.

1. Application Rate. Retro-reflective glass spheres shall be applied at the rate of 10 pounds per 100 square feet of applied markings. This application rate shall be determined by confirming the following consumption rates:

   a. 200 pounds of drop on glass spheres per ton of applied thermoplastic when the thermoplastic is being applied at 0.090 inch film thickness.

   b. 150 pounds of drop on glass spheres per ton of applied thermoplastic when the thermoplastic is being applied at 0.125 inch thickness.

2. Application Method. Retro-reflective glass spheres shall be applied by a mechanical dispenser property calibrated and adjusted to provide proper application rates and uniform distribution of the spheres across the cross section of the entire width of the line. To enable the spheres to embed themselves into the hot thermoplastic, the sphere dispenser shall be positioned immediately behind the thermoplastic application device. This insures that the spheres are applied to the thermoplastic material while it is still in the molten state.

J. Application Thickness.

1. Longitudinal and Transverse Markings. On previously unmarked pavements or pavements where markings have been effectively removed, all lane lines, center lines, transverse markings and pavement markings in traffic areas with :S 1 ,000 vehicles per day per lane shall have a minimum film thickness of 0.090 inch at the edges and a maximum of 0.145 inch at the center. A minimum average film thickness of 0.090 inch shall be maintained. On pavements with existing markings, meeting the traffic requirements stated above, all lane lines, center lines, transverse markings and pavement markings shall have a minimum film thickness of 0.060 inch for re-application over existing strip line.

2. High Wear Longitudinal and Transverse Marking. On previously unmarked pavements or pavements where markings have been effectively removed, all lane lines, center lines, transverse markings and pavement markings in high traffic areas (>1,000 vehicles per day per lane) shall have a minimum film thickness of 0.125 inch at the edges and a maximum of 0.188 inch at the center. A minimum average film thickness of 0.125 inch shall be maintained. On pavements with existing markings, meeting the traffic requirements stated above, all lane lines, center lines, transverse markings and pavement markings shall have a minimum film thickness of 0.090 inch for re-application over existing strip line.

END OF SECTION

SECTION 02768

EPOXY PAVEMENT MARKINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This item includes the application of Epoxy pavement markings, in conformance with the minimum optical and physical properties required for Epoxy pavement marking compound described herein, in a molten state, onto a pavement surface.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 02136 – Waste Material Handling, Testing and Disposal

C. Section 02762 - Blast Cleaning of Pavement

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Payment for Epoxy pavement markings is on a linear foot basis.

2. Payment for words and symbols is for each word or symbol.

3. Unit price bid for each item shall be full compensation for materials, application of pavement markings, equipment, labor, tools, and incidentals necessary to complete Work in accordance with the plans and specifications.

4. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). When Contract is Stipulated Price Contract, payment for work in the Section is included in total Stipulated Price.

1.04 REFERNCES

A. ASTM D 913 – Standard Practice for Evaluating Degree of Pavement Marking Line Wear

B. ASTM E 1347 – Standard Test Method for Color and Color Difference Measurement by Tristimulus Colorimetry

C. ASTM E 1348 – Standard Test Method for Transmittance and Color by Spectrophotometry Using Hemispherical Geometry

D. ASTM E 1349 – Standard Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional Geometry

E. ASTM E 1710 – Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroflectometer

F. TxDOT Special Specification 6116 – Intelligent Transportation System (ITS) Equipment

1.05 QUALITY ASSURANCE

A. Acceptance.

1. Sampling Procedure. Random samples may be taken at the job site at the discretion of the City Traffic Engineer for quality assurance. The City reserves the right to conduct the tests deemed necessary to identify component materials and verify results of specific tests indicated in conjunction with the specification requirements.

2. The sample(s) shall be labeled as to the shipment number, lot number, date, quantity, and any other pertinent information. At least three randomly selected bags shall be obtained from each lot. A 10 pound sample from the three bags shall be submitted for testing and acceptance. The lot size shall be approximately 44,000 pounds unless the total order is less than this amount.

B. Notification.

1. The contractor shall notify the Construction Inspector 72 hours prior to the placement of the epoxy markings to enable the inspector to be present during the application operation. At the time of notification, the Contractor shall indicate the manufacturer and the lot numbers of the thermoplastic that will be used.

a. A check should be made by the contractor to ensure that the approved lot numbers appear on the material package. Failure to do so is cause for rejection.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packaging.

1. Containers. The epoxy material shall be delivered in containers or bags of sufficient strength to permit normal handling during shipment and handling on the job without loss of material.

2. Labeling. Each container shall be clearly marked to indicate the color of the material, the process batch number and/or manufacturer’s formulation number, the manufacturer's name and address and the date of manufacture.

1.07 WARRANTY

A. Warranty or Guarantee. If the normal trade practice for manufacturers is to furnish warranties or guarantees for the materials and equipment specified herein, the Contractor shall turn the guarantees and warranties over to the Engineer for potential dealing with the manufacturers. The extent of such warranties or guarantees will not be a factor in selecting the successful bidder.

PART 2 PRODUCTS

2.01 MATERIAL

A. Use materials that produce an adherent, retroreflective pavement marking system that meets all of the performance requirements of this Specification. Use materials that do not result in the generation of any hazardous materials/wastes, as defined Section 02136 – Waste Material Handling, Testing and Disposal during application or removal. If requested, provide a laboratory report from a commercial laboratory indicating material used does not result in the generation of any hazardous materials/wastes, as defined in Article 1.58, during application or removal.

1. Use Epoxy resin material, which is:

a. 2-component (a predominantly epoxy pigmented resin component with a curing agent component);

b. 100% solids, producing no toxic fumes when heated to application temperature;

c. track-free in less than 40 minutes with appropriate ambient temperature as recommended by the manufacturer;

d. formulated and tested to perform as a pavement marking material with glass spheres applied to the surface.

B. Before work begins, provide a laboratory report from an independent testing laboratory showing that the initial color of each material selected for use conforms to the color limits set forth in Table 1, measured by 45°/0° geometry CIE, D65 Illuminant, 2° standard observation angle in accordance with ASTM E 1347, E 1348, or E 1349.

2.02 SOURCE QUALITY CONTROL

A. Manufacturer’s Responsibility.

1. Sampling and Testing. The manufacturer shall submit test results from an approved independent laboratory. All material samples shall be obtained 20 days in advance of the pavement marking operations. The cost of testing shall be included in the price of epoxy material. The approved independent laboratory's test results shall be submitted to the City Traffic Engineer in the form of a certified test report.

2. Bill of Lading. The manufacturer shall furnish the Material and Tests Laboratory with copies of Bills of Lading for all materials inspected. Bill of lading shall indicate the consignee and the destination, date of shipment, lot numbers, quantity, type of material, and location of source.

3. Material Acceptance. Final acceptance of a particular lot of epoxy will be based on the following.

    a. Compliance with the specification for material composition requirements verified by approved independent laboratory with tests results.

    b. Compliance with the specification for the physical properties required and verified by an approved independent laboratory with test results.

    c. Manufacturer's test results for each lot thermoplastic have been received.

    d. Identification requirements are satisfactory.

PART 3 EXECUTION

3.01 EQUIPMENT

A. Preparation and Application. Use equipment designed for the pavement preparation and application of Epoxy Pavement Markings.

B. Colorimeter. Provide a colorimeter using 45°/0° geometry CIE, D65 Illuminant, 2° standard observation angle meeting the requirements of ASTM E 1347, E 1348, or E 1349.

C. Retroreflectometer. Unless otherwise shown on the plans, provide a portable or mobile retroreflectometer meeting the following requirements.

1. Portable Retroreflectometer. Provide a portable retroreflectometer that meets the requirements of ASTM E 1710.

2. Mobile Retroreflectometer. Provide a mobile retroreflectometer that:

a. is approved by the City of Houston for project evaluation of retroreflectivity, which will include taking a set of readings on stripes designated by City of Houston and comparing them with the readings of a portable retroreflectometer provided by CST that meets the specifications indicated in this Specification;

b. is calibrated daily, before measuring retroreflectivity on any pavement stripe, with a portable retroreflectometer meeting the following requirements: ASTM E 1710, entrance angle of 88.76°, observation angle of 1.05°, and an accuracy of ±15%;

c. requires no traffic control when retroreflectivity measurements are taken and is capable of taking continuous readings; and

d. documents mobile retroreflectometer evaluations, showing average retroreflectivity values for each 0.25-mi. section, or the area of concern if it is less than 0.25 miles, with all deficient sections clearly marked.

3.02 CONSTRUCTION

A. Surface Preparation.

1. General. Prepare the pavement surface using controlled techniques that minimize pavement damage and hazards to the traveling public. Apply the Epoxy Pavement Markings materials according to the manufacturer's recommendations using widths, colors, and shapes, and at locations as shown on the plans. Use traffic control as shown on the plans or as approved. Establish guides to mark the lateral location of pavement markings as shown on the plans or as directed, and have guide locations verified. Use material for guides that will not leave a permanent mark on the roadway.

2. Cleaning. All surfaces shall be clean and dry, before Epoxy can be applied. Loose dirt and debris shall be removed by thoroughly blowing compressed air over the area to be striped. If the Epoxy is to be applied over existing paint lines, the paint line shall be swept with a mechanical sweeper or wirebrush to remove poorly adhered paint and dirt that would interfere with the proper bonding or the thermoplastic. Additional cleaning through the use of compressed air may be required to remove embedded dirt and debris after sweeping. Latence and curing compound shall be removed from all new portland cement concrete surfaces in accordance with Section 02762, "Blast Cleaning of Pavement."

3. Layout. The pavement markings shall be placed in proper alignment with guidelines established on the roadway. Deviation from the alignment established shall not exceed 2 inches and, in addition, the deviation in alignment of the marking being placed shall not exceed 1 inch per 200 feet of roadway nor shall any deviation be abrupt. Remove all applied markings that are not in alignment or sequence as stated in the plans or as stated in the specifications at the Contractor's expense and in accordance with Section 02762, "Blast Cleaning of Pavement."

4. No striping material shall be applied over a guide cord; only longitudinal joints, existing stripes, primer, or other approved type guides will be permitted. In the absence of a longitudinal joint or existing stripe, the Contractor shall mark the points necessary for the placing of the proposed stripe. Edge striping shall be adjusted as necessary so that the edge stripe will be parallel to the centerline and shall not be placed off the edge of the pavement. Longitudinal markings shall be offset at least 2-inches from construction joints of Portland cement concrete surfaces and joints and shoulder breaks of asphalt surfaces.

B. Initial Performance Requirements.

1. Meet the following initial performance requirements after installation. Perform an initial performance evaluation from 7 to 15 days after Epoxy Pavement Markings are installed to verify that the Epoxy Pavement Markings meet the performance requirements for retroreflectivity.

2. Conduct initial retroreflectivity evaluations of placed pavement markings with either a portable or a mobile retroreflectometer, unless otherwise shown on the plans, according to Section 6.B, "Retroreflectivity" of TxDOT Special Specification 6116. The Contractor is responsible for traffic control when conducting performance evaluations.

3. The Engineer will conduct a visual evaluation for color and durability and require testing only if Epoxy Pavement Markings do not appear to meet the performance requirements.

4. For Epoxy Pavement Markings not meeting performance requirements, repair or replace until re-evaluation shows the Epoxy Pavement Markings meet the performance requirements.

   a. Color. Provide Epoxy Pavement Markings consisting of pigments blended to provide color conforming to standard highway colors as shown in Table 1.

Table 1
Color Requirements

Federal 595 Color		Chromaticity Coordinates								Brightness (Y)
		1		2		3		4		
		x	y	x	y	x	y	x	y	
White	17855	.290	.315	.310	.295	.350	.340	.330	.360	60 Min
Yellow	33538	.470	.455	.510	.489	.490	.432	.537	.462	30 Min

b. Retroreflectivity. Provide Epoxy Pavement Markings meeting the minimum retroreflectivity values listed in Table 2.

Table 2
Minimum Retroreflectivity Requirements

Color	Retroreflectivity, mcd/m2/lx, Min
White	250
Yellow	175

c. Durability. Provide Epoxy Pavement Markings that do not lose more than 5% of the striping material in a 1,000-ft. section of continuous stripe or broken stripe (25 broken stripes). Pavement markings must remain in the proper alignment and location.

d. Performance Evaluations. Provide traffic control and conduct evaluations of color, retroreflectivity, and durability as required or directed.

(1) Color. Measure the color using 45°/0° geometry CIE, D65 Illuminant, 2° standard observation angle in accordance with ASTM E 1347, E 1348, or E 1349.

(2) Retroreflectivity. Unless otherwise shown on the plans, conduct retroreflectivity evaluations of pavement markings with either a portable or a mobile retroreflectometer. Make all measurements in the direction of traffic flow, except for broken centerline on 2-way roadways, where measurements will be made in both directions.

(a) If using a portable retroreflectometer, take a minimum of 1 measurement every mile on each series of markings (i.e., edgeline, center skip line, each line of a double line, etc.), at approved locations. If more than 1 measurement is taken, average the measurements. For all markings measured in both directions, take a minimum of 1 measurement in each direction. If the measurement taken on a specific series of markings within each mile segment falls below the minimum retroreflectivity values, take a minimum of 5 more measurements within that mile segment for that series of marking. If the average of these 5 measurements falls below the minimum retroreflectivity requirements, that mile segment of the applied markings does not meet the performance requirement.

(b) If using a mobile retroreflectometer, review the results to determine deficient sections and deficient areas of interest. These areas do not meet the performance requirements.

(3) Durability. Measure the durability in accordance with ASTM D 913 for marking material loss and visual inspection for alignment and location. Conduct evaluations at approved locations.

END OF SECTION

SECTION 02771

CURB, CURB AND GUTTER, AND HEADERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Reinforced concrete curb, reinforced monolithic concrete curb and gutter, and mountable curb.

B. Paving headers and railroad headers poured monolithically with concrete base or pavement.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02751 – Concrete Paving

D. Section 02752 – Concrete Pavement Joints

E. Section 02753 – Concrete Pavement Curing

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for curbs, curbs and gutter, and esplanade curbs is on linear foot basis measured along face of curb.

2. Payment for 3-foot concrete valley gutter is on a linear foot basis.

3. Payment for mountable concrete curbs is on a square foot basis.

4. Payment for concrete paving headers and concrete railroad headers is on a linear foot basis.

5. Payment for headers is on linear foot basis measured between lips of gutters adjacent to concrete base and measured between backs of curbs adjacent to concrete pavement.

6. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit details of proposed form work for approval.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Conform to material and proportion requirements for concrete of Section 02751 - Concrete Paving.

B. Reinforcing Steel: Conform to material requirements for welded wire fabric of Section 02751 - Concrete Paving.

C. Grout: Nonmetallic, non-shrink grout containing no chloride producing agents conforming to following requirements.

1. Compressive strength

a. at 7 days: 3500 psi

b. at 28 days: 8000 psi

2. Initial set time: 45 minutes

3. Final set time: 1.5 hours

D. Preformed Expansion Joint Material: Conform to material requirements for preformed expansion joint material of Section 02752 - Concrete Pavement Joints.

E. Expansion Joint Filler: Conform to material requirements for expansion joint filler of Section 02752 - Concrete Pavement Joints.

F. Mortar: Mortar finish composed of one part Portland cement and 1 1/2 parts of fine aggregate. Use only when approved by Project Manager.

PART 3 EXECUTION

3.01 PREPARATION

A. Prepare subgrade in accordance with applicable portions of sections on excavation and fill, embankment, and subgrade and roadbed.

3.02 PLACEMENT

A. Guideline: Set to follow top line of curb. Attach indicator to provide constant comparison between top of curb and guideline. Ensure flow lines for monolithic curb and gutters conform to slopes indicated on Drawings.

B. Forms: Brace to maintain position during pour. Use metal templates cut to section shown on Drawings.

C. Reinforcement: Secure in position so that steel will remain in place throughout placement. Reinforcing steel shall remain at approximate center of base or pavement as indicated on Drawings.

D. Joints: Place in accordance with Section 02752 - Concrete Pavement Joints. Place dummy groove joints at to match concrete pavement joints at right angles to curb lines. Cut dummy grooves 1/4-inch deep using approved edging tool.

E. Place concrete in forms to required depth. Consolidate thoroughly. Do not permit rock pockets in form. Entirely cover top surfaces with mortar.

3.03 MANUAL FINISHING

A. After concrete is in place, remove front curb forms. Form exposed portions of curb, and of curb and gutter, using mule which conforms to curb shape, as shown on Drawings.

B. Thin coat of mortar may be worked into exposed face of curb using mule and two-handled wooden darby at least 3 feet long.

C. Before applying final finish move 10 foot straightedge across gutter and up curb to back form of curb. Repeat until curb and gutter are true to grade and section. Lap straightedge every 5 feet.

D. Steel trowel finish surfaces to smooth, even finish. Make face of finished curb true and straight.

E. Edge outer edge of gutter with 1/4-inch edger. Finish edges with tool having 1/4 inch radius.

F. Finish visible surfaces and edges of finished curb and gutter free from blemishes, form marks and tool marks. Finished curb or curb and gutter shall have uniform color, shape and appearance.

3.04 MECHANICAL FINISHING

A. Mechanical curb forming and finishing machines may be used instead of, or in conjunction with, previously described methods, when approved by Project Manager. Use of mechanical methods shall provide specified curb design and finish.

3.05 CURING

A. Immediately after finishing operations, cure exposed surfaces of curbs and gutters in accordance with Section 02753 - Concrete Pavement Curing.

3.06 TOLERANCES

A. Top surfaces of curb and gutter shall have uniform width and shall be free from humps, sags or other irregularities. Surfaces of curb top, curb face and gutter shall not vary more than 1/8 inch from edge of straightedge laid along them, except at grade changes.

3.07 PROTECTION

A. Maintain curbs and gutters in good condition until completion of Work.

B. Replace damaged curbs and gutters to comply with this Section.

END OF SECTION

SECTION 02772

CONCRETE MEDIANS AND DIRECTIONAL ISLANDS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Portland cement concrete medians and directional islands.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 02336 – Lime Stabilized Subgrade

C. Section 02337 – Lime/Fly Ash Stabilized Subgrade

D. Section 02338 – Portland Cement Stabilized Subgrade

E. Section 02751 – Concrete Paving

F. Section 02752 – Concrete Pavement Joints

G. Section 02753 – Concrete Pavement Curing

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for concrete medians and directional islands is on square yard basis measured from back of curbs.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Conform to material and proportion requirements for concrete of Section 02751 - Concrete Paving.

B. Reinforcing Steel: Conform to material requirements for welded wire fabric of Section 02751 - Concrete Paving.

C. Preformed Expansion Joint Material: Conform to material requirements for preformed expansion joint material of Section 02752 - Concrete Pavement Joints.

D. Expansion Joint Filler: Conform to material requirements for expansion joint filler of Section 02752 - Concrete Pavement Joints.

E. Subgrade Materials: Conform to subgrade material requirements of Section 02336 - Lime Stabilized Subgrade, Section 02337 - Lime/Fly-Ash Stabilized Subgrade and Section 02338 - Portland Cement Stabilized Subgrade.

PART 3 EXECUTION

3.01 SUBGRADE

A. Prepare subgrade in accordance with applicable portions of sections on excavation and fill and embankment. Section 02336 - Lime Stabilized Subgrade, Section 02337 - Lime/Fly-Ash Stabilized Subgrade and Section 02338 - Portland Cement Stabilized Subgrade.

3.02 PLACEMENT OF CONCRETE

A. Place and finish concrete in accordance with applicable portions of Section 02751 - Concrete Paving.

3.03 JOINTS

A. Install joints in accordance with Section 02752 - Concrete Pavement Joints.

3.04 CONCRETE CURING

A. Cure concrete in accordance with Section 02753 - Concrete Pavement Curing.

3.05 PROTECTION

A. Maintain concrete medians and directional islands in good condition until completion of work.

B. Replace damaged concrete medians and directional islands to comply with this Section.

END OF SECTION

SECTION 02775

CONCRETE SIDEWALKS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Reinforced concrete sidewalks.

B. Wheelchair ramps and curb ramps.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 01576 – Waste Material Disposal

E. Section 02233 – Clearing and Grubbing

F. Section 02320 – Utility Backfill Materials

G. Section 02336 – Lime Stabilized Subgrade

H. Section 02751 – Concrete Paving

I. Section 02752 – Concrete Pavement Joints

J. Section 02753 – Concrete Pavement Curing

K. Section 02761 – Colored Concrete for Medians and Sidewalks

L. Section 02922 – Sodding

M. Section 02951 – Pavement Repair and Restoration

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for concrete sidewalks is on square foot basis.

2. No payment will be made for work outside these limits or in areas where driveway has been removed or replaced for Contractor's convenience.

3. Payment for wheelchair ramps and curb ramps of each type specified is on square foot basis. Staining of wheelchair ramps and curb ramps is included in cost of ramp.

4. Removal and replacement of existing sidewalk, curb or curb and gutter and saw-cutting is paid by unit cost for each item. Sodding will be paid one foot on each side of sidewalk unless otherwise noted.

5. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 31 - Standard Practice for Making and Curing Concrete Test Specimens in Field.

B. ASTM C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

C. ASTM C 42 - Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

D. ASTM C 138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

E. ASTM C 143 - Standard Test Method for Slump of Hydraulic Cement Concrete.

F. ASTM C 172 - Standard Practice for Sampling Freshly Mixed Concrete.

G. ASTM D 698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3).

H. Texas Accessibility Standards of Architectural Barriers Act, Article 9102, Texas Civil Statues.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certified testing results and certificates of compliance.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Conform to material and proportion requirements for concrete of Section 02751 - Concrete Paving.

B. Reinforcing Steel: Conform to material requirements of Section 02751 - Concrete Paving for reinforcing steel. Use No. 3 reinforcing bars.

C. Preformed Expansion Joint Material: Conform to material requirements for preformed expansion joint material of Section 02752 - Concrete Pavement Joints.

D. Expansion Joint Filler: Conform to material requirements for expansion joint material of Section 02752 - Concrete Pavement Joints.

E. Forms: Use straight, unwarped wood or metal forms with nominal depth equal to or greater than proposed sidewalk thickness. The use of 2 inch by 4 inch lumber as forms will not be allowed.

F. Sand Bed: Conform to material requirements for bank run sand of Section 02320 - Utility Backfill Materials.

G. Sodding: Conform to material requirements for sodding of Section 02922 - Sodding.

PART 3 EXECUTION

3.01 REPLACEMENT

A. Replace sidewalks and slope paving which are removed or damaged during construction with thickness and width equivalent to one removed or damaged, unless otherwise shown on Drawings. Finish surface (exposed aggregate, brick pavers, etc.) to match existing sidewalk.

B. Provide replaced and new sidewalks with wheelchair ramps when sidewalk intersects curb at street or driveway.

3.02 PREPARATION

A. Identify and protect utilities which are to remain.

B. Protect living trees, other plant growth, and features designated to remain.

C. Conduct clearing and grubbing operations in accordance with Section 02233 - Clearing and Grubbing.

D. Excavate subgrade 6 inches beyond outside lines of sidewalk. Shape to line, grade and cross section. For soils with plasticity index above 40 percent, stabilize soil with lime in accordance with Section 02336 – Lime-Stabilized Subgrade. Compact subgrade to minimum of 90 percent maximum dry density at optimum to 3 percent above optimum moisture content, as determined by ASTM D 698.

E. Immediately after subgrade is prepared, cover with compacted sand bed to depth as shown on Drawings. Lay concrete when sand is moist but not saturated.

3.03 PLACEMENT

A. Setting Forms: Straight, unwarped wood or metal forms with nominal depth equal to or greater than proposed sidewalk thickness. Use of 2 by 4's as forms will not be allowed. Securely stake forms to line and grade. Maintain position during concrete placement.

B. Reinforcement:

1. Install reinforcing bars.

2. Install reinforcing steel as shown on the drawings. Lay longitudinal bars in walk continuously, except through expansion joints.

3. Use sufficient number of chairs to support reinforcement in manner to maintain reinforcement in center of slab vertically during placement.

4. Drill dowels into existing paving, sidewalk and driveways, secure with epoxy, and provide headers as required.

5. Use sufficient number of chairs for steel reinforcement bars to maintain position of bars within allowable tolerances. Place reinforcement as shown on Drawings. In plane of steel parallel to nearest surface of concrete, bars shall not vary from plan placement by more than 1/12 of spacing between bars. In plane of steel perpendicular to nearest surface of concrete, bars shall not vary from plan placement by more than 1/4 inch.

C. Expansion Joints: Install expansion joints with load transfer units in accordance with Section 02752 - Concrete Pavement Joints.

D. Place concrete in forms to specified depth and tamp thoroughly with "jitterbug" tamp, or other acceptable method. Bring mortar to surface.

E. Strike off to smooth finish with wood strike board. Finish smoothly with wood hand float. Brush across sidewalk lightly with fine-haired brush.

F. Apply coating to wheelchair ramp with contrasting color in accordance with Section 02761 - Colored Concrete for Medians and Sidewalks.

G. Unless otherwise indicated on Drawings, mark off sidewalk joints 1/8 inch deep, at spacing equal to width of walk. Use joint tool equal in width to edging tool.

H. Finish edges with tool having 1/4 inch radius.

I. After concrete has set sufficiently, refill space along sides of sidewalk to one-inch from top of walk with suitable material. Tamp until firm and solid, place sod as applicable. Dispose of excess material in accordance with Section 01576 - Waste Material Disposal. Repair driveways and parking lots damaged by sidewalk excavation in accordance with Section 02951 - Pavement Repair and Restoration.

3.04 CURING

A. Conform to requirements of Section 02753 - Concrete Pavement Curing.

3.05 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. Compressive Strength Test Specimens: Four test specimens for compressive strength test will be made in accordance with ASTM C 31 for each 30 cubic yards or less of sidewalk that is placed in one day. Two specimens will be tested at 7 days. Remaining two specimens will be tested at 28 days. Specimens will be tested in accordance with ASTM C 39. Minimum compressive strength: 3000 psi at 7 days and 3500 psi at 28 days.

C. Yield test for cement content per cubic yard of concrete will be made in accordance with ASTM C 138. When cement content is found to be less than that specified per cubic yard, reduce batch weights until amount of cement per cubic yard of concrete conforms to requirements.

D. If the Contractor places concrete without notifying the laboratory, the City will have the concrete tested by means of core test as specified in ASTM C 42. When concrete does not meet specification, cost of test will be deducted from payment.

E. Sampling of fresh concrete shall be in accordance with ASTM C 172.

F. Take slump tests when cylinders are made and when concrete slump appears excessive.

G. Concrete shall be acceptable when average of two 28 day compression tests is equal to or greater than minimum 28 day strength specified.

H. If either of two tests on field samples is less than average of two tests by more than 10 percent, that entire test shall be considered erratic and not indicative of concrete strength. Core samples will be required of in-place concrete in question.

I. If 28 day laboratory test indicates that concrete of low strength has been placed, test concrete in question by taking cores as directed by Project Manager. Take and test at least three representative cores as specified in ASTM C 42 and deduct cost from payment due.

3.06 NONCONFORMING CONCRETE

A. Remove and replace areas that fail compressive strength tests, with concrete of thickness shown on Drawings.

B. Replace nonconforming sections at no additional cost to City.

3.07 PROTECTION

A. Maintain newly place concrete in good condition until completion of Work.

B. Replace damaged areas.

END OF SECTION

SECTION 02811

LANDSCAPE IRRIGATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pipe and fittings, valves, sprinkler heads, and accessories.

B. Control system.

1.02 RELATED SECTIONS

A. Document 00410 – Bid Form

B. Section 01270 - Measurement and Payment

C. Section 01312 – Coordination and Meetings

D. Section 01330 - Submittal Procedures

E. Section 01755 - Starting Systems

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for landscape irrigation will be made under this Section on lump sum basis.

2. Payment for capped irrigation sleeve, for connection to future system expansion, is on linear foot basis.

3. Refer to Section 01270 - Measurement and Payment.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ANSI/ASTM D 2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.

B. ASTM D 2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure - Rated Pipe (SDR Series).

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

1.06 QUALIFICATIONS

A. Manufacturer: Company specializing in performing work of this section with minimum three years documented experience.

1.07 REGULATORY REQUIREMENTS

A. Conform to applicable code for piping and component requirements.

1.08 PRE-INSTALLATION CONFERENCE

A. Convene one week prior to commencing work of this Section.

1.09 COORDINATION

A. Coordinate work with site landscape grading and delivery of plant life.

1.10 EXTRA MATERIALS

A. Furnish extra components under provisions of Document 00410 - Bid Form.

1. Two sprinkler heads of each type and size.

2. Two valve box keys.

3. Two wrenches for each type head core and for removing and installing each type head.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Electric solenoid controlled underground irrigation system.

B. Source Power: 120 volt.

2.02 PIPE MATERIALS

A. Pipe shall be continuously and permanently imprinted with manufacturer's name, size, schedules, type, and working pressure.

B. PVC Pipe ASTM D 2241; 200 psi pressure rated upstream from controls, 160 psi downstream; solvent welded sockets rubber gasket joints.

C. Fittings: Type and style of connection to match pipe.

D. Solvent Cement: ANSI/ASTM D 2564 for PVC pipe and fittings.

E. Sleeve material: 4-inch schedule 40 PVC.

2.03 OUTLETS

A. Manufacturer's or approved equal:

1. Rainbird Model 1804.

2. Rainbird Model 1812

3. Hunter Model PGP

B. Rotary type sprinkler head: Pop-up type with screens; fully adjustable for flow and pressure; size as indicated; with letter or symbol designating degree of arc and arrow indicating center of spray pattern.

C. Spray Type Sprinkler Head: Pop-up head with full circle, half circle, third circle, quarter circle, and square pattern.

2.04 VALVES

A. Manufacturer's or approved equal:

1. Rainbird Model PEB Series

B. Gate Valves: Bronze construction, non-rising stem, and sized to line.

C. Backflow Preventers: FEBCO 765 Bronze body construction, reduced pressure zone or pressure vacuum breaker type.

D. Valve Box and Cover: rectangular 10 inches by 4 inches or 9 inches round.

2.05 CONTROLLER

A. Manufacturer's or approved equal:

1. Rainbird Model RC1260C

B. Valves: Electric solenoid wiring including required fittings and accessories.

C. Wire conductors: color coded.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify site conditions under provisions of Section 01312 - Coordination and Meetings.

B. Verify location of existing utilities.

C. Verify that required utilities are available, in proper location, and ready for use.

3.02 PREPARATION

A. Piping layout indicated is diagrammatic only. Route piping to avoid plants, ground cover, and structures.

B. Layout and stake locations of system components.

C. Review layout requirements with other affected work. Coordinate locations of sleeves under paving to accommodate system.

3.03 TRENCHING

A. Trench and filling as required.

B. Trench size:

1. Minimum cover over installed supply piping: 18-inches.

2. Minimum cover over installed branch piping: 12-inches.

3. Minimum cover over installed outlet piping: 12-inches.

C. Trench to accommodate grade changes.

D. Maintain trenches free of debris, material, or obstructions that may damage pipe.

E. Do not leave trenches open overnight.

3.04 INSTALLATION

A. Install pipe, valves, controls, and outlets in accordance with manufacturer's instructions.

B. Connect to utilities.

C. Set outlets and box covers at finish grade elevations.

D. Install control wiring as required. Provide 10-inch expansion coil at each valve to which controls are connected, and at 100-foot intervals. Bury wire beside pipe. Mark valves with neoprene valve markers containing locking device. Set valve markers in 160 psi PVC pipe risers exiting from top of valve to finish grade.

E. After piping is installed, but before outlets are installed and filling commences, open valves and flush system with full head of water.

F. Coordinate pipe installation with conduit installation.

3.05 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed.

B. Prior to filling, test system for leakage for whole system to maintain 100 psi pressure for one hour.

3.06 FILLING

A. Cover with 3-inches of sand over piping; fill trench and compact to subgrade elevation. Protect piping from displacement.

3.07 ADJUSTING

A. Adjust control system to achieve time cycles required.

B. Change and adjust head types for full water coverage as directed.

3.08 DEMONSTRATION

A. Demonstrate system under provisions of Section 01755 - Starting Systems.

B. Instruct City's personnel in operation and maintenance of system, including adjusting of sprinkler heads. Use operation and maintenance material as basis for demonstration.

END OF SECTION

SECTION 02871

BIKE RACKS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Class III bike racks and associated support medium as indicated on the standard details. A Class III bike rack shall be a rack where both one wheel and the frame can be secured with a user supplied lock. The Class III rack shall consist of a single U/Hoop.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02752 – Concrete Pavement Joints

D. Section 02775 – Concrete Sidewalks

E. Section 03315 – Concrete for Utility Construction

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Payment is on a unit price basis for each bike rack complete and in place.

2. Payment for bike parking concrete pad is on a square foot basis of surface area for the newly installed concrete slab and shall include placing and finishing the concrete pad and all labor, tools, and incidentals necessary to complete the work.

3. Unit price shall include the excavation, removal and disposal of existing sidewalk, location, placement and installation of bike racks; all materials, including all steel pipe and plate, screws, nuts and bolts and all labor, tools, and incidentals necessary to complete the work.

4. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM A 36 - Standard Specification for Carbon Structural Steel.

B. ASTM A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 – Submittal Procedures.

B. Submit manufacturer's product data for approval including fabrication and installation details, color, and finish of bike racks.

C. Support medium (i.e. existing slab, new pad, etc.) and details of installation.

D. Complete manufacturer's warranty against defects for a period of not less than one year from date of installation.

PART 2 PRODUCTS

2.01 MATERIALS

A. Steel

1. All steel shall be ASTM A-36 1010-1018 low carbon prime steel and the screws, nuts and bolts shall be tamper proof and plated with commercial zinc. The bike racks shall be hot dipped galvanized (ASTM A 123).

B. Portland Concrete Cement

1. Portland cement concrete shall be Class A as specified in Section 03315 – Concrete for Utility Construction.

C. Expansion Joint Materials

1. Expansion joint materials shall conform to Section 02752 – Concrete Pavement Joints.

PART 3 EXECUTION

3.01 CONSTRUCTION OF RACKS

A. The Class III Bike Rack shall consist of a one piece welded inverted U/Hoop assembly of Schedule 40 steel pipe with an outside diameter (OD) of 1.9 inches (48.26 mm) on a minimum 0.25" (6.35 mm) thick base plate.

B. Base Plates

1. All base plates will have two ½" (13 mm) diameter holes per plate for mounting.

2. Rectangular - Dimensions are 6" by 2" (150 mm by 50 mm). Bolt holes will be equidistant between the pole and edge of plate.

3. Round - Diameter must be at least 6" (150 mm) with a 4.5" (114 mm) bolt circle. Bolt holes will be equidistant between the pole and edge of plate.

4. Oval - Length must be at least 6" (150 mm) with a width of at least 3" (76 mm). Bolt holes will be equidistant between the pole and edge of plate, with the center of the bolt hole at least 0.75" (19 mm) from the base plate edge.

C. Each bike rack will be hot dip galvanized after fabrication, unless otherwise indicated.

D. Bike racks will be supported as indicated on the Drawings. The bike rack shall be supported on either existing or newly placed Portland cement concrete slabs.

3.02 INSTALLATION OF BIKE RACKS

A. Bike parking racks shall be installed in existing concrete sidewalks/pavement in accordance with Standard Detail 02871-01.

B. Any construction of new Bike Parking Pads shall be completed in accordance with Section 02775 – Concrete Sidewalks. Unless noted otherwise on the Drawings, the pad shall be 4 inches (102 mm) in thickness.

END OF SECTION

SECTION 02890

PEDESTRIAN CROSSWALK SYSTEM RECTANGULAR RAPID FLASHING BEACON (RRFB)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This specification defines the minimum detailed requirements of a Pedestrian Crosswalk RRFB System that has Rectangular Rapid Flashing Beacons (RRFBs) and is solar-powered for new installations and replacement parts for existing installations. The system field equipment includes controller, cabinet, batteries, battery charger, solar panel, static signs, mounting equipment, communication device, flashing beacons, and other incidentals required for Pedestrian Crosswalk System.

B. The system is to provide a highly visible, enhanced warning for the purpose of alerting road users from both traffic directions of the active pedestrian crossing.

C. Overview: Upon activation by pedestrian push button, the controllers shall activate all RRFB light bars in the crosswalk system simultaneously. RRFB light bars shall flash synchronously and then cease operation after a programmable timeout.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Price

1. This Item will be measured as each system furnished or furnished and installed complete and in place.

2. The work performed, and materials furnished shall be measured as indicated under “Measurement” as each system furnished or furnished and installed and made fully functional and operational and tested in accordance with the requirements in this specification and will be paid for at the unit price bid for each item, as specified in the bid form.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. 47 CFR Part 15 – Radio Frequency Devices

B. AASHTO Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals

C. ASTM A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

D. ASTM B 429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube

E. FHWA Memorandum IA-21 - Interim Approval for Optional Use of Pedestrian-Actuated Rectangular Rapid Flashing Beacons at Uncontrolled Marked Crosswalks

F. FHWA MUTCD – Manual on Uniform Traffic Control Devices

G. SAE J595 - Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles

1.05 SUBMITTALS

A. Each Pedestrian Crosswalk RRFB System both complete and as parts, shall be provided with the following documentation:

1. Complete accurate schematic diagrams

2. Complete parts list including names and part numbers for vendors, for parts not identified by universal numbers.

3. Operating and maintenance manual including simple programming instructions and a programming guide.

1.06 QUALITY ASSURANCE

A. Certification. A Vendor Representative shall provide to the City's Project Manager in writing that the City's installation Contractors have been trained to successfully assemble, program, and operate the beacon assemblies in accordance with manufacturer's specifications and operating manual.

1.07 WARRANTY

A. All equipment, except batteries, shall be warranted free from defects in Material and workmanship for minimum three (3) years from date delivered to the City of Houston warehouse. Batteries shall be warranted as specified in the Battery for Solar Powered Flashing Beacons section of this specification.

PART 2 PRODUCTS

2.01 MATERIALS

A. General Requirements

1. The crosswalk system shall consist of two pole assemblies, or three to four if there is a median. All pole assemblies shall contain one or more warning RRFB light bars, a solar powered control cabinet, and a pedestrian push button for system activation. All control cabinets in the crosswalk system shall be synchronized by Wireless Transceivers, the communication device for the system.

2. An optional Advance Warning RRFB assembly further increases pedestrian safety when required. Active vehicle warning indications shall be visible in a direct line of sight at distances over 1000 feet during the day, and over 1 mile at night.

B. Cabinet Components

1. General: The cabinet shall be of 0.080" thick H-5052 aluminum and certified for NEMA 3R type. All external welds shall be made using the Heliarc method, whereas the wire welding method shall make internal welds. All welds shall be neatly formed and free from cracks, blowholes and other irregularities. The nominal outside dimensions shall be 15-inch (h) x 12.5-inch (w) x 9.9-inch (d). It shall have 2 tamper-resistant stainless-steel hinges, screened vents on cabinet side and door, screened drain holes on the bottom of the cabinet. A UV resistant label shall be applied to the exterior of the cabinet with the following information: model number, serial number, date of manufacture and any applicable regulatory information. The cabinet shall have a door mounted pouch that will store all system documentation.

2. The cabinet will be designed to protect internal equipment from rain, dust, vandalism and other conditions found in harsh environments.

3. The cabinet door opening shall be double flanged around all sides to form a uniform surface. This is to assure maximum contact with the door gasketing material.

4. All inside and outside edges of the cabinet shall be free of burrs.

5. For adequate ventilation of internal components, the cabinet shall be vented with screening included on all vents and drains to prevent insects and other foreign matter from entering.

6. Door and Hardware:

   a. The door will be a minimum of 80% of the front surface area and shall be hinged on the right side when facing the cabinet.

   b. The door gasketing shall be sprayed with silicone lubricant so that it does not adhere to the cabinet body-sealing surface.

7. For security, the cabinet must include at least two tamper-resistant stainless-steel hinges and a replaceable #2 traffic lock with keys.

8. Cabinet Finish: Unless otherwise specified, the outside surface of the cabinet shall have a smooth, uniform, polish aluminum finish. To prevent corrosion, all materials used in the construction or mounting of the control cabinet shall be either aluminum or stainless steel. Anti-vandal mounting hardware shall be available as an option.

9. Cabinet Mounting: For easy installation on a wide range of pole sizes and types, the cabinet shall utilize four 5/16"-18 stainless steel mounting studs that mate to a range of bracket options. To ensure a secure mount to the supporting post, two banding style brackets that fit poles with a 2-3/8” or larger diameter shall be included as standard equipment. Mounting brackets also available for square pole, wooden post, and wall mount applications.

C. Solar Panel

1. The photovoltaic module shall be constructed of an anodized aluminum frame, high-transmission 1/8" tempered glass, with silicon cells encapsulated in double-layer EVA, and with a white polymer backing. The glass shall be high transparent, low iron and tempered. The module frame shall be made from heavy-duty anodized aluminum and adequately sized to attach the desired number and size of solar panels. The mounting bracket shall use tamper proof hardware to secure the PV module to the frame and shall be made of aluminum. The solar panel shall be affixed to a pole top bracket that allows an adjustable angle to provide maximum insolation exposure. To ensure maximum solar insolation regardless of installation location, the post top mounting system shall provide 360° of rotational direction adjustment and upon installation, must be oriented with the collector facing South.

2. The solar panel must be IEC61215 and TUV certified. The solar panel shall operate at 12VDC nominal with a maximum output rating of 65 watts.

   a. The solar panel specifications:

      (1) Overall Size: 25.2" x 25.7"

      (2) Maximum power voltage: 18.65 VDC

      (3) Maximum power current: 3.77 A

      (4) Short circuit current: 3.97 A

      (5) Open circuit voltage: 22.66 VDC

      (6) Operate from -40° to +194°F (-40° to +90°C)

3. All solar panel connectors shall conform to Ingress Protection, IP-67 rating, dust proof, and protected from temporary immersion in water up to 1 meter deep for 30 minutes. Connectors shall be Deutsch DTM series. All solar panel fasteners shall be anti-vandal pin-type set screws. Wrench shall be provided.

D. Battery

1. The Battery shall have a nominal output voltage of 12 VDC and a capacity of 50Ah. It shall be rechargeable type absorbent glass mat and be replaceable independently of other components.

2. The battery shall conform to the following criteria:

   a. Operating temperature range:

      (1) Charge: +32 degrees F to +104 degrees F.

      (2) Discharge: +5 degrees F to +113 degrees F

   b. Storage temperature range of +5 degrees F to +104 degrees F.

   c. Vents: Pressure relief vents permanently attached sealed construction: Will not spill or leak.

   d. Flag Terminals: Type I6, Hold clearances for ¼" bolt.

3. Battery shall be housed in the cabinet specified in the above specification. The battery shall carry two (2) year replacement warranty from date of delivery to the City of Houston, and a prorated warranty up to five (5) years.

E. Rectangular Rapid Flashing Beacons (RRFB) Assembly

1. The Rectangular Rapid Flashing Beacon (RRFB) light bars shall be low voltage and the current controlled from the controller.

2. The RRFB light bar shall be in conformance with all applicable FHWA MUTCD standards and guidelines and shall meet or exceed the requirements specified in FHWA Memorandum IA-21, Interim Approval for Optional Use of Pedestrian-Actuated Rectangular Rapid Flashing Beacons at Uncontrolled Marked Crosswalks.

3. The light LED shall consist of vehicle LED modules with 2 arrays of 8 amber LEDs spaced 7" apart, 7 inch (w) x 3 inch (h), and be SAE J595 Class 1 Certified, and optional pedestrian LED modules that flash simultaneously with the vehicle LED, are 0.5 inch (w) x 1.75 inch (h) side-viewable and either placed on one or both end sides of the light bar housing. The LED arrays shall be designed, located and operated in accordance with the detailed requirements as specified on the plans.

4. The RRFB light bar, when activated, 75 periods of flashing per minute and shall have alternating and simultaneous flash operations following the interim approval compliant Wig-Wag plus Simultaneous (WW+S) flashing pattern And it shall have a minimum life expectancy of 100,000 hours and an operating temperature range of +40 degrees F to +122 degrees F.

5. The light intensity of the vehicle indications shall meet the minimum specifications of Society of Automotive Engineers (SAE) standard J595 (Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles) dated January 2005. Manufacturer Certification of Compliance shall be provided upon request. Active vehicle indications shall be visible at distances over 1000 feet during the day and over 1 mile at night.

6. The housing for the light bar shall be constructed of durable, corrosion-resistant black powder-coated aluminum with stainless steel vandal resistant fasteners having the following dimensions: 22 inch (w) x 4 inch (h) x 1.5 inch (d).

7. Components shall be enclosed and be modular in design whereby any component can be easily replaced without having to uninstall the RRFB assembly.

8. Beacon mounting hardware shall consist of a universal mounting bracket that articulates up to 30 degrees and mounts to most common size metal or wood posts and use a banding or u-blot to round pole or bolt to square pole.

9. Include mounting hardware for either single or back-to-back pole mounting that is universal to the pole type.

10. Assembly shall house two rapidly and alternately flashing rectangular yellow LED array vehicle indications and one side-mounted yellow LED array pedestrian indication.

11. Assembly shall have two vehicle RRFB indications that are approximately 7” wide x 2.8” high, each with 8 yellow LEDs in its array and one pedestrian indication that is approximately 0.5” wide x 1.7” high with 8 individual yellow LEDs in its array.

12. Assembly shall have overall dimensions of approximately 23.6” wide x 3.8” high x 1.4” deep.

F. Controller & Charge Controller

1. The programmable flash controller shall be housed in the NEMA 3R Type control cabinet specified. It shall include integrated constant-current LED drivers with a minimum of two-channel output for driving one or two RRFB units.

2. The device shall have a power indicator light, status LED lights, at minimum 1 digital input and 2 digital output lines, a micro-USB or similar port for connection, and a backlit LCD display.

3. The controller shall automatically adjust the LED drive current control to optimize brightness for the ambient lighting conditions determined by the phototransistor input.

4. It shall have the LED drive outputs reach the full output current as programmed within the duration of the 100ms on-time and include an integrated Real Time Clock (RTC) with on-board battery backup.

5. It shall have the capability of RS232 communication for programming with Windows-based software.

6. The controller shall be capable of solar charging the system battery, including a completely drained battery pack. It shall automatically provide Low Voltage Disconnect (LVD) to protect batteries when needed, and automatically provide load-reconnection once battery levels have been restored to an acceptable value. It shall include a minimum of two General Purpose Inputs and Outputs (GPIO).

7. The device shall be FCC and ISED compliant, have a range of up to 900 feet minimum without an antenna, utilize the license free 900 MHz frequency hopping spread spectrum with minimum 10 different RF patterns to prevent interference between collocated radio systems. It shall be able to connect to up to 16 devices on one network. An optional antenna may be used to increase connection range if needed and at the City's approval.

8. The enclosure shall be IP67 rated for protection against dust and moisture.

9. Output shall have the following "WW+S" flash pattern during each of its 800 millisecond flash periods:

    a. Left LED illuminates for approximately 50 milliseconds

    b. Both LEDs stay dark for approximately 50 milliseconds

    c. Right LED illuminates for approximately 50 milliseconds

    d. Both LEDs stay dark for approximately 50 milliseconds

    e. Left LED illuminates for approximately 50 milliseconds

    f. Both LEDs stay dark for approximately 50 milliseconds

    g. Right LED illuminates for approximately 50 milliseconds

    h. Both LEDs stay dark for approximately 50 milliseconds

    i. Both LEDs illuminate for approximately 50 milliseconds

    j. Both LEDs stay dark for approximately 50 milliseconds

k. Both LEDs illuminate for approximately 50 milliseconds

l. Both LEDs stay dark for approximately 250 milliseconds

10. The controller shall be independently replaceable of other control panel components and be able to monitor internal temperature.

G. Communication Device

1. The wireless transceiver shall operate wirelessly at 900 Mhz, utilizing Frequency Hopping Spread Spectrum (FHSS) technology to minimize the effects of external RF interference and operate on the license-free ISM band and comply with Part 15 of FCC rules.

2. Device shall seamlessly integrate with the controller to ensure sequential activation of other radio- equipped devices in the system.

3. Device shall include an integrated LCD and joystick button for setup and troubleshooting, including readouts of flash duration (timeout), battery conditions, and LED testing functionality.

4. Device shall include two LED indicators for status and troubleshooting.

5. Device shall be capable of operating as a transmitter or receiver.

6. All receiver nodes can repeat a signal a single time.

7. Device shall be capable of providing site-survey data for verification of signal strength between network devices.

8. Device shall include network-wide modification of sign controller settings and output durations, using programmability from any networked transceiver without the use of additional equipment or software.

9. Synchronize the system components to activate the indications within 120 msec of one other and remain synchronized throughout the duration of the flash (timeout) cycle.

10. Device shall have an operating voltage range of 3.3VDC to 15VDC.

11. Device shall be replaceable independently of other components.

H. Pedestrian Push Buttons

1. The push buttons shall be ADA compliant, field adjustable directional arrow, and be Polara iNX model or approved equal.

2. The push button shall have an activation confirmation feature that consists of yellow LEDs and voice confirmation that are activated when push button is pressed with an adjustable operating force range of 0.5 to 3.5 lbs. The speaker shall be field replaceable, weather resistant, have a 10 watt audio amplifier and a maximum volume of 100 dB at 1 meter.

3. The push button shall have a rated power of 10 to 24 Vdc, have a maximum idle current draw of approximately 9 mA @ 12 Vdc.

4. The operating temperature range shall be from -30 degrees to +165 degrees F.

5. All wiring shall be Underwriters' Laboratories (UL) approved for voltages involved.

6. The enclosure shall be a NEMA 250 Type 4X housing that is powder coated cast aluminum cover and backplate. Yellow powder coat finish is standard.

7. An instructional sign shall be retroreflective sheeting with tamper-resistant mounting screws and it shall be situated above the push button. The standard size for the sign is 9-inch x 12-inch. Any variation will be at the City's discretion.

I. Signs

1. The Pedestrian Crosswalk RRFB System shall include a back-to-back Non-vehicular Warning Pedestrian Crossing Traffic (W11-2) static sign with back-to-back Supplemental Warning (W16-7P) static plaques that are MUTCD compliant and constructed on 5052-H32 aluminum.

   a. W11-2: Specifications: 36" Diamond, 2.25" Rad with two (2) 3/8" holes 36" apart on center; Sheeting: DG3 Fluorescent Yellow-green.

   b. W16-7P: Specifications: 24" x 12" 0.080 gauge, 1.5" Rad with two (2) 3/8" holes 1.5" in center, Sheeting: DG3 Fluorescent Yellow-green.

2. An alternative to the Warning Pedestrian Crossing Traffic static sign is an integrated LED-enhanced flashing Warning Pedestrian Crossing Traffic sign that is edge-lit such as the TAPCO Blinker Sign or City approved alternative.

   a. The sign shall be constructed on 0.080" gauge aluminum, have an enclosed aluminum channel to protect wiring against inclement weather, tampering and vandalism, have amber environmentally-sealed, high-power LEDs with a life expectancy of 100,000 hours and an operating temperature range of -40 degrees to +122 degrees F.

J. Pole Assembly

1. The pedestal pole assembly is required for support of the Pedestrian Crosswalk RRFB System. Refer to **Error! Reference source not found.** and **Error! Reference source not found.** included in this specification for details of assembly items.

2. Pole shaft shall be one-piece galvanized steel pipe. It shall be made of Schedule 80 aluminum alloy 6061-T6 manufactured in accordance with ASTM B429, threaded on one end with outside dimensions of 4.5".

3. The pedestal base assembly shall be FHWA certified, meet AASHTO breakaway requirements, arranged to be mounted on a concrete base, attached by four internal galvanized anchor bolts of standard size 1" x 42". The base shall be made of cast aluminum and it shall include an 8.5" square handhole cover that is also made of cast aluminum. The door shall be secured by a 5/16"-18 x 1" hex head bolt.

4. Breakaway pole shall meet the requirements shown in standard detail 02582-04.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. Cabinet Mounting

1. Cabinets shall not physically or aerially encroach sidewalks, pedestrian walking paths, or bikeways.

2. Cabinet shall be mounted above the W11-2 sign in cases where the cabinet is encroaching in areas where parking or pedestrian movements occur, per MUTCD 2A.18.

3. The clearance between the base of the cabinet and the top of the push button assembly shall be at minimum 2-inches.

4. The cabinet shall be arranged for side of pole mounting. The mounting brackets shall be supplied as part of the complete cabinet package.

5. The pole shall be a standard specified outer diameter aluminum pedestal pole and shall be supplied with one end threaded for easy installation into a pedestal base.

6. The pole shall be 13' – 15' length Schedule 40 pipe raw aluminum as required.

7. The pedestal base shall be TP-358 cast aluminum that mounts on a concrete foundation attached by four internal anchor bolts imbedded in the foundation. The pedestal base shall have a large 8.5" square hand hole cover allowing access to the interior.

B. Solar Panel Mounting Hardware

1. The photovoltaic (PV) module mounting assembly shall be constructed of galvanized steel (ASTM A-153 Class A) or aluminum, of adequate design and strength to provide a means of securely attaching the PV module frame to a pole at a permanent angle of 45 to 50 degrees. The pole mounting hardware shall accommodate a steel 4.5-inch O.D. pole. The bracket shall be at an inscribed angular position about the pole. Mounting hardware may mount on the side of the pole or on the top of the pole as long as the bracket is of adequate strength to withstand the weight and wind stresses.

C. Physical and Electrical Interface

1. A physical and electrical interface needs to be maintained for the connection of the controller unit. This interface will need to be a terminal strip on the rear of the control panel. This terminal strip shall be where the harness will hook up for the controller unit. The terminal strip will need to be clearly labeled DC+,DC-, earth ground, relay N/O, relay common.

2. A physical and electrical interface will have to be maintained between the solar panel, batteries, and signals; both can be utilized on (1) terminal block to save space. All labeling shall be silk-screened.

3.02 FIELD QUALITY CONTROL

A. Testing: Pedestrian Crosswalk RRFB System shall meet or exceed all applicable Texas Manual on Uniform Traffic Control Devices and /or Institute Transportation Engineers standards and these specifications. In addition to testing of pre-shipment samples, complete testing of school zone beacon assemblies may be required at any time prior to acceptance. ITE specified signal lamp intensity shall be maintained.

3.03 TRAINING

A. Training requirements are listed below. The City shall furnish the training classroom and the Project Manager shall schedule the training sessions.

1. Assembly. One (8) hour training class on field assembly training shall be provided as requested by the city Project Manager, for the City's installation Contractors and City of Houston's, Houston Public Works - Transportation and Drainage Operations personnel. The instructional training shall be for up to twenty (20) persons at the request of the Project Manager.

2. Maintenance. One training class consisting of eight (8) hours of Maintenance training shall be provided for up to twenty (20) persons, as requested by the City Project Manager.

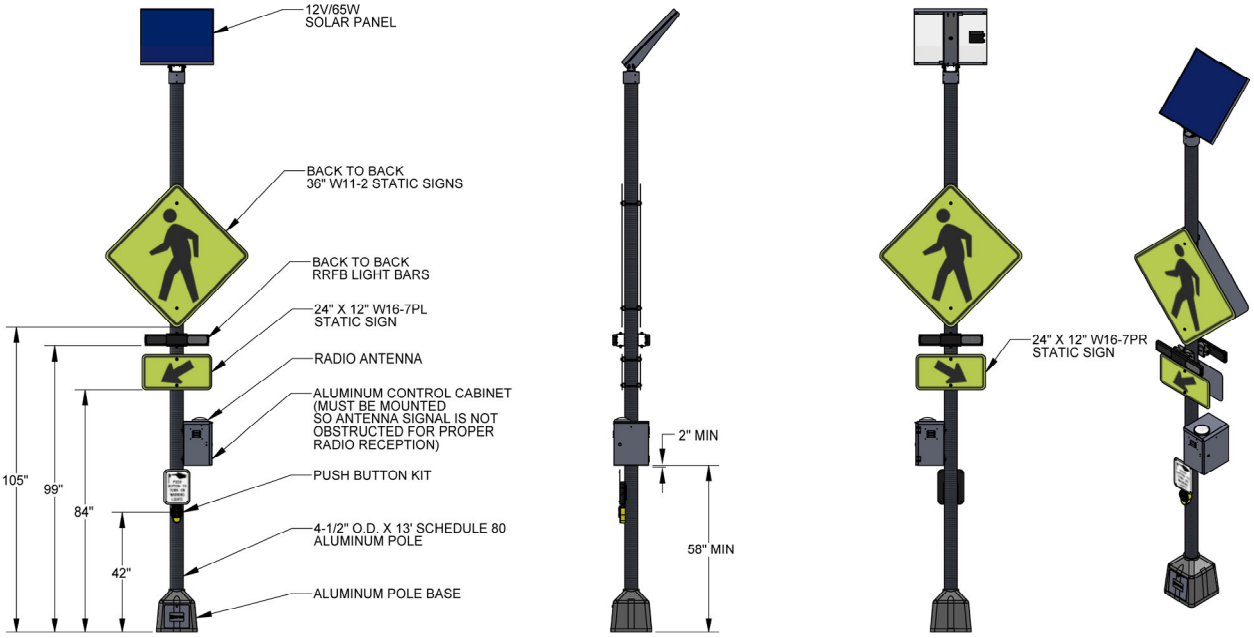


Figure 1- RRFB with W11-2 Static Sign Assembly

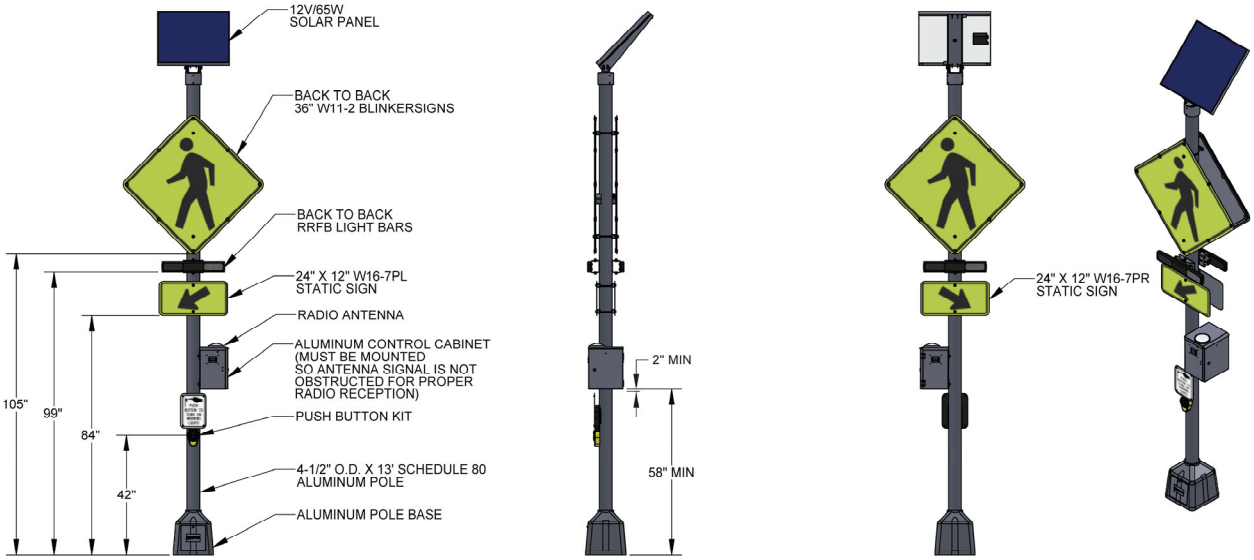


Figure 2- RRFB with W11-2 Blinker Sign Assembly

END OF SECTION

SECTION 02893

TRAFFIC SIGNAL CONSTRUCTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This specification consists of the requirements to construct traffic signals in the City of Houston.

1.02 RELATED SECTIONS

A. Document 00410 – Bid Form

B. Section 01270 – Measurement and Payment

C. Section 01755 - Starting Systems

D. Section 01785 – Project Record Documents

E. Section 02951 - Pavement Repair and Restoration

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. With exception to Work described in 1.03.A.2, no separate payment shall be made for traffic signal construction under this Section.

a. Items and work processes for traffic signal construction in this section are incidental to furnishing and installing a functioning traffic signal, complete and in place with all appurtenances.

b. Payment will be included under various traffic signal component unit price items in Document 00410 – Bid Form.

(1) Payment for traffic control devices will be on the basis of each device installed as shown on the drawings or as directed by the City Engineer and/or the approved City of Houston Representative.

c. Traffic control and regulation during construction will be paid according to Section 01555 – Traffic Control and Regulation.

d. Before doing any work or ordering any materials, the Contractor and Subcontractors shall verify all measurements of existing and new work and shall be responsible for their correctness. Any difference which may be found shall be submitted to the Engineer and/or the approved City of Houston Representative for consideration before proceeding with the work. No extra compensation will be allowed because of differences between actual dimensions and measurements indicated on the drawings.

2. Remove and salvage of existing traffic signal equipment will be measured by each traffic signal.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price per Intersection (Lump Sum) If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 SPECIAL REQUIREMENTS

A. The requirements of this contract encompass the construction of new traffic signal installations either installed 1.) concurrent with the street or roadway improvement phases of the work so that the signals will be in operation at the time the intersection is open to traffic, or 2.) as traffic signal or traffic signal related improvements.

B. The purpose and intent of this specification is for the Contractor to furnish all labor, materials, tools, equipment, tests, adjustments and all other incidentals necessary to install and/or modify a traffic signal system. The Contractor shall also install items furnished by the City of Houston, specified herein. All materials and equipment furnished for installation under this contract shall be new and unused, unless otherwise specified. Contractor shall furnish and install or install materials as specified herein.

C. All bidders shall visit the job site prior to bidding in order to acquaint themselves with all job site conditions and problems, if any, and all other factors that may affect the bid on all project specific contracts. On work order type projects, all bidders shall thoroughly familiarize themselves with City of Houston requirements and general field conditions. Any discrepancy between drawings and specifications shall be resolved prior to bidding.

D. These specifications together with the reference Drawings and Contract Documents require the furnishings of all superintendence, labor, tools, equipment and apparatus necessary for the complete working system of the traffic signal installation(s). All submittals need to be pre-approved prior to the job and by the inspector as directed by the Engineer and/or the approved City of Houston Representative.

E. Email Traffic Signal Engineering and Operations, (citytrafficprojmgr@houstontranstar.org) for coordination and inspection of traffic signal work. Contractor is required to notify daily activities to City Traffic Signal Inspector via email (citytrafficinspector@houstontranstar.org) before 7:30 A.M.

F. All control equipment shall confirm to ITE and NEMA specifications and in accordance with the drawings and specifications.

G. All construction will be in accordance with the Texas Manual on Uniform Traffic Control Devices, latest revisions, and in accordance with the drawings and specifications.

H. All wiring throughout each traffic signal installation shall be in strict accordance with the National Electric Code, all local applicable codes and shall also comply with all requirements of CenterPoint Energy, in order that service may be obtained from them. All costs for code compliance are to be included in the bid for this contract.

1.05 REFERENCES

A. References: References to known standard specifications in the Specification shall mean and intend latest edition of such specification adopted and published at date of invitation to submit Proposals.

B. Reference to technical society, organization or body is made in Specifications in accordance with the following abbreviations:

1. AASHO: American Association of State Highway Officials
2. ACI: American Concrete Institute
3. AIEE: American Institute of Electrical Engineers*
4. AISC: American Institute of Steel Construction
5. AISI: American Iron and Steel Institute
6. ASA: American Standards Association
7. ASTM: American Society for Testing and Materials
8. AWSC: American Welding Society Code
9. FS: Federal Specification
10. IMSA: International Municipal Signal Association
11. IPCEA: Insulated Power Cable Engineers Association
12. ITE: Institute of Traffic Engineers

13. MUTCD: Manual on Uniform Traffic Control Devices for Streets and Highways

14. NBFU: National Board of Fire Underwriters

15. NBS: National Bureau of Standards

16. NEC: National Electrical Code

17. NEMA: National Electrical Manufacturers Association

18. OSHA: Occupational Safety and Health Association

19. UL: Underwriters' Laboratories

* IEEE (Institute of Electrical and Electronics Engineers) – name changed from AIEE & IRE (Institute of Radio Engineers)

1.06 PERMITS, LAWS, CODES, ETC.

A. The contractor and subcontractors shall comply with all Federal, State and local Laws, Codes and Ordinances applicable to the work and all requirements of the National board of Fire Underwriters having jurisdiction. If the above laws, codes or ordinances conflict with specification, then the laws, codes or ordinances shall govern except where Specification exceeds them in quality of quantity of materials or labor. Obtain and pay for all permits required in connection with the execution of the work as required. The Engineer and/or the approved City of Houston Representative shall be furnished with certified copies of these permits if requested.

1.07 COOPERATION WITH BUILDING OFFICIALS

A. Cooperate with local and other governmental officials and inspectors at all times. If such official or inspector deems special inspection necessary, provide assistance and facilities that will expedite their inspection. Any materials and or workmanship which are rejected by the Traffic Signal Inspector by reason of failure to conform to the requirements of the drawings or specifications, shall be removed and replaced by the contractor at their own expense.

1.08 SUBSTITUTIONS

A. Except in special instances, the Technical Sections of these specifications list more than one manufacturer of the products specified. Products of listed manufacturers conform basically to design and performance requirements as indicated on the Drawings and specified herein and Contractor in proposing their use shall indicate by detail drawings and/or descriptive data any modifications of items or assemblies necessary to provide the indicated and/or specified work.

B. Requests for substitutions of materials must be submitted in writing to the Engineer and/or the approved City of Houston Representative by the Contractor. These substitutions will only be considered if fewer than three manufacturers are listed in the Specifications.

C. Under no circumstances will the Engineer and/or the approved City of Houston Representative be required to provide that a product proposed for substitution is, or is not, of equal quality to the product specified. It is mandatory that the Contractor submit to the Engineer and/or the approved City of Houston Representative, in Writing, all evidence necessary to support this contention that the item proposed for substitution is equal to the item indicated by the Contract Documents. Items submitted for substitution must be submitted one month prior to bid opening.

1.09 MANUFACTURER'S SPECIFICATION AND INSTRUCTIONS

A. Install all manufactured items, materials and equipment in strict accordance with the manufacturer's recommended specifications except that the Specifications herein, where more stringent, shall be complied with.

1.10 RECORD DRAWINGS

A. Provide and maintain in proper order and in good, clean condition at the project sites, one complete set of prints of all project drawings in accordance with Section 01785 – Project Record Documents. On this set of drawings, the Contractor shall neatly print and accurately inscribe, in red pencil, any and all changes or deviations from construction and installation as originally indicated in the plans and specifications. This set of prints shall be delivered to City of Houston - Traffic Signal Engineering and Operations at Houston TranStar Second Floor, 6922 Old Katy Road, at the time of final acceptance of the work by the City in order to provide the City with an “AS BUILT” set of plans.

1.11 TEMPORARY FACILITIES

A. Weather Protection

1. Contractor shall at all times provide protection against weather, so as to maintain all work, materials, apparatus, and fixtures free from injury and damages. At the end of the day’s work, all new work likely to be damaged shall be covered or otherwise protected.

2. Wet work shall not be performed when temperature is below 40˚ F, or is likely to go below 40˚ F, within the ensuing 48 hours, except when sufficient protective heat is provided and the Engineer’s and/or the approved City of Houston Representative’s approval in writing is obtained.

3. Contractor shall construct and maintain all necessary temporary drainage and do all pumping necessary to keep excavations, pits and trenches free of water.

B. Operation of Equipment

1. When electrical or other equipment is installed, it shall be the responsibility of the Contractor to check out same for a period of time as required by the Engineer and/or the approved City of Houston Representative for proper testing of the equipment. All items of equipment, testing instruments and incidentals necessary for proper testing of equipment shall be furnished by Contractor.

C. When any temporary facility is no longer needed for the proper conduct of the work as determined by the Engineer and/or the approved City of Houston Representative, the Contractor shall completely remove it from the project and shall repair or replace all material, equipment and finished surfaces damaged in doing so.

D. Contractor shall provide a portable toilet as needed.

1.12 PROTECTION

A. Provide barricades, fences, lights, etc., for protection of property and the public as required by local and/or State Ordinances. Contractor will be held liable for all damage to property and/or persons.

B. All barricades and signs shall conform to Texas MUTCD. Such barricades and protective signs shall be provided by the Contractor at their expense.

C. Flow of traffic shall not be interrupted completely without the approval of the Engineer and/or the approved City of Houston Representative. Restriction and minor diversion will be kept to a minimum. No work will be permitted in the traffic lanes during peak hours from 7:00 to 9:00 AM and 4:00 to 6:00 PM Monday through Friday. Any open cuts in the intersections during these hours will be covered with steel plates to maintain uninterrupted traffic.

D. Flagmen shall be certified flagmen or off-duty uniformed peace officers of the law. Contractor shall provide flagmen to direct traffic when directed by the Area Engineer and/or the approved City of Houston Representative of the Traffic Management and Maintenance Division. This does not relieve Contractor of responsibility of taking other steps and providing other personnel who he may deem necessary for protection of work and public.

E. Appropriate Personal Protective Equipment shall be worn by all contract personnel when on the job-site.

1.13 RESTORING DAMAGED AREAS

A. For all work at identified intersections and along communication cable routing, in the event that sidewalks, pavement, curbs, wheelchair ramps, driveways, landscaped areas, areas with special pavement treatment, sprinkler systems, lighting systems, or other items or properties both public and private that are damaged during this construction, shall be restored to their prior condition without expense to the City of Houston. No separate payment will be made for the restoration of these items.

B. Where signal poles are installed inside the existing 4 foot sidewalk or within 12 inches of either side of the existing sidewalk, the Contractor shall provide a minimum of 4 foot paved sidewalk 12 inches away from edge of the signal pole. The horizontal slope for the sidewalk shall be 2 percent.

1.14 WARRANTY

A. All items installed under this specification, having a manufacturer's guarantee shall be installed by or under the direction of the manufacturer or the manufacturer's certified agent, when so required to conform with the manufacturer's guarantee, and all such manufacturer's guarantees, warranties and bonds shall be forwarded to the City of Houston representative.

B. The Contractor, by accepting this contract, guarantees all workmanship, materials and equipment performed or furnished and installed under this specification for a period of one year from date of completion and shall, at their entire expense and within said term of guarantee, repair, replace or adjust all faulty, broken, or maladjusted materials and/or equipment furnished and installed under this specification, including lamp replacement.

PART 2 PRODUCTS

2.01 MATERIALS

A. Contractor is responsible for furnishing all materials and labor for construction of items as shown on drawings and other incidentals necessary to provide a fully operational traffic control signal. The Contractor shall furnish and install all materials, with exception of materials to be provided by the City of Houston.

B. Material should be installed according to the technical specifications and standard details under the direction of the City of Houston representative assigned to the project.

C. In addition to all items to be furnished and installed by the Contractor, the Contractor shall furnish and install all items necessary for the complete signal system including but not limited to the following incidental materials:

1. All conduit nipples, couplings, grounding bushings, elbows, sweeps and service heads.

2. All reinforcing steel and ties.

3. Concrete, sand, cement, gravel, asphalt, earth fill.

4. Span guy, down guys, anchor rod assemblies.

5. Sidewalk guy assemblies (if necessary).

6. Guy guards, three bolts clamps, lag screws.

7. 5/8" Thru-bolts, nuts, washers, thimble-eye nuts and bolts.

8. 5/16" Stranded galvanized steel cable for guys and catenaries.

9. ¼" Stranded galvanized steel cable for messengers.

10. Strand vises and links as needed.

11. Meter loop assemblies complete.

12. Signal mounting hardware.

13. Copperweld ground rods and clamps furnished and installed in all foundations and each pullbox.

14. Flexible stainless steel cable strap ties. Cable ties shall be Panduit Part #MLT 4H-LP or equivalent.

15. #6 or #8 Soft bare copper wire for grounding poles, conduits, etc.

16. Miscellaneous hardware.

D. Interconnect cable shall be communications grades as follows:

1. Type PE-38 or PE-22 (aerial)

2. Type PE-39 (underground)

E. All proposed changes in the signalization plan must be submitted to the City of Houston, in writing, for approval.

F. The Contractor shall be responsible for the protection of all present utilities that have been located by the various utility companies. They shall also maintain and protect the existing traffic signals and their related equipment from damage caused by subcontractors and employees under the Contractor's Contract but only to the extent of the Contractor's normal work operation, and the Contractor shall not be responsible for routine maintenance, normal wear and tear, or an act of God, unless otherwise specified.

G. The contractor shall bag all newly installed signal heads and/or pedestrian signal heads with burlap until final inspection and acceptance by the City of Houston Representative. The signal shall be wrapped with burlap at least twice so that the entire signal head is covered, and cannot be seen until it is placed in operation. The signal shall be de- energized while not in use. If, in the opinion of the Engineer and/or the approved City of Houston Representative, the new heads would create a hazard condition to motorists and/or pedestrians, the heads shall not be installed until one hour before turning on the new equipment.

H. All existing traffic signal equipment removed by the Contractor shall be tagged to identify location. A representative of Traffic Signal Engineering and Operations shall be given 24 hour notice before delivery of an approval location by the Engineer and/or the approved City of Houston Representative. Equipment not identified will not be accepted and equipment not returned will result in the withholding of payment to the Contractor. Traffic Signal Engineering and Operations personnel will issue a receipt to Contractor for returned equipment.

I. When the City Traffic Engineer and/or the approved City of Houston Representative determines that the need for a traffic signal is critical to the public welfare, early "turn on" of the signal shall be required before the completion of the project. If the need arises, the City of Houston will assume the responsibility for maintenance and liability, or negotiate with the Contractor for maintenance and liability for such a signal.

J. The City Traffic Engineer and/or the approved City of Houston Representative may, at any time, authorize City of Houston personnel to enter the controller cabinet in order to restore any and all signal equipment to proper operation if the malfunction or non- function of such equipment poses a hazard or inconvenience to motorists or pedestrians. Such authorized entry may occur at any time within the period of the Contract and such authorized entry shall in no way relieve the Contractor or manufacture of their respective warranties.

K. During the burn-in period, the Contractor shall restore operation of the installation within four (4) hours after notification of a malfunction. If the Contractor does not respond within four (4) hours, the City of Houston shall have the option of making the necessary repair and billing the Contractor for the actual time and materials required.

L. When replacing sidewalks or curb and gutters, it shall be the responsibility of the Contractor to reinstall them to match existing color and/or surface texture.

M. Materials specified herein shall be installed as per Traffic and Transportation Construction Details drawings-02893 series and the City of Houston Traffic Signal Standard Specifications.

N. The Contractor shall be responsible for having an authorized manufacturer representative of traffic control equipment present as per the requirements of Specification Section 01755, "STARTING SYSTEMS".

O. Each work order or intersection shall be a stand alone "Turn Key Job" by the Contractor.

P. A steel template of the proper dimensions shall be furnished and used by the Contractor to secure anchor bolts while constructing pole foundations.

Q. Flexible stainless steel cable ties for strapping signal cable to messenger shall be min:

1. 13.38-inches long, 120 lb. min. tensile holding strength, 3/16-inch to 3-1/2-inches wire bundle range. (Panduit Part #MLT 4H-LP or approved equal).

2.02 PRECONSTRUCTION MEETING

A. The Traffic & Transportation Division for Traffic Signal Contracts shall schedule a Preconstruction Meeting at TranStar after award of contract and prior to commencement of construction. The Contractor or the Contractor's authorized representative will be required to attend.

B. For roadway contracts, the preconstruction meeting for the traffic signal work shall be coordinated by the roadway project manager.

2.03 MATERIALS FURNISHED BY THE CITY

A. Prior to material pick up, a written notice is required sixty (60) calendar days in advance. This letter shall be addressed to:

City of Houston - Traffic Signal Engineering & Operations Traffic & Transportation Division
6922 Old Katy Road (Houston TranStar)
Houston, Texas 77024

B. Materials furnished by the City shall be picked up by the Contractor at the City of Houston – Transportation and Drainage, Traffic Operation and Maintenance Center, 2200 Patterson Street, Houston, Texas 77007, after giving a minimum of two (2) working days notice to the City of Houston by emailing to: (citytrafficprojmgr@houstontranstar.org) . This is in addition to the written requirements listed above. These materials will be furnished at no cost to the Contractor.

C. Any and all material furnished by the City to the Contractor which is not used in this contract is the property of the City of Houston and shall be returned to the locations specified by the Traffic Signal Inspector before final payment is made to the contractor.

2.04 PRODUCT DATA, SHOP DRAWINGS, AND SAMPLES

A. Contractor shall provide three (3) complete bound sets of Product Data, including: illustrations, standard schedules, performance charts, instructions, brochures, diagrams, and other information to illustrate materials or equipment for all Contractor furnished equipment.

B. Contractor shall furnish shop drawings, as required in the standard specifications and standard details, or as required by the Engineer and/or the approved City of Houston

C. Representative. As a minimum, Contractor shall be required to furnish shop drawings for all structural elements, including cabinets, traffic signal poles, traffic signal arms, luminaires, luminaire supports, vehicular traffic signal head mounts, and pedestrian signal head mounts prior to ordering or fabricating these elements. Shop drawing submittals are required for each of the preceding elements. Contractor is not required to furnish shop drawings for any equipment furnished by the City of Houston.

D. Contractor shall furnish samples, or prototypes, of the following equipment within the specified time frame.

Item	Calendar Days from Bid Award
Controller Cabinet Assembly	45
Traffic Signal Controllers	60

PART 3 EXECUTION

3.01 OPERATION OF NEW & EXISTING TRAFFIC SIGNALS DURING CONTRACT PERIOD

A. To facilitate construction, the Contractor shall be required to install temporary poles, guys, cables, signals, conduits, wiring and adjustments as needed for temporary traffic signal operation during construction. The Contractor will be responsible for furnishing and installing all materials as directed by the City of Houston Signal Inspector for temporary traffic signal installation. The Contractor shall contact the signal inspector assigned to the project with a daily progress report. The Contractor shall coordinate and obtain approval from the City of Houston signal inspector for all material as well as the configuration of the temporary traffic signal prior to installation. Proposed configurations and materials for the temporary traffic signal installation shall be submitted to the City of Houston Traffic Signal Engineering and Operations no less than five (5) working days prior to implementation. Operational timing and phasing of the temporary traffic signal installation during construction will be the responsibility of the City of Houston Traffic Management & Maintenance Branch personnel. Temporary traffic signal work will not be paid for directly, but shall be considered incidental to Traffic Control during construction. All temporary facilities shall be removed as directed by the signal inspector and remain the property of the Contractor upon operation of the new traffic signal construction.

B. The Contractor shall maintain existing signal installation(s) operation during construction of the new signal system. The Contractor may be required to photograph the existing signal to document existing status and functionality of all signal hardware and devices before beginning construction. It is the Contractor's responsibility to maintain all existing signal hardware and devices including signal heads and bulbs, interconnect, pedestrian elements, etc. The Contractor will not be responsible for power consumption of the signal during construction, and for work with the controller or inside the cabinet unless a city representative is onsite or as directed otherwise by the City of Houston. The Contractor shall submit all existing intersection documentation to the city inspector for the project before commencing work. The Contractor shall respond within two (2) hours after notification from appropriate City of Houston personnel. If the Contractor does not respond, the City of Houston will make necessary repairs and bill the contractor at an overtime rate (1.5X) for work performed.

> The Contractor shall provide a minimum of five (5) working days notice to City of Houston representative at 713-881-3172 when seeking approval for a change in location, method of operation of traffic signals or traffic lanes, or change in traffic patterns or timing plans.

C. The Contractor shall provide a minimum of two (2) days notice when seeking approval regarding the replacement of an existing traffic signal installation.

D. The Signal Contractor shall be billed for any repair work performed on overtime (1.5X) for any repairs required because of Contractor negligence.

E. Uniformed Police Officers shall be employed by the contractor and are required to be on the job site. It shall be mandatory to have Uniformed Police Officer(s) for traffic signal turn-ons. Certified flagmen or Uniformed Police Officers may be used, as needed, for lane closures. It is the Contractor's responsibility to use the appropriate personnel for lane closures. The Texas Manual On Uniform Traffic Control Devices will be observed for all lane closures.

F. All work in this contract, requiring signal outages, or lane closures, shall be performed between the hours of 9:00 A.M. and 4:00 P.M. Monday through Friday, unless prior authorization has been obtained from the Engineer and/or the approved City of Houston Representative.

G. Down time, if any, shall be kept to an absolute minimum. The switch over from the old system, or signal turn-on, shall be accomplished within the six (6) hours between 9:00 A.M. and 3:00 P.M. Contractor shall furnish and install all temporary traffic control (stop signs, flagmen, uniformed officers, etc.) during any down time, in addition to all required construction signs. Contractor shall inform the city of Houston to schedule a turn-on date a minimum of 72 hours in advance of need.

H. The Contractor shall hire a traffic engineer approved by the City of Houston to implement the traffic signal timings for the temporary signal system(s) and any modifications to the traffic control plan.

I. The Contractor shall furnish the City of Houston with a 24-hour telephone number for the purpose of forwarding malfunction calls. In the event that the Contractor cannot be reached at the above mentioned number, the City of Houston will take the necessary action to restore the traffic signal system to normal operation and all expenses incurred will be deducted from the final payment of the work order. All City of Houston labor expense shall be billed at overtime (1.5X) rates.

J. Contractor will be required to respond immediately and to initiate emergency maintenance operations on the jobsite a maximum of four (4) hours after the call is received from City of Houston. The Contractor shall pursue repairs to the traffic signal system and have it back in normal operation within a maximum of six (6) hours after call is received by the City of Houston, or a representative of the City of Houston.

3.02 CHARACTER OF WORKMEN AND EQUIPMENT

A. All equipment and workmen provided by the contractor for work hereunder shall be the best available for the kind of work being performed. Any person employed by the Contractor whom the City of Houston may deem temporarily or permanently incompetent or unfit to perform the work, shall under written instruction of the Engineer and/or the approved City of Houston Representative be removed from the job, and such person shall not again be employed on the work. Failure by the Contractor to provide adequate equipment may result in annulment of this contract as herein provided.

3.03 ELECTRICAL WORK

A. Electrical work is defined as installing cables, electrical terminations, and signal turn-ons. Installation of conduits is EXCLUDED from electrical work. Installation of loop wire in sawcut is EXCLUDED from electrical work.

B. All Contractor personnel working on City of Houston traffic signals performing duties directly involving setting up or installing signs, signals, pushbuttons, or traffic control shall be International Municipal Signal Association (IMSA) certified Level I, or greater. An IMSA certified Level II technician shall be present on site during all cabinet terminations and during the installation of all signs, pavement markings, signals, pushbuttons, and traffic control.

3.04 SALVAGED MATERIALS

A. At existing traffic signal installations which are to be updated or modernized by the Contractor, all abandoned wire, cable, signals, poles, pole bases, pole tops, mast arms, signs and other miscellaneous equipment shall be taken down and/or removed. All equipment shall be reduced to simplest form. These salvaged materials are the property of the City of Houston and are to be delivered and unloaded to the location or locations designated by the City of Houston Traffic Signal Inspector assigned to the project.

3.05 ELECTRICAL SERVICE

A. The Contractor shall notify the City of Houston Traffic Signal Inspector assigned to the project within seven (7) days of Contractor award for power at intersection.

3.06 SUBCONTRACTING

A. If a vendor subcontracts any portion of a contract for any reason, they must include, in writing, the name and address of the subcontractor, name of the person to be contacted including telephone number and extent of work to be performed. This information is to be submitted with bid proposal. In the event of a change during construction, Contractor is required to submit new information to the Engineer and/or the approved City of Houston Representative, for approval, five (5) days prior to using the subcontractor on the job. City of Houston reserves the right to reject a bid of any bidder if the bid names a subcontractor who has previously failed in the proper performance of an award or failed to deliver on time contracts of a similar nature, or who is not in a position to perform properly under this award. City of Houston reserves the right to make determination as to the foregoing.

3.07 SYSTEM GROUNDING

A. All poles, cabinets, conduits, signal common, and service common shall be bonded with a No. 8 AWG bare copper wire, or equal, to form a continuous system and effectively grounded to 5/8-inch x 8 foot copperweld ground rods.

3.08 STRANDED GALVANIZED STEEL CABLE

A. Guy, messenger and catenary wires shall be Siemens Martin Grade, seven strand, galvanized, high strength steel cable, 5/16 inch diameter for guy and catenary wires and ¼ inch diameter for messenger wires.

3.09 POLE RAKING

A. Poles shall be set with a sufficient amount of rake so that they are plumb with the signal load or slightly raked away from the signal load. Cantilever pole structures and 4-1/2” OD steel poles should be plumb; strain poles should have a slight backward rake (1 to 2 inches); wood poles shall utilize down guys to maintain appropriate signal height clearance during construction. The Contractor shall rake the poles to the satisfaction of the Traffic Signal Inspector.

B. Rake is hereby defined as the inclination to the vertical measured at the top of the structure in the opposite direction of the strain axis.

3.10 ABANDONED FOUNDATIONS

A. The tops of unused foundations shall be removed to a depth of two feet (minimum) below grade and back-filled according to specifications.

3.11 LOADS AND STRESSES DUE TO CONSTRUCTION OPERATIONS

A. Contractor shall have full responsibility for preventing over-stresses of any structure, cables, poles or any part of them during construction. This also applies to existing work facilities affected by Contractor's operations. The Contractor shall fully check the effect of Contractor's operations in this regard and shall provide temporary supports and connections required to assure safety and stability of both new and existing work to prevent over-stress of any part thereof.

3.12 APPARATUS LOCATION

A. The locations of all poles, controllers, actuators and signals shown on the plans are diagrammatic only. The specific locations of such devices shall be decided by the appropriate design personnel and shall be staked out under their direction. Vehicular and pedestrian traffic signals shall be placed and aligned as the City of Houston Traffic Signal Inspector directs.

3.13 CONCRETE POUR

A. The time of day of the concrete pour shall be stipulated by the Contractor.

3.14 SEQUENCE OF WORK

A. Each new signalized intersection shall be in operable condition including electrical service within fourteen (14) days after the first signal pole is installed, unless conditions caused by a paving contractor or roadway construction contractor prevents the completion of the intersection(s).

B. The order in which the intersections are to be completed may be specified by the Engineer and/or the approved City of Houston Representative and it shall be the sole responsibility of the Contractor to schedule and coordinate their work. All work shall be coordinated in such a manner as to prevent delays resulting from work to be performed by others and to complete the Contractor's work within the specified time.

C. On the day when the intersection is to be turned on or its "Turn On" date, the Contractor will be given a "punch list" from the Signal Inspector for any items that need attention concerning the conditions of signal equipment. These items shall be completed within ten (10) days of the date on the "punch list" given to the contractor.

3.15 UTILITY COORDINATION

A. The Contractor shall contact the Lone Star Notification Center (713-223-4567, in Houston, 800-669-8344, outside Houston) 72 hours before commencing any work to locate any utility lines in the construction area. It is the Contractor's responsibility to physically locate any water and sewer lines and to adjust the location of any foundation(s), for approval by the City of Houston Traffic Signal Engineering and Operations.

3.16 UNDERGROUND UTILITIES

A. The exact location of underground utilities and pipelines is not certain. The Contractor shall contact the Utility Coordinating Committee (U.C.C.) to determine exact locations of underground utilities prior to drilling for foundations or any other work that might interfere with or damage present facilities. Contractor shall be responsible for keeping the transmittal number from the U.C.C. current during construction.

3.17 LOCAL CONDITIONS

A. The Contractor shall make any additional investigations he deems necessary to properly bid any and all work related thereto. No additional compensation will be made available to the Contractor for work arising from failure to examine the site and/or subsoil conditions. Staking of specific locations by the Engineer and/or the approved City of Houston Representative shall not remove the Contractors responsibility for any damage caused by the Contractor to any underground utility.

3.18 RIGHTS OF VARIOUS INTERESTS

A. Wherever work being done by the City's forces or by any other Contractor is contiguous to work covered by this contract, the respective rights of the various interests involved shall be established by Engineer and/or the approved City of Houston Representative, to secure completion of the various portions of the work in general harmony.

3.19 TRENCHING

A. No trenching shall be allowed within five feet of a tree.

3.20 DIRECTIONAL DRILLING, BORE, AND JACK

A. No open cutting or trenching of streets, driveways and sidewalks shall be allowed without prior approval of the Engineer and/or the approved City of Houston Representative at each location. All conduit runs under streets, driveways or sidewalks shall be by directional drilling, bore, or jack. Water jetting methods shall not be accepted.

3.21 PUBLIC SAFETY AND CONVENIENCE

A. All work done under this contract shall be done in compliance with the Texas Manual on Uniform Traffic Control Devices (TMUTCD). Each operation shall be considered a work zone area and shall be treated in accordance with the TMUTCD.

B. The Contractor shall have a Certified Worksite Traffic Supervisor who will be responsible for initiating, installing, and maintaining all traffic control devices as described in the TMUTCD. The Worksite Traffic Supervisor shall have at least one (1) year of experience directly related to worksite traffic control in a supervisory or responsible capacity and shall be certified by the American Traffic Safety Services Association or International Municipal Signal Association. The Worksite Traffic Supervisor will be incidental to Maintenance of Traffic and will not be measured separately for payment.

C. The Worksite Traffic Supervisor shall be available on a twenty-four (24) hour day basis and shall review the project on a day to day basis as well as being involved in all changes to traffic control. The Worksite Traffic Supervisor shall have access to all equipment and materials needed to maintain traffic control and handle traffic related situations. The Worksite Traffic Supervisor shall insure that routine deficiencies are corrected with a twenty-four (24) hour period.

D. The Worksite Traffic Supervisor shall be available on the site within forty-five (45) minutes after notification of an emergency situation, prepared to positively respond to repair the work zone traffic control or to provide alternate traffic arrangements.

E. Failure of the Worksite Traffic Supervisor to comply with these provisions may be grounds for decertification or removal from the project or both. Failure to maintain a designated Worksite Traffic Signal Supervisor or failure to comply with these provisions will result in temporary suspension of all activities except traffic and such other activities deemed to be necessary for project maintenance and safety.

F. The Contractor shall at all times so conduct their work as to insure the least possible obstruction to normal pedestrian and vehicular traffic including access to all public and private properties during all stages of construction, and inconvenience to the general public and the residents in the vicinity of the work, and to insure the protection of persons and property, in a manner satisfactory to the City Engineer and/or the approved City of Houston Representative.

G. The Contractor shall provide all barricades and take all necessary precautions to protect buildings and personnel. All work shall be complete in every respect and accomplished in a workmanlike manner and contractor shall provide for removal of all debris from City of Houston property.

H. The successful bidder shall at all times guard against damage or loss to the property of the City of Houston or of other vendors or contractors and shall be held responsible for replacing or repairing any such loss or damage. Any damage to landscaping in the work area, including sod shall be replaced at the Contractor’s expense.

I. Prior to closing any section of the project to traffic, the Contractor shall furnish, erect and maintain barricades and warning signs at and in the vicinity of all construction projects at all times, both day and night, during the construction period of the contract, and all such barricades and warning signs, shall be in conformance with the requirements of Part 6 Temporary Traffic Control of the Texas Manual on Uniform Traffic Control Devices and as shown on the drawings.

J. Unless otherwise set forth in these specifications, the Contractor shall receive no direct compensation for furnishing, erecting, and maintaining the necessary barricades, lights, flares, signs, or for any other incidentals necessary for the good and proper safety, convenience, and direction of traffic during the period prior to final inspection and acceptance by the City of Houston.

3.22 SPECIAL REQUIREMENTS

A. A Steel Template shall be furnished by and used by the Contractor to secure anchor bolts while constructing pole foundations.

B. Pole Foundations shall be capped where needed, in order to provide a smooth, flat, and level surface. Capping shall consist of a one (1) inch thick mortar cap prepared with a 1:3 sand-cement mortar ratio. The cap shall be steel trowel finished.

C. Extra-length Concrete Pole Foundations shall be provided when required by site conditions. Reinforcing steel shall be increased by the same length as the increase in foundation length. Rods shown on Foundation Details shall be increased as follows: Each extra foot of foundation shall require on additional foot of length for hooked rods and two additional turns for helix.

D. All Special Foundations shall be designated and approved by the appropriate design engineer and/or the approved City of Houston Representative.

E. Sono Tube shall be used when the City of Houston Traffic Signal Inspector deems it necessary.

3.23 CONCRETE FINISHING

A. Honeycombed surfaces or other defects shall be patched with mortar of the same consistency as the mortar from which the concrete is made. Such mortar shall be well trowelled and then floated to remove trowel marks.

B. Finish for Formed Surfaces After patching above specified, exposed formed surfaces shall be finished by removing form marks, fins and other projections.

C. Finish for Uniformed Surfaces

1. Patches in streets, driveways and walks shall be finished to match adjacent surfaces.

2. Surfaces not Otherwise Specified – Steel trowel finish.

3.24 CONCRETE CURING

A. Immediately after placing or finishing, concrete surfaces shall be protected against moisture loss for a minimum of seven (7) days. Wet earth, waterproof paper, vinyl sheets or cotton mats shall be placed over concrete during curing period in order to insure fulfillment of this requirement. Membrane curing method may be used EXCEPT when concrete surfaces are to receive additional concrete or mortar, or are to be painted.

3.25 CONCRETE/PAVEMENT REPAIR

A. Repairs to concrete pavement shall be in accordance with Public Works Drawing Numbers 02951-04 and 02951-05 titled, “Pavement Repair Details for Street Cuts”, and Specification Section 02951, “Pavement Repair and Restoration”.

3.26 FLEXIBLE BASE PAVEMENT REPAIR

A. Repairs to flexible base pavement shall be made in accordance with Public Works Drawing Number 02951-04 titled, “Pavement Repair Details for Street Cuts”, and Specification Section 02951, “Pavement Repair and Restoration”.

3.27 TRAFFIC SIGNAL TESTING SERVICES

A. Procedures

1. Selection:

a. City of Houston shall employ an Independent Testing Laboratory to ensure Contract Document compliance.

2. Test Reports

a. Testing laboratory will furnish reports to the Engineer, Structural Engineer, City of Houston and Contractor covering all of its determinations and all of its control services. Reports will show all data customarily listed by the laboratory in reporting such tests including daily reports on quantities and types of materials together with location in the project. Form of reports will be as approved by the Engineer and/or the approved City of Houston Representative.

3. Test Methods

a. Tests and inspections will be conducted in accordance with the requirements of these Specifications or, if not herein specified in accordance with the latest standards of the American Society for Testing and Materials or other recognized authorities.

4. Contractor’s Responsibility

a. Cooperate with the testing laboratory and:

(1) Make available, without cost, samples of all materials to be tested.

(2) Furnish such normal labor as is necessary to obtain samples at the project and to assist in making slump tests and casting and curing cylinders.

(3) Advise the laboratory of the identity of material sources and instruct these suppliers to allow inspections by the laboratory, and notify the laboratory sufficiently in advance of operations to allow for completion of initial tests and assignment of inspection personnel.

(4) Contractor shall provide laboratory testing for each different concrete load.

b. Rejected Materials and/or Workmanship

(1) If, after initial tests have been performed, any materials and/or workmanship are rejected by the testing laboratory, Contractor shall pay for any subsequent testing required for materials which have been rejected and/or replaced.

(2) Any materials and/or workmanship which are rejected by the testing laboratory by reason of failure to conform to the requirements of the Drawings and/or Specifications, shall be removed and replaced with new acceptable materials by the Contractor at the Contractor's own expense.

5. Additional Responsibility

a. The testing of all cable furnished shall be properly tested by the manufacturer and data submitted through the Contractor to the Engineer and/or the approved City of Houston Representative.

b. All cable furnished to the job site shall be properly tested on the reel use.

3.28 PRELIMINARY WORK

A. Procedures

1. City Requirements

a. City requirements relating to the work of this section shall be ascertained by the Contractor. Contractor shall comply with all such requirements, including those relating to continued maintenance until completion of the project.

(1) If the City should require that certain portions of the work be performed by City personnel and equipment, all costs in connection therewith which are chargeable against the project shall be paid by the Contractor as an obligation of this Section.

(2) If re-routing of vehicular and/or pedestrian traffic is necessary to complete work of this Contract, Contractor shall submit a copy of the Contractor's proposed re- routing plan to the City and the Engineer and/or the approved City of Houston Representative for approval seventy-two (72) hours before proceeding with the work.

(3) Re-installation and restoration of use of existing public and private installations, which are temporarily and/or permanently removed and/or relocated for work of this Contract, shall be performed as a part of the work of this Section

2. Existing Installations of City-Owned Property

a. Perform all work relative to removal, storage and/or protection of existing installations of street lights and signs, fire hydrants, manholes, and other existing installations in the way of project construction.

b. Provide and maintain approved temporary protection of existing installations until project completion and acceptance. Remove temporary protection when, and as, directed by the City.

c. Existing facilities which are no longer required shall be disconnected as directed. Comply with the requirements of municipal agencies having jurisdiction over such work.

d. Unless otherwise directed, all abandoned facilities shall be removed by Contractor and the holes and trenches filled with approved compacted fill.

END OF SECTION

SECTION 02911

TOPSOIL

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnishing and placing topsoil for finish grading and for seeding, sodding, and planting.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01576 – Waste Material Disposal

C. Section 02315 – Roadway Excavation

D. Section 02320 – Utility Backfill Materials

E. Section 02921 – Hydro Mulch Seeding

F. Section 02922 – Sodding

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for topsoil under this Section. Include payment in Section 02921 - Hydro Mulch Seeding or Section 02922 - Sodding.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

PART 2 PRODUCTS

2.01 TOPSOIL

A. Topsoil shall be fertile, friable, natural sandy loam surface soil obtained from excavation or borrow operations having following characteristics:

1. pH value of between 5.5 and 6.5

2. Liquid limit: 50 or less

3. Plasticity index: 20 or less

4. Gradation: maximum of 10 percent passing No. 200 sieve

B. Topsoil shall be reasonably free of subsoil, clay lumps, weeds, non-soil materials, and other litter or contamination. Topsoil shall not contain roots, stumps, and stones larger than 2 inches.

C. Obtain topsoil from naturally well-drained areas where topsoil occurs at minimum depth of 4 inches and has similar characteristics to that found at placement site. Do not obtain topsoil from areas infected with growth of, or reproductive parts of nut grass or other noxious weeds.

PART 3 EXECUTION

3.01 EXAMINATION

A. Excavate topsoil for esplanades and areas to receive grass or landscaping from areas to be further excavated. Stockpile in area approved by Project Manager.

B. Stockpile topsoil to depth not exceeding 8 feet. Cover to protect from erosion.

3.02 TOPSOIL EXCAVATION

A. Conform to excavation and stockpiling requirements of Section 02315 - Roadway Excavation.

3.03 PLACEMENT

A. Place no topsoil until subgrade has been approved. For areas to be seeded or sodded, scarify or plow existing material to minimum depth of 4 inches, or as indicated on Drawings. Remove vegetation and foreign inorganic material. Place 4 inches of topsoil on loosened material and roll lightly with appropriate lawn roller to consolidate topsoil.

B. Increase depth of topsoil to 6 inches when placed over sand bedding and backfill materials specified in Section 02320 - Utility Backfill Material.

C. For areas to receive shrubs or trees, excavate existing material and place topsoil to depth and dimensions shown on Drawings.

D. Remove spilled topsoil from curbs, gutters, and, paved areas and dispose of excess topsoil in accordance with requirements of Section 01576 - Waste Material Disposal.

E. Place topsoil to promote good drainage and compact with light roller. Water topsoil after placement until saturated for minimum depth 6 inches, fill in and recompact areas of settlement.

3.04 PROTECTION

A. Protect topsoil from wind and water erosion until planting is completed.

END OF SECTION

SECTION 02912

TREE, PLANT, AND HARDSCAPE PROTECTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Tree root barriers; various depths and combinations may be required.

B. Tree trunk protectors.

C. Water barriers.

D. Staking and guying materials.

1.02 RELATED SECTIONS

A. Section 01270 - Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for root barrier shall be on a linear foot basis for height noted.

2. Payment for tree trunk protector, water barriers and staking material shall be on a linear foot basis for height noted.

3. Refer to Section 01270-Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). When Contract is Stipulated Price Contract, payment for Work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM D 256 - Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics

B. ASTM D 638 - Standard Test Method for Tensile Properties of Plastics

C. ASTM D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D. ASTM D 2240 - Standard Test Method for Rubber Property—Durometer Hardness

1.05 DEFINITIONS

A. Tree root barrier: Mechanical barrier and root deflector to prevent tree roots from damaging hardscapes and landscapes.

B. Tree trunk protector: Material to protect young tree trunks from rodents, string trimmers, and lawn mowers.

C. Water barriers:

1. Controls run-off, preventing hardscape damage.

2. Prevents irrigation water from percolating under pavement.

3. Water corral for planting areas preventing pavement damage and saves water.

4. Prevents snow, ice, and saltwater run-off from polluting planting areas adjacent to roadways and parking areas.

5. Liner to separate golf greens and turf.

6. Bamboo control.

1.06 SUBMITTALS

A. Product data: Manufacturers standard literature defining materials for use on this Project.

1. Submit product data in accordance with Section 01330 – Submittal Procedures.

B. Shop drawings:

1. Indicate locations and extent for tree root barrier material.

2. Indicate trees receiving tree trunk protectors.

3. Indicate locations and extent of water barriers.

4. Indicate trees and plants to be staked and guyed.

C. Samples if required by Architect:

1. Tree root barrier: One full length panel.

2. Tree trunk protector: One unit.

3. Water barrier: One lineal foot of material.

4. Staking and guying: One lineal foot.

D. Quality control submittals; manufacturer’s instructions: Complete installation instructions for each item specified; may be combined with product data.

1.07 QUALITY ASSURANCE

A. Qualifications; manufacturer: Minimum 20 years experience in tree and plant protection and accessories.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping: Provide materials in original unopened containers with manufacturer's labels intact and legible.

B. Acceptance at site:

1. Damaged materials determined by visual inspection will not be accepted.

2. Remove rejected materials from Project site immediately.

C. Storage and protection: Store materials in dry area in manufacturer's protective packaging; in original containers with labels and instruction instructions intact.

PART 2 PRODUCTS

2.01 MATERIALS

A. Acceptable manufacturers:

1. Products of manufacturers meeting indicated standards and specified material properties are acceptable for use, subject to approval of product list and samples.

B. Basic Material Properties of Tree Root Barriers

Material and Thickness		Homopolymer Polyethylene
Properties	ASTM Test Method	Value Homopolymer Polyethylene
Tensile Stress Yield	D638	3800
Elongation at Break %	D638	10%
Tensile Modulus	D638	155,000
Notched Izod Impact	D256	0.4 – 0.4
Flexural Modulus 73 PSI	D790	145,000
Hardness Shore	D2240	P66

2.02 MANUFACTURED UNITS

A. Tree root barriers:

1. Shall be produced 12” – 48” depth.

2. Material: 0.080-inch wall thickness, nominal, injection molded 50% post-consumer recycled polypropylene panels with UV inhibitors.

3. Panel Specifics:

   a. 7/16-inch Wide integral molded 0.08-inch thickness double top edge with stiffening ribs; bottom edge attached to vertical root deflecting ribs.

   b. Integral molded 0.080-inch thickness by 2-inch deep vertical root directing ribs spaced at 6.0-inch O.C.

   c. Integral molded 0.080-inch thickness by 2-inch long by 3/8-inch wide horizontal anti-lift ground lock tabs; minimum three per panel.

4. Preassembled joiner system for panel connection to adjacent panel.

5. Refer to standard details for root barrier installation.

B. Tree trunk protectors:

1. Material: 0.060-inch thickness polyethylene with UV inhibitors, recyclable.

2. Size: 9-inch high by single length accommodating tree up to 4-inch dia.

3. Larger trees indicated for protection: Couple two or more sections together.

C. Water barriers:

1. Product standard of quality: Water Barrier WB Series.

2. Material: 0.030-inch 0.040-inch thickness High Density Polyethylene (HPDE).

3. Sizes: 24-inch, 30-inch, and 36-inch wide by 300-feet rolls.

4. Manufacturers standard sealing tape.

5. Sealant: Silicone type recommended by water barrier manufacturer for certain applications; applications requiring sealant indicated in manufacturers product data.

D. Staking and guying materials:

1. Material: Flat, woven polypropylene; 900 lb. break strength.

2. Size: wide by manufacturers standard roll lengths.

2.03 ACCESSORIES

A. Provide related materials for complete installation of specified materials.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verification of conditions:

1. Verify other work in other sections, in, at, and around landscaping work is complete to extent that no damage will occur to newly planted materials or, any possible construction related damage will be minimal and replacement plant material is readily available for planting at no additional cost.

2. Obtain verification, in writing, from work required in other Sections directly involving work in this Section regarding correct grades have been provided, coordination of topsoil spreading, and lawns and grasses planting.

3. The contractor shall fulfill the responsibilities below prior to beginning work. Failure to do so will require removal or replanting work in this section.

a. Provide written notification to Architect of unacceptable conditions.

b. Receive verification of written notice.

3.02 PREPARATION

A. Surface protection: Use methods necessary to prevent damage to completed site work performed in other Sections. Protect access to and areas around planted materials. Restore damaged areas to original compaction, grades, and lines; repair damaged grassed areas.

3.03 INSTALLATION

A. Tree root barriers: Install in accord with manufacturers reviewed installation instructions where indicated on reviewed shop drawings with vertical root directing ribs facing inwards towards trees or plants; connect panels together as required.

B. Tree trunk protectors:

1. Install in accord with manufacturers reviewed installation instructions where indicated on reviewed shop drawings.

2. Join two or more segments together for trees over 4-inch dia.

C. Water barriers:

1. Install where indicated on reviewed shop drawings in accord with manufacturers reviewed installation instructions using material widths required for conditions encountered.

2. Seal to hardscape surfaces with specified sealant.

3. Join material lengths with manufacturers sealing tape.

D. Staking and guying materials:

1. Immediately after planting, guy and stake designated trees and large plants.

2. Include tightening of guying materials to bring trees and plants to upright position.

END OF SECTION

SECTION 02915

TREE PLANTING

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. This section specifies the requirements and standards for planting trees using a mechanical tree spade and container grown trees.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 - Submittal Procedures

C. Section 01576 - Waste Material Disposal

1.03 MEASUREMENT AND PAYMENT

A. Unit Price per tree.

1. Payment for tree planting is on unit price basis for each tree planted and shall include cost of watering during maintenance period for trees not served by irrigation system.

2. When shown on Drawings or directed by Project Manager to remove and relocate tree affected by trench zone, work shall be paid for under one of the following bid items.

a. Bid item "Remove and Relocate Tree" includes moving tree with truck mounted tree spade and replanting same tree in new location. Payment is for each tree removed and relocated.

b. Bid item "Remove, Temporary Store and Replant Tree" includes moving tree with truck mounted tree spade and replanting tree at temporary location, (determined by Contractor) maintaining tree until construction is complete and replanting same tree back to its original location. Payment is for each tree removed, stored and replanted.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ANSI Z 60.1 - Nursery Stock, most current publication.

B. Code of Federal Regulations, Title 40, Part 503 – Standards for the Use or Disposal of Sewage Sludge

C. Texas Administrative Code, Title 30, Chapter 332 – Composting

D. United States Composting Council (USCC) Seal of Testing Assurance (STA) program

1.05 SUBMITTALS

A. Submittals shall conform to requirements of Section 01330-Submittal Procedures.

B. Submit physical address for location of trees. Trees shall be tagged in field for transplanted trees, and at the nursery for container trees, for inspection by City Engineer or City Forester. Tag shall be securely attached to branch, shall be waterproof, and shall legibly bear designation of botanical and common name. Submit right of entry agreement for City Engineer or City Forester to access tree farm or nursery in order to inspect trees.

C. Submit following documentation for Compost to be utilized:

1. Feedstock by percentage in the final compost.

2. Documentation that the compost meets federal and state health and safety regulations.

3. Documentation that the composting process has met time and temperature requirements.

4. Copy of producer’s STA certification.

5. Copy of the current TCEQ compliance statement signed by facility manager for any biosolids compost utilized.

1.06 QUALITY ASSURANCE

A. Transplanted trees shall be planted by a contractor specializing in tree spade planted trees. The contractor shall have a minimum of 8 years experience in planting trees with truck mounted tree spades. The contractor shall have immediate access to required trees in a tree farm/field located within 40 miles of project site. Container trees shall be planted by Landscaping firm with a minimum of 3 years experience in planting container grown trees.

1.07 WARRANTY

A. Contractor shall warrant trees against defects including death, unsatisfactory growth, or loss of shape due to improper pruning, maintenance, or lack of moisture, for 2 year after completion of construction (substantial completion). Contractor shall plumb leaning trees during warranty period.

B. Remove and replace trees found to be dead during warranty period. Remove and replace trees which have more than 40% twig and/or foliage dieback or are in doubtful condition at the end of warranty period, or if approved by City Engineer, extend warranty period for such trees for a full growing season. Any trees that are required to be replaced under warranty shall be replaced at no addition cost to owner.

PART 2 PRODUCTS

2.01 TREES

A. Substitutions of specified tree species and sizes, and tree spade and container size shall not be made without written approval from City Engineer. When specified planting material is not obtainable, submit proof on non-availability together with proposal for use of equivalent material. Substitutions of larger size than specified will be allowed, provided it meets requirements article 2.01.B through E of this section, but shall be provided at no additional cost to owner.

B. Provide trees which are straight and symmetrical and have persistently preferred main leader. Co-dominant or dual leaders will not be allowed or accepted. Trees with a significant number of v-crotches, or trees with major branches that have v-crotches will not be allowed or accepted. The crown shall be in good overall proportion to the entire height of the tree. The minimum crown spread and height shall conform to the following standards for each tree:

1. Transplant Trees:

    a. 3” diameter tree shall have a minimum canopy spread of 50” diameter, total tree height of 8 feet, and canopy height of 5 feet.

    b. 4” diameter tree shall have a minimum canopy spread of 70” diameter, overall tree height of 10 feet, and a canopy height of 6.5 feet.

    c. 5” diameter tree shall have a minimum canopy spread of 90” diameter, overall tree height of 12 feet, and a canopy height of 8 feet.

    d. 7” diameter tree shall have a minimum canopy spread of 110” diameter, overall tree height of 15 feet, and a canopy height of 10 feet.

2. Container Trees:

    a. Tree diameter, overall tree height, and canopy height shall conform to ANSI Z 60.1 (most current publication).

C. Tree diameter and/or container/spade size shall be as specified on the drawings. Tree diameter to be measured 6 inches above natural grade or planting media for each tree.

D. Trees shall be healthy, vigorous, and in overall good condition. Trees shall be free of disease, insects, eggs, larvae; and free of defects such as wasp galls, knots, trunk wounds or scars, abrasions or disfigurement.

E. Foliage shall be dark green, as dark as is typical for the given species. The tree foliage shall not be chlorotic, necrotic, or dying back.

2.02 SOIL CONDITIONER OR ROOT STIMULATOR

A. Root stimulator shall contain at a minimum the following ingredients: Ectomycorrhizal Fungi, VA Mycorrhizal(VAM) Fungi, Rhizosphere Bacillus spp., Kelp Meal, Humic Acid, and Soluble Yucca.

2.03 SAND BACKFILL

A. Sand backfill shall be a fine sandy loam, typical of the soil at the project site, or fine bank sand. The back fill shall be free of noxious weeds, grasses, sticks, roots or stone and shall be consistent in texture.

2.04 COMPOST

A. Compost shall have been produced by aerobic (biological) decomposition of organic matter. Compost feedstock may include, but is not limited to, leaves and yard trimmings, biosolids, food scraps, food-processing residuals, manure or other agricultural residuals, forest residues, bark, and paper. Compost and wood chips shall not contain any visible refuse, other physical contaminants, or any substance considered harmful to plant growth. Compost shall not contain materials that have been treated with chemical preservatives as a compost feedstock or as a wood chip. Compost shall not contain mixed municipal solid waste compost. Compost shall meet all applicable 40 CFR 503 standards for Class A biosolids and TCEQ health and safety regulations as defined in the TAC, Chapter 332, including the time and temperature standards in Subchapter B, Part 23. Meet the requirements of the United States Composting Council (USCC) Seal of Testing Assurance (STA) program.

2.05 MULCH

A. Mulch shall be shredded hardwood, free of noxious weed seeds.

2.06 WATER

A. Water shall be potable from municipal water supplies.

2.07 SOURCE QUALITY CONTROL

A. Notify City Engineer, prior to delivery and planting, with location where trees that have been tagged for planting may be inspected. Trees will be inspected for compliance with this specification.

PART 3 EXECUTION

3.01 EQUIPMENT (APPLIES TO TRANSPLANT TREES)

A. Tree spade shall be in good condition with minimum tolerances between digging blades. All blades shall be true to their designed spade free of bends and deformities. The tree spade shall be mounted on suitable, stable machines capable of supporting the weight of all dug materials and heavy enough to force all blades into the soil to full depth. Holes to receive machine transplanted trees shall be dug with machines of like size and manufacture to that which is used to dig the intended tree.

B. Trees shall be transplanted with minimum tree spade sizes for maximum tree diameter per the following standards:

1. Maximum tree diameter for 50” tree spade shall be 3”
2. Maximum tree diameter for 60” tree spade shall be 4”
3. Maximum tree diameter for 80” tree spade shall be 5”
4. Maximum tree diameter for 90” tree spade shall be 7”
5. Maximum tree diameter for 120” tree spade shall be 9”

3.02 PREPARATION FOR PLANTING

A. Schedule work so that planting can proceed as rapidly as the planting site becomes available. Plant trees after final grades are established and prior to planting of turf, unless otherwise approved by City Engineer in writing. If planting of trees occurs after seeding work, protect turf areas and promptly repair damage to turf resulting from tree planting operations.

B. Layout individual trees at locations shown on Drawings. In case of conflicts, notify City Engineer before proceeding with work. Trees shall be laid out and approved by City Engineer and City Forester prior to planting.

C. The contractor shall be responsible for locating and confirming underground utilities.

D. Trees shall be pruned, at the farm, to remove dead, diseased, dying, or broken branches that will be detrimental to the future shape or structure of the tree. Old pruning stubs should also be removed. All pruning cuts should be made sufficiently close to the branch collar, so as not to leave a protruding stub, without cutting into the branch collar. Each cut shall be made with the appropriately sized pruning shear, which should have properly matched, sharpened blades. Pruning cuts shall not be painted or otherwise treated.

E. Trees are subject to inspection at the tree farm or location of collection. When directed, provide and use serialized locking tags on trees.

F. Contractor shall notify City Engineer and City Forester at least 48 hours before delivering trees to worksite. Coordinate with City for inspection and approval of materials upon delivery. Remove rejected trees from the worksite and replace as directed.

G. Container grown trees shall be thoroughly watered prior to leaving tree farm or nursery.

3.03 COLLECTING, TRANSPORTING AND PLANTING

A. Transplant Trees

1. Tree shall be centered in tree spade at digging.

2. No damage to branches or trunk shall be allowed while backing onto tree at tree farm, digging tree, or pulling away from tree after planting. Damage to tree trunk caused by the digging or planting of the tree, will be grounds for non-acceptance of tree under this specification.

3. Roots protruding from the digging blades shall be pruned flush with the root ball prior to planting.

4. Contractor shall ensure tree is tied down so that the total height of the tree spade and tree do not exceed legal height limits.

5. Tree shall be covered with an open-weave fabric tarp to minimize wind damage and desiccation of leaves during transportation from collection site to planting site.

6. Each tree shall be planted in its final planting site within 4 hours of being dug from the collection site.

7. Tree shall be planted plumb and the root ball shall be set 2-3 inches above the finished grade.

8. No staking or guying of the tree should be installed.

9. Voids between existing grade and tree root ball shall be backfilled with sand backfill. The sand backfill should be thoroughly watered into the voids, so that no air packets remain.

10. A water holding basin shall be constructed around each tree. The basin should be constructed with the sand backfill and shall be constructed directly over the void between the existing grade and root ball, 6-8" in height, and 8-10" in width. The top of the root ball shall not be covered with sand backfilled or any other type of soil.

11. Prior to mulching, each tree shall be thoroughly watered 2 separate times. Each time the watering basin should be filled with water and the water allowed to soak the tree and force sand backfill into all voids. After the second watering basin should be rebuilt to its original shape.

12. Each tree shall be thoroughly soaked with root stimulator, per label instructions.

13. Mulching shall be completed within 24 hours of planting. A 4" deep layer of mulch shall be applied to the entire water holding basin and top of root ball. No mulch shall be applied directly against the trunk of the tree.

14. Control dust caused by planting operations. Dampen surfaces as required. Comply with pollution control regulations of governing authorities.

B. Container Trees

1. Excavate planting pit to a depth equal to planting media height in container, or 1-2" shallower. Do not over excavate, to ensure planted root ball rest on undisturbed sound soil. Planting pit shall have a diameter that is at least 2 feet wider than diameter of root ball.

2. When conditions detrimental to plant growth are encountered, such as unsatisfactory soil, obstructions, or adverse drainage conditions, notify City Engineer and/or City Forester.

3. Edges of planting pit shall be scarified with gouges a minimum of 1" deep and 1" wide spaced no wider than 8" on center.

4. Trees shall be planted within 24 hours of excavating planting pits to minimize soil desiccation.

5. Trees shall be handled by container during transportation and planting. Trees shall not be handled by grasping trunk only.

6. Trees shall be covered with open weave tarp in transportation from nursery to planting site, to minimize tree and leaf desiccation.

7. Deliver trees after preparations for planting have been completed and plant immediately. If planting does not occur within 6 hours of delivery, set trees in shade, protest from weather and mechanical damage, and keep root balls moist by covering with mulch, compost, burlap, or other acceptable means of retaining moisture. Water trees as needed to avoid root ball desiccation.

8. Each tree shall be removed from container without cracking or disturbing root ball. The circumference of the root ball shall be scored with sharp utility knife ½" deep, from top to bottom of ball, at 8" intervals to cut any circling roots.

9. Set root ball in planting pit, on undisturbed soil, in center of pit and plumb plant. Top of root ball shall be at same elevation of finished grade or 1-2" above finished grade.

10. Backfill planting pit around root ball in lifts, each lift shall be 1/3 the depth of the root ball. Pit shall be thoroughly watered after each lift to remove air pockets. Backfill shall consist of the following materials:

    a. Soil excavated from planting pit: 75 percent

    b. Compost: 15 percent

    c. Peat moss: 10 percent

11. Construct a plant basin at least 6 inches deep with an inside diameter equal to the planting pit diameter and with a level top around the plant unless otherwise indicated on plans. Use excavated soil from the planting pit, amended backfill material, or approved material for the basin.

12. Mulching shall be completed within 24 hours of planting. A 4" deep layer of mulch shall be applied to entire water holding basin and top of root ball. No mulch shall be applied directly against the trunk of the tree.

13. Each tree shall be guyed and staked immediately after planting. Each tree shall have a minimum of 2 post; more may be required depending on soil structure. Provide adequate number of post to ensure tree stability during establishment. Tree shall be secured by plastic tree chain, do not use wire with plastic or rubber guards.

14. Control dust caused by planting operations. Dampen surfaces as required. Comply with pollution control regulations of governing authorities.

3.04 FIELD QUALITY CONTROL

A. City Engineer may reject unsatisfactory or defective material at anytime during progress of work. Contractor shall remove rejected trees immediately from site and replace with specified materials. Plant material not installed in accordance with these specifications will be rejected.

B. An inspection to determine final acceptance will be conducted by City Engineer and City Forester at the end of the 24 month maintenance period. Additional inspections will be conducted for extended warranty periods provided for in paragraph 1.07B.

3.05 MAINTENANCE PERIOD

A. Contractor shall maintain trees during planting operations and for a period of 24 months after completion of construction (substantial completion).

B. Contractor shall water trees during maintenance period to ensure tree establishment. Trees served with bubblers or drip irrigation will not require manual watering.

C. Contractor shall apply a minimum of 25 gallons of water to each tree weekly, or more if required to maintain healthy vigorous growth. No watering shall be required during weeks when the planting site receives at least 1" of rainfall. Rainfall to be measured at planting site.

3.06 CLEANUP AND PROTECTION

A. During planting work, keep pavement clean and work area in an orderly condition.

B. No open planting holes shall be left at planting site without immediate supervision by planting personnel. Use plywood, or other suitable material, to cover open hole when not under immediate supervision.

C. Protest planting work and material from damage due to planting operations. Maintain protection during installation and maintenance period. Treat, repair, or replace damaged planting work as directed by City Engineer.

D. Dispose of excess soil and waste in accordance with requirements of Section 01576-Waste Material Disposal. On-site burning of combustible materials will not be permitted.

END OF SECTION

SECTION 02921

HYDRO MULCH SEEDING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Seeding, fertilizing, mulching, and maintenance of areas indicated on Drawings.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01576 – Waste Material Disposal

D. Section 01740 – Site Restoration

E. Section 02911 – Topsoil

F. Section 02922 – Sodding

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for hydro mulch seeding is on an acre basis, within limits of construction if shown on the drawings.

2. Topsoil is included in the unit price for hydro mulch seeding and is not paid for separately.

3. No payment will be made for hydro mulch seeding under this Section if limits of constructions are not shown on the drawings. Include payment in Section 01740 – Site Restoration.

4. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. Federal Seed Act regulations

B. Texas Seed Law.

C. Texas Fertilizer Law

D. U.S. Department of Agriculture rules

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certification from supplier that each type of seed conforms to these specifications and requirements of Texas Seed Law. Certification shall accompany seed delivery.

C. Submit certificate stating that fertilizer complies with these specifications and requirements of Texas Fertilizer Law.

PART 2 PRODUCTS

2.01 MATERIALS

A. Topsoil: Conform to material requirements of Section 02911 - Topsoil.

B. Seed: Conform to U.S. Department of Agriculture rules and regulations of Federal Seed Act and Texas Seed Law. Seed shall be certified 90 percent pure and furnish 80 percent germination and meet following requirements:

1. Rye: Fresh, clean, Italian rye grass seed (lollium multi-florum), mixed in labeled proportions. As tested, minimum percentages of impurities and germination must be labeled. Deliver in original unopened containers.

2. Bermuda: Extra-fancy, treated, lawn type common bermuda (Cynodon dactylon). Deliver in original, unopened container showing weight, analysis, name of vendor, and germination test results.

3. Wet, moldy, or otherwise damaged seed will not be accepted.

4. Seed requirements, application rates, and planting dates are:

TYPE	APPLICATION RATE POUNDS/A	PLANTING DATE
Hulled Common Bermuda Grass 98/88 Unhulled Common Bermuda Grass 98/88	40 40	Jan 1 to Mar 31
Hulled Common Bermuda Grass 98/88	40	Apr 1 to Sep 30
Hulled Common Bermuda Grass 98/88 Unhulled Common Bermuda Grass 98/88 Annual Rye Grass (Gulf)	40 40 30	Oct 1 to Dec 31

C. Fertilizer: Dry and free flowing, inorganic, water soluble commercial fertilizer, which is uniform in composition. Deliver in unopened containers which bear manufacturers guaranteed analysis. Caked, damaged, or otherwise unsuitable fertilizer will not be accepted. Fertilizer shall contain minimum percentages of following elements:

1. Nitrogen: 10 Percent

2. Phosphoric Acid: 20 Percent

3. Potash: 10 Percent

D. Mulch:

1. Virgin wood cellulose fibers from whole wood chips having minimum of 20 percent fibers 0.42 inches in length and 0.01 inches in diameter.

2. Cellulose fibers manufactured from recycled newspaper and meeting same fiber content and size as for cellulose fibers from wood chips.

3. Dye mulch green for coverage verification purposes.

E. Soil Stabilizer: "Terra Tack 1" or approved equal.

F. Weed control agent: Pre-emergent herbicide for grass areas, such as "Benefin," or approved equal.

PART 3 EXECUTION

3.01 PREPARATION

A. Place and compact topsoil in accordance with requirements of Section 02911 - Topsoil.

B. Dispose of Objectionable and Waste Materials in accordance with Section 01576 - Waste Material Disposal.

3.02 APPLICATION

A. Seed: Apply uniformly at rates given in Paragraph 2.01 B for type of seed and planting date.

B. Fertilizer: Apply uniformly at rate of 500 pounds per acre.

C. Mulch: Apply uniformly at rate of 50 pounds per 1000 square feet.

D. Soil Stabilizer: Apply uniformly at rate of 40 pounds per acre.

E. Weed Control Agent: Apply at manufacturer's recommended rate prior to hydro mulching.

F. Sod: Lay single row of sod along perimeter where top soil and pavement intersect. Apply in conformance to Section 02922 - Sodding.

G. Suspend operations under conditions of drought, excessive moisture, high winds, or extreme or prolonged cold. Obtain Project Manager approval before resuming operations.

3.03 MAINTENANCE

A. Maintain grassed areas minimum of 90 days, or as required to establish an acceptable lawn. For areas seeded in fall, continue maintenance following spring until acceptable lawn is established.

B. Maintain grassed areas by watering, fertilizing, weeding, and trimming.

C. Repair areas damaged by erosion by regrading, rolling and replanting.

D. Reseed small, sparse grass areas. When sparse areas exceed 20 percent of planted area, reseed by hydro mulch.

E. Mow grass when height reaches 3 1/2 inches or greater on average before final acceptance. Mow to height of 2 1/2 inches.

END OF SECTION

SECTION 02922

SODDING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Restoration of existing lawn areas disturbed by construction shall be by installation of new sod.

B. Planting of sod within areas designated on Drawings for purpose of surface stabilization, channel stabilization or vegetation buffer strips.

C. Sod is defined as blocks, squares, strips of turfgrass, and adhering soil used for vegetative planting. To be placed edge to edge for complete coverage.

D. Lawn is defined as ground covered with fine textured grass kept neatly mowed.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01576 – Waste Material Disposal

D. Section 01740 – Site Restoration

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for sodding is on square yard basis.

2. For utility construction, no separate payment will be made for sodding. Include payment in Section 01740 - Site Restoration.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

1.05 QUALITY ASSURANCE

A. Sod only when weather and soil conditions are deemed by Project Manager to be suitable for proper placement.

B. Water and fertilize new sod.

C. Guarantee sod to be growing 30 days after substantial completion.

D. Notify Project Manager 10 days before end of maintenance period for inspection.

PART 2 PRODUCTS

2.01 SOD

A. Species: Bermuda (Cynodon Dactylon), Buffalo (Buchloe Dactyloides), or St. Augustine (Stenotaphrum Secundatum) Gulf Coast variety to match existing sod.

B. Contents: 95 percent permanent grass suitable to climate in which it is to be placed; not more than 5 percent weeds and undesirable grasses; good texture, free from obnoxious grasses, roots, stones and foreign materials.

C. Size: 12 inch wide strips, uniformly 2 inches thick with clean-cut edges.

D. Sod is to be supplied and maintained in healthy condition as evidenced by grass being normal green color.

2.02 FERTILIZER

A. Available nutrient percentage by weight: 12 percent nitrogen, 4 percent phosphoric acid, and 8 percent potash; or 15 percent nitrogen, 5 percent phosphoric acid, and 10 percent potash.

2.03 WEED AND INSECT TREATMENT

A. Provide acceptable treatment to protect sod from weed and insect infestation. Submit treatment method to Project Manager for approval. Install insect and disease control within guidelines set forth by Structural Pest Control Board of the State of Texas.

2.04 WATER

A. Potable, available on-site through Contractor's water trucks. Contractor may use City of Houston hydrants when water use is measured through Contractor's meter. Do not use private resident's water.

2.05 BANK SAND

A. Free of clay lumps, roots, grass, salt or other foreign material.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify that soil placement and compaction have been satisfactorily completed. Verify that soil is within allowable range of moisture content.

B. Top soil shall be free of weeds and foreign material immediately before sodding.

C. Do not start work until conditions are satisfactory. Do not start work during inclement or impending inclement weather.

D. Rake areas to be sodded smooth, free from unsightly variations, bumps, ridges or depressions.

E. Spread 2 inch layer of bank sand over areas to be sodded prior to planting of sod.

F. Apply fertilizer at rate of 25 pounds per 1000 square feet. Apply after raking soil surface and not more than 48 hours prior to laying sod. Mix thoroughly into upper 2 inches of soil. Lightly water to aid in dissipation of fertilizer.

3.02 APPLICATION

A. Full Sodding: Lay sod with closely fitted joints leaving no voids and with ends of sod strips staggered. Lay sod within 24 hours of harvesting.

B. On slopes 2:1 and steeper, lay sod perpendicular to slope and secure every row with wooden pegs at maximum 2 feet on center. Drive pegs flush with soil portion of sod.

C. Prior to placing sod, on slopes 3:1 or where indicated, place Hold/Gro or Roll Lite or equal over topsoil. Securely anchor in place with posts sunk firmly into ground at maximum 16 feet on center along pitch of slope and equal to width of wire mesh horizontally across slopes.

D. After sod is laid, irrigate thoroughly to secure 6-inch minimum penetration into soil below sod.

E. Tamp and roll sod with approved equipment to eliminate minor irregularities and to form close contact with soil bed immediately after planting and watering. Submit type of tamping and rolling equipment to be used to Project Manager for approval, prior to construction.

3.03 MAINTENANCE

A. Maintenance Period:

1. Begin maintenance immediately after each section of grass sod is installed and continue for 30 day period from date of substantial completion.

2. Resod unacceptable areas.

3. Water, fertilize, control disease and insect pests, mow, edge, replace unacceptable materials, and perform other procedures consistent with good horticultural practice to ensure normal, vigorous and healthy growth. Install disease control within guidelines set forth by Structural Pest Control Board of the State of Texas.

B. Watering:

1. Water lawn areas once a day with minimum 1/2 inch water for first 3 weeks after area is sodded.

2. After 3 week period, water twice a week with 3/4 inch of water each time unless comparable amount has been provided by rain.

3. Make weekly inspections to determine moisture content of soil unless soil is in frozen condition.

4. Water in afternoon or at night to enable soil to absorb maximum amount of water with minimum evaporation.

C. Mowing:

1. Mow sod at intervals which will keep grass height from exceeding 3 1/2 inches.

2. Set mower blades at 2 1/2 inches.

3. Do not remove more than one-half of grass leaf surface.

4. Mow sodded areas requiring mowing within 1 month after installation with light-weight rotary type mower. Mow sod only when dry and not in saturated or soft condition.

5. Remove grass clippings during or immediately after mowing.

D. Fertilizer and Pest Control:

1. Evenly spread fertilizer composite at rate of 40 pounds per 5000 square feet or as recommended by manufacturer. Do not place fertilizer until 2 weeks after placement of sod.

2. Restore bare or thin areas by topdressing with mix of 50 percent sharp sand and 50 percent sphagnum peat moss.

3. Apply mixture 1/4 to 1/2 inch thick.

4. Treat areas of heavy weed and insect infestation as recommended by treatment manufacturer.

E. Restrict all traffic from sodded areas until sod is established or for minimum 10 days during growing season. Use wood lath and plastic tape to cordon sodded areas. Maintain tape and lath throughout for minimum 30 days during growing season.

3.04 CLEANUP

A. During course of planting, remove excess and waste materials; keep lawn areas clean and take precautions to avoid damage to existing structures, plants, grass, and streets.

B. Remove barriers, signs, and other Contractor material and equipment from project site at termination of establishment period.

C. Dispose of unused materials and rubbish in accordance with Section 01576 – Waste Material Disposal.

END OF SECTION

SECTION 02951

PAVEMENT REPAIR AND RESTORATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Repairing and replacing streets, highways, and other pavements as required per street cut ordinance that have been cut, broken, or damaged due to utility excavation.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01576 – Waste Material Disposal

C. Section 02221 – Removing Existing Pavements, Structures, Wood, and Demolition Debris

D. Section 02315 – Roadway Excavation

E. Section 2316 - Excavation and Backfill for Structures

F. Section 2317 – Excavation and Backfill for Utilities

G. Section 2318 - Extra Unit Price Work for Excavation and Backfill

H. Section 02319 – Borrow

I. Section 02330 – Embankment

J. Section 02336 – Lime Stabilized Subgrade

K. Section 02337 – Lime/Fly Ash Stabilized Subgrade

L. Section 02338 – Portland Cement Stabilized Subgrade

M. Section 02711 – Hot Mix Asphalt Base

N. Section 02712 – Cement Stabilized Base Course

O. Section 02713 – Recycled Crushed Concrete Base Course

P. Section 02741 – Asphaltic Concrete Pavement

Q. Section 02751 – Concrete Paving

R. Section 02754 – Concrete Driveways

S. Section 02771 – Curb, Curb and Gutter, and Headers

T. Section 02775 – Concrete Sidewalks

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for pavement repair and replacement for utility projects is on a square yard basis and includes surface and base materials as required per street cut ordinance.

2. Measurement for utility projects: Match actual pavement replaced but no greater than maximum pavement replacement limits in accordance with the street cut ordinance or otherwise shown on drawings.

3. Refer to Section 01270 - Measurement and Payment for other unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this section is included in total Stipulated Price.

PART 2 PRODUCTS

2.01 MATERIALS

A. Subgrade:

1. Provide backfill material as required by applicable excavation and fill sections (Sections 02315 through 02319) and Section 02330 - Embankment.

2. Provide material for stabilization as required by applicable portions of Section 02336 - Lime Stabilized Subgrade, Section 02337 - Lime/Fly-Ash Stabilized Subgrade, and Section 02338 - Portland Cement Stabilized Subgrade.

B. Base: Provide base material as required by applicable portions of Section 02711 - Hot Mix Asphaltic Base Course, Section 02712 - Cement Stabilized Base Course, and Section 02713 - Recycled Crushed Concrete Base Course.

C. Pavement: Provide paving materials as required by applicable portions of Section 02741 - Asphaltic Concrete Pavement, Section 02751- Concrete Paving, Section 02754 - Concrete Driveways, and Section 02771 - Curb, Curb and Gutter, and Headers, and Section 02775 - Concrete Sidewalks.

PART 3 EXECUTION

3.01 PREPARATION

A. Notify City prior to commencement of excavation in pavement for which an Excavation in Public Way permits has been obtained. Follow directions contained in the permit.

B. Conform to requirement of Section 02221 - Removing Existing Pavements, Structures, Wood, and Demolition Debris, for removals.

C. Saw cut pavement 18 inches wider than width of trench needed to install utilities unless otherwise indicated on Drawings.

D. When removing pavement to existing deformed metal strip (i.e. dummy joint), saw cut pavement minimum 2 inches deep on opposite side of deformed metal strip. Place saw joint far enough behind deformed metal strip to obtain continuously straight joint. Remove damaged portion of deformed metal strip as required to provide proper joint. Saw cut and remove metal strip before placement of new concrete pavement.

E. Protect edges of existing pavement to remain from damage during removals, utility placement, backfill, and paving operations. For concrete pavement, protect undisturbed subgrade that is to remain to support replacement slab.

F. Dowel in existing pavement where no reinforcement is found or is broken due to construction activities. Unless otherwise directed by Project Manager, provide No. 6 bars 24 inches long, drilled and embedded 8 inches into center of existing slab with 'PO-ROC' epoxy grout or approved equal. Space dowels to match new pavement reinforcement spacing.

G. Provide transitional paving and earthwork as required to tie proposed pavement to existing pavement when unable to dowel new pavement into existing pavement.

3.02 INSTALLATION

A. Parking Areas, Service Drives, Driveways, and Sidewalks: Replace with material equal to or better than existing or as indicated on Drawings. Conform to applicable requirements of sections referenced in Paragraph 2.01, Materials.

B. Street Pavements and Curbs, Curbs and Gutters: Replace subgrade, base, and surface course with like materials or as indicated on Drawings and City of Houston Standard Detail 02951.01. Curbs and curbs and gutters shall match existing. Conform to requirements of sections referenced in Paragraph 2.01, Materials.

C. For concrete pavement, install size and length of reinforcing steel and pavement thickness indicated on Drawings and City of Houston Standard Detail 02751.01. Place types and spacing of joints to match existing or as indicated on Drawings.

D. Where existing pavement consists of concrete pavement with asphaltic surfacing, resurface with minimum 2-inch depth asphaltic pavement.

E. Repair state highway and county crossings in accordance with TxDOT permit or county requirements as appropriate and within 1 week after utility work is installed.

3.03 WASTE MATERIAL DISPOSAL

A. Dispose of waste material in accordance with requirements of Section 01576 - Waste Material Disposal.

3.04 PROTECTION

A. Maintain pavement in good condition until completion of Work.

B. Replace pavement damaged by Contractor's operations at no cost to City.

END OF SECTION

SECTION 02960

MILLING PAVEMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Milling of existing asphalt or concrete pavement surface as required for installation of speed humps or pavement overlay.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 02741 – Asphaltic Concrete Pavement

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for removing existing pavement surface by milling is on a square yard basis. Separate pay items and measurements will be made for milling of asphalt surface or milling of concrete surface as applicable.

2. No separate payment under this section for milling associated with installation of speed humps. Payment for installation of speed humps including cost for milling of existing asphalt or concrete pavement shall be per Section 02741 - Asphaltic Concrete Pavement.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. For milling and installing of speed humps, the contractor shall use an appropriate type of milling machine to remove the existing asphalt or concrete surface as shown. The milling machine shall be capable of milling a minimum 18 inch wide path and also shall be able to turn in tight corners.

B. The teeth of the machine shall be capable of milling concrete or asphalt as appropriate. The equipment for removing the pavement surface shall be a power operated planing machine with a minimum six-foot cutting width. For detail work and for cutting widths less than six feet, equipment with less than six-foot cutting widths will be allowed. The equipment shall be self-propelled with sufficient power, traction and stability to maintain accurate depth of cut and slope. The equipment self-propelled with sufficient power, traction and stability to maintain accurate depth of cut and slope. The equipment shall be capable of cutting four inches of asphaltic concrete pavement, one inch of Portland cement concrete pavement, or a combination of two inches of asphaltic concrete pavement and one half inch Portland concrete pavement in one continuous operation.

C. The equipment shall be equipped with an approved automatic dual longitudinal grade control system and a transverse control system unless otherwise directed by the project manager. The longitudinal controls shall be capable of operating from any longitudinal grade reference, including stringline, ski, mobile stringline, or matching shoe. The transverse controls shall have an automatic system for controlling cross slope at a given rate.

D. The grade reference used by the Contractor may be of any type approved by the project manager. Control points shall be established for the finished profile. These points shall be set at intervals not to exceed 50 feet. The Contractor shall set the grade reference from the control points. The grade reference shall have sufficient support so that the maximum deflection shall not exceed 1/16 inch between supports.

E. The machine shall have a manual system providing for uniformly varying the depth of cut while the machine is in motion, thereby making it possible to cut flush to all inlets, manholes, or other obstructions within the paved area. The speed of the machine shall be variable in order to leave the desired grid pattern.

F. The machine shall be equipped with integral loading and reclaiming devices to immediately remove material being cut from the surface of the roadway and discharge the cuttings into a truck, all in one operation. The machine shall be equipped with devices to control dust created by the cutting action.

G. Various machines may be permitted to make trail runs to demonstrate the capabilities of that machine. Any machine that is incapable of meeting the requirements of this Section, in the opinion of the project manager, will not be permitted.

H. A street sweeper equipped with a water tank, spray assembly to control dust, a pick-up broom, a gutter broom, and a dirt hopper shall be provided by the Contractor. The street sweeper shall be capable of removing cuttings and debris from the planed pavement. Other sweeping equipment may be provided in lieu of the street sweeper when approved by the project manager in writing.

I. The Contractor shall provide any other equipment and personnel necessary for proper operation of the planing machine, to minimize dust and to remove cuttings.

PART 3 EXECUTION

3.01 PREPARATION

A. The Contractor shall not mill roadway more than 7 calendar days prior to construction.

B. If Contractor does not install speed hump in the specified time, the City, without notice to the Contractor, may effect repairs to the milled area and deduct the cost of the expense incurred by the City for repair work from currently due or future invoiced amounts.

3.02 MILLING

A. The existing pavement to within 1 foot of the face of the curb shall be removed for a depth of one inch or otherwise designated or shown on drawing for milling of the existing pavement.

B. The pavement surface shall be removed for the length, depth and width and to the typical section shown on drawings. The planed surface shall provide a satisfactory riding surface free from gouges, continuous longitudinal grooves, ridges, oil film and other imperfections of workmanship and shall have a uniform textured appearance.

C. When removing an asphaltic concrete pavement from an underlying Portland cement concrete pavement, all of the asphaltic concrete pavement shall be removed, leaving a uniform surface of Portland cement concrete, unless otherwise directed by the project manager.

D. Any vertical or near vertical longitudinal face exceeding 1 ¼ inches in height in the pavement surface open to traffic at the end of a work period shall be sloped a minimum of 1:1. Transverse faces that are present at the end of a work period shall be tapered in a manner acceptable to the project manager.

E. Loose Portland cement concrete material from the operation shall be disposed of at sites obtained by the Contractor or otherwise approved by the project manager. All materials removed under this contract become the property of the Contractor. Contractor shall legally dispose of all such removed materials.

F. Pavement that is not removed by the planing machine adjacent to steep curbs, inlets, manholes or other obstructions shall be removed by other methods acceptable to the project manager.

G. The pavement and curb surfaces shall be swept with a street sweeper or other sweeping equipment to remove all debris leaving a clean and presentable condition.

H. Milling is required along the outside perimeter of the hump to the depth of one inch on both concrete and asphalt pavement. Mill the existing pavement to within one foot of the curb face.

3.03 PROTECTION

A. Damage to water valve, water meters, manholes, curbs or other improvements shall be repaired or replaced at no additional cost to the City.

3.04 SURFACE TEXTURE AND TESTS

A. In areas where traffic will be permitted, the texture product shall be a grid pattern or any other pattern with discontinuous longitudinal striations that will provide, in the opinion of the project manager, a satisfactory temporary riding surface.

B. The surface of the pavement, after planing, shall be ready for HMAC overlay and shall be true to the established line, grade and cross section. The pavement surface, when tested with a 10-foot straightedge placed parallel to the centerline of the roadway or tested by other equivalent or acceptable means, shall not have any deviation greater than 1/8 inch in 10 feet. The deviations shall be measured from the top of the texture. Any point in the surface not meeting this requirement shall be corrected as directed by the project manager at the Contractor's expense.

END OF SECTION

SECTION 02983

REMOVAL AND RESTORATION OF BRICK PAVED STREETS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Brick paving work for removal and restoration of existing brick paved streets; either exposed or overlaid is directed toward preservation of historic items.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

D. Section 02317 – Excavation and Backfill for Utilities

E. Section 02321 – Cement Stabilized Sand

F. Section 02951 – Pavement Repair and Restoration

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for removal and restoration of brick paved streets is on square yard basis.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 91 - Standard Specification for Masonry Cement.

B. ASTM C 109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars.

C. ASTM C 270 - Standard Specification for Mortar for Unit Masonry.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certification from manufacturer that bricks and masonry cement meet applicable requirements of reference standards.

1.06 HANDLING AND STORAGE

A. Take extreme care when excavating in or adjacent to brick paved surface.

B. Remove bricks by hand and clean them of mortar, grout, sand or tar.

C. Protect brick at work site from theft, breakage, and damage. Store brick on site in secure, locked area.

D. Place cleaned brick on pallets and strap them for delivery to City's storage location at 812 Gillette Street. Place brick in area designated for historically sensitive items, as directed by City Employee at location. Have City Employee sign delivery ticket validating delivery, including quantity of brick stored.

PART 2 PRODUCTS

2.01 BRICK MASONRY UNITS FOR PAVING

A. Reuse existing bricks in order to restore brick paved surface to its original or better condition.

B. Replace bricks which become damaged or cracked with new paving bricks that match existing brick. Remove damaged bricks from site.

C. Provide replacement paving bricks that match existing brick in dimension, durability, and color. New paving bricks may be obtained from manufacturer which provides antique brick replicas. Antique brick may be purchased from Contractor's source.

2.02 MORTAR

A. Masonry Cement: Cement manufactured in United States and conforming to requirements of ASTM C 91.

B. Mixing Water: Clean, free from harmful amounts of acids, alkalis and organic material.

C. Type and Strength: Comply with requirements of ASTM C 270, Type M, with compressive strength of 2500 psi at 28 days.

D. Brick Foundation Base: Use cement-stabilized sand as specified in Section 02321 - Cement Stabilized Sand.

PART 3 EXECUTION

3.01 RESTORATION OF PAVEMENT FOR OVERLAID BRICK STREETS

A. The restoration of brick pavement section which is below existing overlay is not required. Replacement of pavement after completing utility work can be accomplished without replacing brick. Use paving materials matching existing to restore pavement section. Refer to Section 02951 - Pavement Repairs and Restoration.

3.02 PREPARATION FOR RESTORATION OF EXPOSED BRICK STREET

A. Ensure that subgrade to support brickwork is at proper grades and elevation. Correct improperly prepared surfaces. Before starting brick paving work, verify that work surfaces and masonry are free of dirt, grease, oil, or other harmful materials.

B. Excavate and compact backfill according to Section 02317 - Excavation and Backfill for Utilities. Place 6 inches of cement stabilized sand base to elevation of brick foundation in accordance with Section 02321 - Cement Stabilized Sand.

3.03 WEATHER REQUIREMENTS

A. Lay no masonry when temperature of outside air is below 40 degrees F, unless satisfactory means are provided to heat materials and protect work from cold and frost.

B. Maintain mortar at 40 degrees F or above and ensure that mortar will harden without freezing.

3.04 MORTAR MIXING

A. Proportion mortar ingredients by methods that will ensure accurate measure. Mix in power- driven, drum-type mixer as follows:

1. Combine 3/4 of required water and all masonry cement.

2. Mix briefly, then add water in small quantities until workability of batch is satisfactory to masons.

3. Mix for minimum of 3 minutes and completely empty drum before recharging for next batch.

B. Retemper mortar that has stiffened because of evaporation of water by adding water as frequently as needed to restore desired consistency. Use and place mortar in final position within 2 1/2 hours after initial mixing.

3.05 BRICK PLACEMENT

A. Ensure that brick foundation base is properly graded and compacted in order to match grade of surrounding existing brick pavement. Provide for proper drainage without ponding.

B. Place bricks level to create smooth and uniform surface for vehicles.

C. Where fresh masonry joins partially set or totally set masonry, clean surfaces of set masonry. Remove loose mortar and brick.

D. Wet brick to obtain best possible bond.

E. Immediately remove mortar droppings and splashing as work progresses to facilitate final cleaning.

3.06 JOINTS

A. Completely fill joints in brick and other materials with mortar as each course is laid.

B. Make joints uniform 3/8 inch wide or match existing joint width, unless otherwise shown on Drawings.

C. When mortar is "thumbprint" hard, tool exposed joints with round jointer that is slightly larger than width of mortar joint. In tooling, make sure that cracks and crevices are closed.

D. Point holes in masonry. Cut out defective joints and repoint.

3.07 FIELD QUALITY CONTROL

A. Test under provisions of Section 01454 - Testing Laboratory Services.

B. Mold minimum of one set of mortar samples for each day's placement, or as directed by Project Manager. Mold three 2 inch square cubes. Test one cube for compressive strength at 7 days and test other 2 cubes for compressive strength at 28 days in accordance with ASTM C 109.

END OF SECTION

SECTION 03315

CONCRETE FOR UTILITY CONSTRUCTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Cast-in-place concrete work for utility construction or rehabilitation, such as slabs on grade, small vaults, site-cast bases for precast units, and in-place liners for manhole rehabilitation.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 01454 – Testing Laboratory Services

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No payment will be made for concrete for utility construction under this Section. Include cost in applicable utility structure.

2. Obtain services of and pay for certified testing laboratory to prepare design mixes shall be considered incidental to the bid item for the applicable utility structure.

3. Payment for extra grade 60 reinforcing steel in place is on per pound basis.

4. Payment for extra class A concrete with or without forms is on a cubic yard basis.

5. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ACI 117 - Standard Tolerances for Concrete Construction and Materials.

B. ACI 211.1 - Standard Practice for Selecting Proportions for Normal - Density and High - Density Concrete.

C. ACI 302.1R - Guide for Concrete Floor and Slab Construction.

D. ACI 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete.

E. ACI 308.1-23 - External Curing of Cast-in-Place Concrete-Specification.

F. ACI 309R - Guide for Consolidation of Concrete.

G. ACI 311.6-18 - Specification for Testing Ready-Mixed Concrete.

H. ACI 311.7-18 - Specification for Inspection of Concrete Construction.

I. ACI 315-18 - Guide to Presenting Reinforcing Steel Design Details.

J. ACI 318 - Building Code Requirements for Reinforced Concrete and Commentary.

K. ACI 544.3-08 - Guide for Specifying, Proportioning, and Production of Fiber-Reinforced Concrete.

L. ASTM A 615 - Standard Specification for Deformed and Plain Carbon -Steel Bars for Concrete Reinforcement.

M. ASTM A 767 - Standard Specifications for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.

N. ASTM A 775 - Standard Specification for Epoxy-Coated Reinforcing Steel Bars.

O. ASTM A 820 - Standard Specification for Steel Fibers for Fiber-Reinforced Concrete.

P. ASTM A 884 - Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement.

Q. ASTM A 1064 - Standard Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.

R. ASTM C 31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.

S. ASTM C 33 - Standard Specification for Concrete Aggregates.

T. ASTM C 39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

U. ASTM C 42 - Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

V. ASTM C 94 - Standard Specification for Ready-Mixed Concrete.

W. ASTM C 138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

X. ASTM C 143 - Standard Test Method for Slump of HydraulicCement Concrete.

Y. ASTM C 150 - Standard Specification for Portland Cement.

Z. ASTM C 172 - Standard Practice for Sampling Freshly Mixed Concrete.

AA. ASTM C 173 - Standard Test Method for Air Content of Freshly Mixed Concrete by Volumetric Method.

BB. ASTM C 231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

CC. ASTM C 260 - Standard Specification for Air-Entraining Admixtures for Concrete.

DD. ASTM C 309 - Standard Specifications for Liquid Membrane-Forming Compounds for Curing Concrete.

EE. ASTM C 494 - Standard Specification for Chemical Admixtures for Concrete.

FF. ASTM C 595 - Standard Specification for Blended Hydraulic Cements.

GG. ASTM C 685 - Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing.

HH. ASTM C 1064 - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.

II. ASTM C 1077 - Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.

JJ. CPMB 100M-00 - Concrete Plant Standards of the Concrete Plant Manufacturers Bureau.

KK. CRD-C572 - Corps of Engineers Specifications For Polyvinyl Chloride Waterstops.

LL. CRSI MSP-1 - Manual of Standard Practice.

MM. CRSI - Placing Reinforcing Bars.

NN. Federal Specification SS-S-210A - Sealing Compound, Preformed Plastic, for Expansion Joints and Pipe Joints.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Submit proposed mix design and test data for each type and strength of concrete in Work.

C. Submit laboratory reports prepared by independent testing laboratory stating that materials used comply with requirements of this Section.

D. Submit manufacturer's mill certificates for reinforcing steel. Provide specimens for testing when required by Project Manager.

E. Submit certification from concrete supplier that materials and equipment used to produce and deliver concrete comply with this Specification.

F. When required on Drawings, submit shop drawings showing reinforcement type, quantity, size, length, location, spacing, bending, splicing, support, fabrication details, and other pertinent information.

G. For waterstops, submit product information sufficient to indicate compliance with this Section, including manufacturer's descriptive literature and specifications.

1.06 HANDLING AND STORAGE

A. Cement: Store cement off the ground in well-ventilated, weatherproof building.

B. Aggregate: Prevent mixture of foreign materials with aggregate and preserve gradation of aggregate.

C. Reinforcing Steel: Store reinforcing steel to protect it from mechanical injury and formation of rust. Protect epoxy-coated steel from damage to coating.

PART 2 PRODUCTS

2.01 CONCRETE MATERIALS

A. Cementitious Material:

1. Portland Cement: ASTM C 150, Type II, unless use of Type III is authorized by Project Manager; or ASTM C 595, Type IP. For concrete in contact with sewage use Type II cement.

2. When aggregates are potentially reactive with alkalis in cement, use cement not exceeding 0.6 percent alkali content in form of Na2O + 0.658K20.

B. Water: Clean, free from harmful amounts of oils, acids, alkalis, or other deleterious substances, and meeting requirements of ASTM C 94.

C. Aggregate:

1. Coarse Aggregate: ASTM C 33. Unless otherwise indicated, use following ASTM standard sizes: No. 357 or No. 467; No. 57 or No. 67, No. 7. Maximum size: Not larger than 1/5 of narrowest dimension between sides of forms, nor larger than 3/4 of minimum clear spacing between reinforcing bars.

2. Fine Aggregate: ASTM C 33.

3. Determine potential reactivity of fine and coarse aggregate in accordance with Appendix to ASTM C 33.

D. Air Entraining Admixtures: ASTM C 260.

E. Chemical Admixtures:

1. Water Reducers: ASTM C 494, Type A.

2. Water Reducing Retarders: ASTM 494, Type D.

3. High Range Water Reducers (Superplasticizers): ASTM C 494, Types F and G.

F. Prohibited Admixtures: Admixtures containing calcium chloride, thiocyanate, or materials that contribute free chloride ions in excess of 0.1 percent by weight of cement.

G. Reinforcing Steel:

1. Use new billet steel bars conforming to ASTM A 615, ASTM A 767, or ASTM A 775, grade 40 or grade 60, as shown on Drawings. Use deformed bars except where smooth bars are specified. When placed in work, keep steel free of dirt, scale, loose or flaky rust, paint, oil or other harmful materials.

2. Where shown, use welded wire fabric with wire conforming to ASTM A 1064 or ASTM A 884. Supply gauge and spacing shown, with longitudinal and transverse wires electrically welded together at points of intersection with welds strong enough not to be broken during handling or placing.

3. Wire: ASTM A 1064. Use 16 1/2 gauge minimum for tie wire, unless otherwise indicated.

H. Fiber:

1. Fibrillated Polypropylene Fiber:

a. Addition Rate: 1.5 pounds of fiber per cubic yard of concrete.

b. Physical Properties:

(1) Material: Polypropylene

(2) Length: 1/2 inch or graded

(3) Specific Gravity: 0.9l

c. Acceptable Manufacturer: W. R. Grace Company, Fibermesh, or approved equal.

2. Steel Fiber: Comply with applicable provisions of ACI 544.3-08 and ASTM A 820.

a. Ratio: 50 to 200 pounds of fiber per cubic yard of concrete.

b. Physical Properties

(1) Material: Steel

(2) Aspect Ratio (for fiber lengths of 0.5 to 2.5 inch, length divided by diameter or equivalent diameter): 30:1 to 100:1

(3) Specific Gravity: 7.8

(4) Tensile Strength: 40-400 ksi

(5) Young's Modulus: 29,000 ksi

(6) Minimum Average Tensile Strength: 50,000 psi

(7) Bending Requirements: Withstand bending around 0.125-inch diameter mandrel to angle of 90 degrees, at temperatures not less than 60 degrees F, without breaking

I. Curing Compounds: Type 2 white-pigmented liquid membrane-forming compounds conforming to ASTM C 309.

2.02 FORM WORK MATERIALS

A. Lumber and Plywood: Seasoned and of good quality, free from loose or unsound knots, knot holes, twists, shakes, decay and other imperfections which would affect strength or impair finished surface of concrete. Use S4S lumber for facing or sheathing. Forms for bottoms of caps: At least 2 inches (nominal) lumber or 3/4 inch form plywood backed adequately to prevent misalignment. For general use, provide lumber of 1inch nominal thickness or form plywood of approved thickness.

B. Form work for Exposed Concrete Indicated to Receive Rubbed Finish: Form or form-lining surfaces free of irregularities; plywood of 1/4 inch minimum thickness, preferably oiled at mill.

C. Chamfer Strips and Similar Moldings: Redwood, cypress, or pine that will not split when nailed and which can be maintained to true line. Use mill-cut molding dressed on all faces.

D. Form Ties: Metal or fiberglass of approved type with tie holes not larger than 7/8 inch in diameter. Do not use wire ties or snap ties.

E. Metal Forms: Clean and in good condition, free from dents and rust, grease, or other foreign materials that tend to disfigure or discolor concrete in gauge and condition capable of supporting concrete and construction loads without significant distortion. Countersink bolt and rivet heads on facing sides. Use only metal forms which present smooth surface and which line up properly.

2.03 PRODUCTION METHODS

A. Use either ready-mixed concrete conforming to requirements of ASTM C 94, or concrete produced by volumetric batching and continuous mixing in accordance with ASTM C 685.

2.04 MEASUREMENT OF MATERIALS

A. Measure dry materials by weight, except volumetric proportioning may be used when concrete is batched and mixed in accordance with ASTM C 685.

B. Measure water and liquid admixtures by volume.

2.05 DESIGN MIX

A. Use design mixes prepared by certified testing laboratory in accordance with ASTM C 1077 and conforming to requirements of this section.

B. Proportion concrete materials based on ACI 211.1 to comply with durability and strength requirements of ACI 318, and this specification. Prepare mix design of Class A concrete so minimum cementitious content is 564 pounds per cubic yard. Submit concrete mix designs to Project Manager for review.

C. Proportioning on basis of field experience or trial mixtures in accordance with requirements of ACI 318 may be used, when approved by Project Manager.

D. Classification:

CLASS	TYPE	MINIMUM COMPRESSIVE STRENGTH (LBS/SQ. IN.)		MAXIMUM W/C RATIO	AIR CONTENT (PERCENT)	CONSISTENCY RANGE IN SLUMP (INCHES)
		7-DAY	28-DAY			
A	Structural	3200	4000	0.45	4± 1	2 to 4*
B	Pipe Block Fill, Thrust Block	----	1500	----	4± 1	5 to 7
*When ASTM C 494, Type F or Type G admixture is used to increase workability, this range may be 6 to 9.						

E. Add steel or polypropylene fibers only when called for on Drawings or in another section of these Specifications.

F. Determine air content in accordance with ASTM C 138, ASTM C 173 or ASTM C 231.

G. Use of Concrete Classes: Use classes of concrete as indicated on Drawings and other Specifications. Use Class B for unreinforced concrete used for plugging pipes, seal slabs, thrust blocks, trench dams, tunnel inverts and concrete fill unless indicated otherwise. Use Class A for all other applications.

2.06 PVC WATERSTOPS

A. Extrude from virgin polyvinyl chloride elastomer. Use no reclaimed or scrap material. Submit waterstop manufacturer's current test reports and manufacturer's written certification that material furnished meets or exceeds Corps of Engineers Specification CRD-C572 and other specified requirements.

B. Flat Strip and Center-Bulb Waterstops:

1. Thickness: not less than 3/8 inch.

2. Acceptable Manufacturers:

a. Kirkhill Rubber Co., Brea, California

b. Water Seals, Inc., Chicago, Illinois

c. Progress Unlimited, Inc., New York, New York

d. Greenstreak Plastic Products Co., St. Louis, Missouri

e. Approved equal

2.07 RESILIENT WATERSTOP

A. Resilient Waterstop: Where shown on Drawings; either bentonite- or adhesive-type material.

B. Bentonite Waterstop:

1. Material: 75 percent bentonite, mixed with butyl rubber-hydrocarbon containing less than 1.0 percent volatile matter, and free of asbestos fibers or asphaltics.

2. Manufacturer's rated temperature ranges: For application, 5 to 125 degrees F; in service, -40 to 212 degrees F.

3. Cross-sectional dimensions, unexpanded waterstop: 1 inch by 3/4 inch.

4. Provide with adhesive backing capable of producing excellent adhesion to concrete surfaces.

C. Adhesive Waterstop:

1. Preformed plastic adhesive waterstop at least 2 inches in diameter.

2. Meets or exceeds requirements of Federal Specification SS-S-210A.

3. Supplied wrapped completely by 2 part protective paper.

4. Submit independent laboratory tests verifying that material seals joints in concrete against leakage when subjected to minimum of 30 psi water pressure for at least 72 hours.

5. Provide primer, to be used on hardened concrete surfaces, from same manufacturer who supplies waterstop material.

6. Acceptable Manufacturer: Synko-Flex Preformed Plastic Adhesive Waterstop, Synko-Flex Products, Inc.; or approved equal.

PART 3 EXECUTION

3.01 FORMS AND SHORING

A. Provide mortar-tight forms sufficient in strength to prevent bulging between supports. Set and maintain forms to lines designated such that finished dimensions of structures are within tolerances specified in ACI 117. Construct forms to permit removal without damage to concrete. Forms may be given slight draft to permit ease of removal. Provide adequate clean out openings. Before placing concrete, remove extraneous matter from within forms.

B. Install rigid shoring having no excessive settlement or deformation. Use sound timber in shoring centering. Shim to adjust and tighten shoring with hardwood timber wedges.

C. Design Loads for Horizontal Surfaces of Forms and Shoring: Minimum fluid pressure, 175 pounds per cubic foot; live load, 50 pounds per square foot. Maximum unit stresses: 125 percent of allowable stresses used for form materials and for design of support structures.

D. Back form work with sufficient number of studs and wales to prevent deflection.

E. Re-oil or lacquer liner on job before using. Facing may be constructed of 3/4 inch plywood made with waterproof adhesive backed by adequate studs and wales. In such cases, form lining will not be required.

F. Unless otherwise indicated, form outside corners and edges with triangular 3/4 inch chamfer strips (measured on sides).

G. Remove metal form ties to depth of at least 3/4 inch from surface of concrete. Do not burn off ties. Do not use pipe spreaders. Remove spreaders which are separate from forms as concrete is being placed.

H. Treat facing of forms with approved form coating before concrete is placed. When directed by Project Manager, treat both sides of face forms with coating. Apply coating before reinforcement is placed. Immediately before concrete is placed, wet surface of forms which will come in contact with concrete.

3.02 PLACING REINFORCEMENT

A. Place reinforcing steel accurately in accordance with approved Drawings. Secure steel adequately in position in forms to prevent misalignment. Maintain reinforcing steel in place using approved concrete and hot-dip galvanized metal chairs and spacers. Place reinforcing steel in accordance with CRSI Publication "Placing Reinforcing Bars." Request inspection of reinforcing steel by Project Manager and obtain acceptance before concrete is placed.

B. Minimum spacing center-to-center of parallel bars: 2 1/2 times nominal bar diameter. Minimum cover measured from surface of concrete to face of reinforcing bar unless shown otherwise on Drawings: 3 inches for surfaces cast against soil or subgrade, 2 inches for other surfaces.

C. Detail bars in accordance with ACI 315-18. Fabricate reinforcing steel in accordance with CRSI Publication MSP-1, "Manual of Standard Practice." Bend reinforcing steel to required shape while steel is cold. Excessive irregularities in bending will be cause for rejection.

D. Do not splice bars without written approval of Project Manager. Approved bar bending schedules or placing drawings constitute written approval. Splice and development length of bars shall conform to ACI 318, Chapters 7 and 12, and as shown on Drawings. Stagger splices or locate at points of low tensile stress.

3.03 EMBEDDED ITEMS

A. Install conduit and piping as shown on Drawings. Accurately locate and securely fasten conduit, piping, and other embedded items in forms.

B. Install waterstops as specified in other sections and according to manufacturer's instructions. Securely position waterstops at joints as indicated on Drawings. Protect waterstops from damage or displacement during concrete placing operations.

3.04 BATCHING, MIXING AND DELIVERY OF CONCRETE

A. Measure, batch, mix, and deliver ready-mixed concrete in accordance with ASTM C 94. Produce ready-mixed concrete using automatic batching system as described in CPMB 100M-00 - Concrete Plant Standards of the Concrete Plant Manufacturers Bureau, Part 2 - Plant Control Systems.

B. Measure, mix and deliver concrete produced by volumetric batching and continuous mixing in accordance with ASTM C 685.

C. Maintain concrete workability without segregation of material and excessive bleeding. Obtain approval of Project Manager before adjustment and change of mix proportions.

D. Ready-mixed concrete delivered to site shall be accompanied by batch tickets providing information required by ASTM C 94. Concrete produced by continuous mixing shall be accompanied by batch tickets providing information required by ASTM C 685.

E. When adverse weather conditions affect quality of concrete, postpone concrete placement. Do not mix concrete when air temperature is at or below 40 degrees F and falling. Concrete may be mixed when temperature is 35 degrees F and rising. Take temperature readings in shade, away from artificial heat. Protect concrete from temperatures below 32 degrees F until concrete has cured for minimum of 3 days at 70 degrees F or 5 days at 50 degrees F.

F. Clean, maintain and operate equipment so that it thoroughly mixes material as required.

G. Hand-mix only when approved by Project Manager.

3.05 PLACING CONCRETE

A. Give sufficient advance notice to Project Manager (at least 24 hours prior to commencement of operations) to permit inspection of forms, reinforcing steel, embedded items and other preparations for placing concrete. Place no concrete prior to Project Manager's approval.

B. Schedule concrete placing to permit completion of finishing operations in daylight hours. However, when necessary to continue after daylight hours, light site as required. When rainfall occurs after placing operations are started, provide covering to protect work.

C. Use troughs, pipes and chutes lined with approved metal or synthetic material in placing concrete so that concrete ingredients are not separated. Keep chutes, troughs and pipes clean and free from coatings of hardened concrete. Allow no aluminum material to be in contact with concrete.

D. Limit free fall of concrete to 4 feet. Do not deposit large quantities of concrete at one location so that running or working concrete along forms is required. Do not jar forms after concrete has taken initial set; do not place strain on projecting reinforcement or anchor bolts.

E. Use tremies for placing concrete in walls and similar narrow or restricted locations. Use tremies made in sections, or provide in several lengths, so that outlet may be adjusted to proper height during placing operations.

F. Place concrete in continuous horizontal layers approximately 12 inches thick. Place each layer while layer below is still plastic.

G. Compact each layer of concrete with concrete spading implements and mechanical vibrators of approved type and adequate number for size of placement. When immersion vibrators cannot be used, use form vibrators. Apply vibrators to concrete immediately after depositing. Move vibrator vertically through layer of concrete just placed and several inches into plastic layer below. Do not penetrate or disturb layers previously placed which have partially set. Do not use vibrators to aid lateral flow concrete. Closely supervise consolidation to ensure uniform insertion and duration of immersion.

H. Handling and Placing Concrete: Conform to ACI 302.1R, ACI 304R and ACI 309R.

3.06 WATERSTOPS

A. Embed waterstops in concrete across joints as shown. Waterstops shall be continuous for extent of joint; make splices necessary to provide continuity in accordance with manufacturer's instructions. Support and protect waterstops during construction operations; repair or replace waterstops damaged during construction.

B. Install waterstops in concrete on one side of joints, leaving other side exposed until next pour. When waterstop will remain exposed for 2 days or more, shade and protect exposed waterstop from direct rays of sun during entire exposure and until exposed portion of waterstop is embedded in concrete.

C. Splicing PVC Waterstops:

1. Splice waterstops by heat-sealing adjacent waterstop sections in accordance with manufacturer’s printed instructions.

2. Butt end-to-end joints of two identical waterstop sections may be made in forms during placement of waterstop material.

3. Prior to placement in form work, prefabricate waterstop joints involving more than two ends to be joined together, angle cut, alignment change, or joining of two dissimilar waterstop sections, allowing not less than 24 inches long strips of waterstop material beyond joint. Upon inspection and approval by Project Manager, install prefabricated waterstop joint assemblies in form work, and butt-weld ends of 24 inches strips to straight- run portions of waterstop in forms.

D. Setting PVC Waterstops:

1. Correctly position waterstops during installation. Support and anchor waterstops during progress of work to ensure proper embedment in concrete and to prevent folding over of waterstop by concrete placement. Locate symmetrical halves of waterstops equally between concrete pours at joints, with center axis coincident with joint openings. Thoroughly work concrete in joint vicinity for maximum density and imperviousness.

2. Where waterstop in a vertical wall joint does not connect with any other waterstop, and is not intended to be connected to waterstop in future concrete placement, terminate waterstop 6 inches below top of wall.

E. Replacement of Defective Field Joints: Replace waterstop field joints showing evidence of misalignment, offset, porosity, cracks, bubbles, inadequate bond or other defects with products and joints complying with Specifications.

F. Resilient Waterstop:

1. Install resilient waterstop in accordance with manufacturer's instructions and recommendations.

2. When requested by Project Manager, provide technical assistance by manufacturer's representative in field at no additional cost to City.

3. Use resilient waterstop only where complete confinement by concrete is provided; do not use in expansion or contraction joints.

4. Where resilient waterstop is used in combination with PVC waterstop, lap resilient waterstop over PVC waterstop minimum of 6 inches and place in contact with PVC waterstop. Where crossing PVC at right angles, melt PVC ribs to form smooth joining surface.

5. At free top of walls without connecting slabs, stop resilient waterstop and grooves (where used) 6 inches from top in vertical wall joints.

6. Bentonite Waterstop:

a. Locate bentonite waterstop as near as possible to center of joint and extend continuous around entire joint. Minimum distance from edge of waterstop to face of member: 5 inches.

b. Where thickness of concrete member to be placed on bentonite waterstop is less than 12 inches, place waterstop in grooves at least 3/4 inch deep and 1 1/4 inches wide formed or ground into concrete. Minimum distance from edge of waterstop placed in groove to face of member: 2.5 inches.

c. Do not place bentonite waterstop when waterstop material temperature is below 40 degrees F. Waterstop material may be warmed so that it remains above 40 degrees F during placement but means used to warm it shall in no way harm material or its properties. Do not install waterstop where air temperature falls outside manufacturer's recommended range.

d. Place bentonite waterstop only on smooth and uniform surfaces; grind concrete smooth when necessary to produce satisfactory substrate, or bond waterstop to irregular surfaces using epoxy grout which completely fills voids and irregularities beneath waterstop material. Prior to installation, wire brush concrete surface to remove laitance and other substances that may interfere with bonding of epoxy.

e. In addition to adhesive backing provided with waterstop, secure bentonite waterstop in place with concrete nails and washers at 12 inches maximum spacing.

7. Adhesive Waterstop:

a. With wire brush thoroughly clean concrete surface on which waterstop is to be placed and then coat with primer.

b. If surface is too rough to allow waterstop to form complete contact, grind to form adequately smooth surface.

c. Install waterstop with top protective paper left in place. Overlap joints between strips minimum of 1 inch and cover back over with protective paper.

d. Do not remove protective paper until just before final form work completion. Place concrete immediately. time that waterstop material is uncovered prior to concrete placement shall be minimized and shall not exceed 24 hours.

3.07 CONSTRUCTION JOINTS

A. Definitions:

1. Construction joint: Contact surface between plastic (fresh) concrete and concrete that has attained initial set.

2. Monolithic: Manner of concrete placement to reduce or eliminate construction joints; joints other than those indicated on Drawings will not be permitted without written approval of Project Manager. Where so approved, make additional construction joints with details equivalent to those indicated for joints in similar locations.

3. Preparation for Construction Joints: Roughen surface of concrete previously placed, leaving some aggregate particles exposed. Remove laitance and loose materials by sandblasting or high-pressure water blasting. Keep surface wet for several hours prior to placing of plastic concrete.

3.08 CURING

A. Comply with ACI 308.1-23. Cure by preventing loss of moisture, rapid temperature change and mechanical injury for period of 7 curing days when Type II or IP cement has been used and for 3 curing days when Type III cement has been used. Start curing as soon as free water has disappeared from concrete surface after placing and finishing. A curing day is any calendar day in which temperature is above 50 degrees F for at least 19 hours. Colder days may be counted when air temperature adjacent to concrete is maintained above 50 degrees F. In continued cold weather, when artificial heat is not provided, removal of forms and shoring may be permitted at end of calendar days equal to twice required number of curing days. However, leave soffit forms and shores in place until concrete has reached specified 28-day strength, unless directed otherwise by Project Manager.

B. Cure formed surfaces not requiring rubbed-finished surface by leaving forms in place for full curing period. Keep wood forms wet during curing period. Add water as needed for other types of forms. Or, at Contractor's option, forms may be removed after 2 days and curing compound applied.

C. Rubbed Finish:

1. At formed surfaces requiring rubbed finish, remove forms as soon as practicable without damaging surface.

2. After rubbed-finish operations are complete, continue curing formed surfaces by using either approved curing/sealing compounds or moist cotton mats until normal curing period is complete.

D. Unformed Surfaces: Cure by membrane curing compound method.

1. After concrete has received final finish and surplus water sheen has disappeared, immediately seal surface with uniform coating of approved curing compound, applied at rate of coverage recommended by manufacturer or as directed by Project Manager. Do not apply less than 1 gallon per 180 square feet of area. Provide satisfactory means to properly control and check rate of application of compound.

2. Thoroughly agitate compound during use and apply by means of approved mechanical power pressure sprayers equipped with atomizing nozzles. For application on small miscellaneous items, hand-powered spray equipment may be used. Prevent loss of compound between nozzle and concrete surface during spraying operations.

3. Do not apply compound to dry surface. When concrete surface has become dry, thoroughly moisten surface immediately prior to application. At locations where coating shows discontinuities, pinholes or other defects, or when rain falls on newly coated surface before film has dried sufficiently to resist damage, apply additional coat of compound at specified rate of coverage.

3.09 REMOVAL OF FORMS AND SHORING

A. Remove forms from surfaces requiring rubbing only as rapidly as rubbing operation progresses. Remove forms from vertical surfaces not requiring rubbed-finish when concrete has aged for required number of curing days. When curing compound is used, do not remove forms before 2 days after concrete placement.

B. Leave soffit forms and shores in place until concrete has reached specified 28-day strength, unless directed otherwise by Project Manager.

3.10 DEFECTIVE WORK

A. Immediately repair defective work discovered after forms have been removed. When concrete surface is bulged, uneven, or shows excess honeycombing or form marks which cannot be repaired satisfactorily through patching, remove and replace entire section.

3.11 FINISHING

A. Patch honeycomb, minor defects and form tie holes in concrete surfaces with cement mortar mixed one part cement to two parts fine aggregate. Repair defects by cutting out unsatisfactory material and replacing with new concrete, securely keyed and bonded to existing concrete. Finish to make junctures between patches and existing concrete as inconspicuous as possible. Use stiff mixture and thoroughly tamp into place. After each patch has stiffened sufficiently to allow for greatest portion of shrinkage, strike off mortar flush with surface.

B. Apply rubbed finish to exposed surfaces of formed concrete structures as noted on Drawings. After pointing has set sufficiently, wet surface with brush and perform first surface rubbing with No. 16 carborundum stone, or approved equal. Rub sufficiently to bring surface to paste, to remove form marks and projections, and to produce smooth, dense surface. Add cement to form surface paste as necessary. Spread or brush material, which has been ground to paste, uniformly over surface and allow to reset. In preparation for final acceptance, clean surfaces and perform final finish rubbing with No. 30 carborundum stone or approved equal. After rubbing, allow paste on surface to reset; then wash surface with clean water. Leave structure with clean, neat and uniform-appearing finish.

C. Apply wood float finish to concrete slabs.

3.12 FIELD QUALITY CONTROL

A. Testing shall be performed under provisions of Section 01454 - Testing Laboratory Services.

B. Unless otherwise directed by Project Manager, following minimum testing of concrete is required. Testing shall be performed by qualified individuals employed by approved independent testing agency, and conform to requirements of ASTM C 1077.

1. Take concrete samples in accordance with ASTM C 172.

2. Make one set of four compression test specimens for each mix design at least once per day and for each 150 cubic yards or fraction thereof. Make, cure and test specimens in accordance with ASTM C 31 and ASTM C 39.

3. When taking compression test specimens, test each sample for slump according to ASTM C 143, for temperature according to ASTM C 1064, for air content according to ASTM C 231, and for unit weight according to ASTM C 138.

4. Inspect, sample and test concrete in accordance with ASTM C 94, Section 13, 14, and 15, and ACI 311.6-18 and ACI 311.7-18.

C. Test Cores: Conform to ASTM C 42.

D. Testing High Early Strength Concrete: When Type III cement is used in concrete, specified 7-day and 28-day compressive strengths shall be applicable at 3 and 7 days, respectively.

E. If 7-day or 3-day test strengths (as applicable for type of cement being used) fail to meet established strength requirements, extended curing or resumed curing on those portions of structure represented by test specimens may be required. When additional curing fails to produce required strength, strengthening or replacement of portions of structure which fail to develop required strength may be required by Project Manager, at no additional cost to City.

3.13 PROTECTION

A. Protect concrete against damage until final acceptance by City.

B. Protect fresh concrete from damage due to rain, hail, sleet, or snow. Provide protection while concrete is still plastic, and whenever precipitation is imminent or occurring.

C. Do not backfill around concrete structures or subject them to design loadings until components of structure needed to resist loading are complete and have reached specified 28-day compressive strength, except as authorized otherwise by Project Manager.

END OF SECTION

SECTION 04061

MORTAR

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Mortar and grout for masonry.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01292 – Schedule of Values

C. Section 01330 – Submittal Procedures

D. Section 01450 – Contractor's Quality Control

E. Section 01454 – Testing Laboratory Services

F. Section 01610 – Basic Product Requirements

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for mortar under this Section. Include payment in Lump Sum for building or structure with price breakdown included in Schedule of Values.

2. Refer to Section 01270 - Measurement and Payment and Section 01292- Schedule of Values.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 REFERENCES

A. ASTM C 143 - Standard Testing Method for Slump of Hydraulic Cement Concrete.

B. ASTM C 144 - Standard Specification for Aggregate for Masonry Mortar.

C. ASTM C 150 - Standard Specification for Portland Cement.

D. ASTM C 207 - Standard Specification for Hydrated Lime for Masonry Purposes.

E. ASTM C 270 - Standard Specification for Mortar for Unit Masonry.

F. ASTM C 404 - Standard Specification for Aggregates for Masonry Grout.

G. ASTM C 476 - Standard Specification for Grout for Masonry.

H. ASTM C 780 - Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry.

I. ASTM C 109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars.

1.05 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Include design mix, indicate Property Method used, required environmental conditions, and admixture limitations.

C. Samples: Submit two ribbons of each mortar color, illustrating color and color range.

D. Submit test reports under provisions of Section 01450 - Contractor's Quality Control.

E. Submit test reports on mortar indicating conformance to ASTM C 270.

F. Submit test reports on grout indicating conformance to ASTM C 476.

G. Submit manufacturer's certificate under provisions of Section 01450 - Contractor's Quality Control, that products meet or exceed specified requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site and store and protect products under provisions of Section 01610 - Basic Product Requirements.

B. Maintain packaged materials clean, dry, and protected against dampness, freezing, and foreign matter.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Maintain materials and surrounding air temperatures to minimum 50 degrees F prior to, during, and 48 hours after completion of masonry work.

PART 2 PRODUCTS

2.01 MATERIALS

A. Portland Cement: ASTM C 150, Type I, white color.

B. Masonry Cement: Not permitted.

C. Mortar Aggregate: ASTM C 144, standard masonry type. Grading and color suitable for type of masonry, one source for entire project. (Not less than 5 percent shall pass No. 100 sieve).

D. Hydrated Lime: ASTM C 207, Type S.

E. Grout Aggregate: ASTM C 404.

F. Water: Clean and potable.

2.02 MORTAR COLOR

A. Mortar Color: Mineral oxide pigment; color; to be selected by Project Manager from manufacturer's samples.

2.03 ADMIXTURES

A. Antifreeze: Antifreeze admixtures will not be permitted.

B. Accelerator: Accelerator may be used only with approval of Project Manager.

2.04 MORTAR

A. Mortar for Load Bearing Walls and Partitions: ASTM C 270, Type S utilizing Property Method to achieve 1800 psi strength.

B. Mortar for Non-load Bearing Walls and Partitions: ASTM C 270, Type S utilizing the Property Method to achieve 1800 psi strength.

C. Mortar for Masonry Below Grade or in Contact with Earth: ASTM C 270, Type M utilizing the Property Method to achieve 2500 psi strength.

D. Pointing Mortar: ASTM C 270, Type N, using the Property Method to achieve 750 psi strength.

2.05 MORTAR MIXING

A. Thoroughly mix mortar ingredients in quantities needed for immediate use in accordance with ASTM C 270 to achieve strengths noted in Paragraph 2.04.

B. Add mortar color and admixtures in accordance with manufacturer's instructions. Provide uniformity of mix and coloration.

C. Do not use anti-freeze compounds to lower freezing point of mortar.

D. If water is lost by evaporation, retemper only within 2 hours of mixing.

E. Use mortar within 2 hours after mixing at temperatures of 80 degrees F, or 2 1/2 hours at temperatures under 50 degrees F.

2.06 GROUT

A. Bond Beams, Lintels, and Other Areas to be Grouted Solid: 3000 psi strength at 28 days; 7 to 8 inches slump per ASTM C 143; mixed in accordance with ASTM C 476, Fine Grout.

2.07 GROUT MIXING

A. Thoroughly mix mortar ingredients in quantities needed for immediate use in accordance with ASTM C 476, Fine Grout.

B. Add admixtures in accordance with manufacturer's instructions. Provide uniformity of mix.

C. Do not use anti-freeze compounds to lower freezing point of grout.

2.08 MIX TESTS

A. Test mortar and grout in accordance with Section 01454 - Testing Laboratory Services.

B. Testing of Mortar Mix: Test in accordance with ASTM C 780. Test mortar mix for compressive strength, consistency, mortar aggregate ratio, water content, air content, and splitting tensile strength.

C. Testing of Grout Mix: Test in accordance with ASTM C 109. Test grout mix for compressive strength and slump.

PART 3 EXECUTION

3.01 EXAMINATION

A. Request inspection of spaces to be grouted.

3.02 PREPARATION

A. Apply bonding agent to existing concrete surfaces.

B. Plug clean out holes with masonry units to prevent leakage of grout materials. Brace masonry for wet grout pressure.

3.03 INSTALLATION

A. Install mortar and grout in accordance with manufacturer's instructions.

B. Work grout into masonry cores and cavities to eliminate voids.

C. Do not displace reinforcement while placing grout.

D. Remove grout spaces of excess mortar.

END OF SECTION

SECTION 04210

BRICK MASONRY FOR UTILITY CONSTRUCTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Brick masonry work in utility construction for permanent or temporary installation of below ground structures.

B. Brick masonry in repair and rehabilitation of utility lines and associated structures.

1.02 RELATED SECTIONS

A. Section 01330 – Submittal Procedures

B. Section 01454 – Testing Laboratory Services

C. Section 02085 – Valve Boxes, Meter Boxes, and Meter Vaults

D. Section 02086 – Adjusting Manholes, Inlets, and Valve Boxes to Grade

E. Section 02087 – Brick Manholes for Storm Sewer

F. Section 02555 – Manhole Rehabilitation

G. Section 02632 – Cast-In-Pace Inlets, Headwalls, and Wingwalls

H. Section 04061 – Mortar

1.03 UNIT PRICES

A. No payment will be made for brick masonry under this Section unless specifically noted in bid documents. Include payment in unit price for applicable utility structure section.

1.04 REFERENCES

A. ASTM C 32 - Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale).

B. ASTM C 55 - Standard Specification for Concrete Building Brick.

C. ASTM C 62 – Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale).

D. ASTM C 67 - Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile.

E. ASTM C 91 – Standard Specification for Masonry Cement.

F. ASTM C 109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens).

G. ASTM C 140 - Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.

H. ASTM C 270 - Standard Specification for Mortar for Unit Masonry.

1.05 SUBMITTALS

A. Submittals shall conform to requirements of Section 01330 - Submittal Procedures.

B. Submit certification from the manufacturer that brick units meet applicable requirements of reference standards.

C. As an alternate to providing certification, submit test results that show brick units meet applicable requirements of reference standards, when tested by an approved independent testing laboratory. Test result submittals shall be at no cost to the City.

1.06 HANDLING AND STORAGE

A. Handle and store brick to prevent damage.

B. Store brick and mortar mix off the ground and in a dry place. Cover mortar mix to protect from weather.

PART 2 PRODUCTS

2.01 CLAY AND SHALE BRICK MASONRY UNITS

A. Manholes and Structures: Use brick units made from clay or shale conforming to requirements of ASTM C 32, Grade MM, either cored or solid. Units shall have the following physical properties:

1. Compressive Strength: 2200 psi minimum for individual brick; 2500 psi average for five bricks.

2. Size: 2-1/4" by 7-5/8" by 3-5/8".

3. Test Procedure: ASTM C 67.

B. Sewer Brick: Use brick units made from clay or shale conforming to requirements of ASTM C 32, Grade SM, either cored or solid. Units shall have the following physical properties:

1. Compressive Strength: 3750 psi minimum for individual brick; 5000 psi average for 5 bricks.

2. Size: 2-1/4" by 7-5/8" by 3-5/8".

3. Test Procedure: ASTM C 67.

2.02 CONCRETE BRICK MASONRY UNITS

A. Manholes and Structures: Conform to requirements of ASTM C 55, grade S-1.

B. Dimensions: 2-1/4" by 7-5/8" by 3-5/8".

2.03 MORTAR

A. Provided mortar conforming to the requirements of Section 04061 - Mortar.

PART 3 EXECUTION

3.01 EXAMINATION

A. Ensure that foundations and other surfaces to support brickwork are at proper grades and elevations. Correct improperly prepared surfaces. Work surfaces and masonry shall be free of dirt, grease, oil, or other harmful materials before starting brick masonry work.

3.02 WEATHER REQUIREMENTS

A. Lay no masonry when temperature of outside air is below 50 F, unless satisfactory means are provided to heat materials and protect work from cold and frost.

B. Maintain mortar at 50 F or above and ensure that mortar will harden without freezing.

3.03 BRICK PLACEMENT

A. Use sewer brick where exposed to flow. Where not exposed to flow, use manhole brick.

B. Lay sewer brick with the 2-1/4" by 7-5/8" side exposed to flow.

C. Lay manhole bricks so that in every fifth course the long axis of bricks are perpendicular to the long axis of the four preceding courses.

D. Lay curved courses, and courses in different planes, using bonded and keyed construction.

E. Lay brick plumb and true with courses level and uniformly spaced. Adjust the bond of face brick so that no course will terminate with a piece less than one-half length of brick.

F. Dampen brick prior to placement.

G. Where fresh masonry joins partially set or totally set masonry, clean surfaces of set masonry. Remove loose mortar and brick. Wet brick to obtain the best possible bond.

H. Immediately remove mortar droppings and splashing as work progresses to facilitate final cleaning.

3.04 JOINTS

A. Completely fill joints in brick and other materials with mortar as each course is laid.

B. Make joints in exposed brickwork a uniform 3/8-inch wide, unless otherwise shown on Drawings.

C. When mortar is "thumbprint" hard, tool exposed joints with a round or other suitable jointer that is slightly larger than width of the mortar joint. In tooling, make sure that cracks and crevices are closed.

D. Point holes in exposed masonry. Cut out defective joints and repoint.

3.05 FIELD QUALITY CONTROL

A. Testing will be performed under provisions of Section 01454 - Testing Laboratory Services.

B. A minimum of one set of mortar samples shall be molded for each day's placement as directed by Project Manager. Mold three 2-inch cube specimens. One cube will be tested for compressive strength at 7 days and 2 cubes will be tested for compressive strength at 28 days in accordance with ASTM C 109.

C. Each load of bricks delivered to the jobsite shall be tested.

1. Test clay bricks in accordance with ASTM C 67.

2. Test concrete bricks in accordance with ASTM C 140.

END OF SECTION

THE FOLLOWING ITEMS SHOULD BE CHECKED FOR COORDINATION DURING DESIGN:

****
A. Coordinate this specification with other related specifications including the following related Sections.
****

RELATED SECTIONS
Section 02087 - Brick Manholes for Storm Sewers.
Section 02632 - Cast-in-Place Inlets, Headwalls, and Wingwalls.
Section 02085 - Valve Boxes, Meter Boxes, and Meter Vaults.
Section 02086 - Adjusting Manholes, Inlets, and Valve Boxes to Grade.
Section 02555 - Manhole Rehabilitation.

SECTION 05501

METAL FABRICATIONS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Bolts, anchors, nuts, sleeves, concrete anchors, scheduled items, and other miscellaneous metal items not specifically included under other sections of these specifications.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. No separate payment will be made for metal fabrications under this section. Include payment as part of the Work in appropriate sections.

2. Refer to Section 01270 - Measurement and Payment.

B. Stipulated Price (Lump Sum). If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.04 REFERENCES

A. ASTM A 36 - Standard Specification for Carbon Structural Steel.

B. ASTM A 53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

C. ASTM A 123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

D. ASTM A 153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

E. ASTM A 276 - Standard Specification for Stainless Steel Bars and Shapes.

F. ASTM A 307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength.

G. ASTM A 500 - Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Round and Shapes.

H. ASTM A 501 - Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.

I. ASTM F 593 - Stainless Steel Bolts, Hex Cap Screws, and Studs.

J. ASTM F 594 - Stainless Steel Nuts.

K. AWS A 2.0 - Standard Welding Symbols.

L. AWS D 1.1 - Structural Welding Code.

M. SSPC-SP-2 Hand Tool Cleaning

1.05 SUBMITTALS

A. Submit following Section 01330 - Submittal Procedures.

B. Shop Drawings: Indicate profiles, sizes, thickness, grade class, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories. Include erection drawings, elevations, and details where applicable.

C. Indicate welded connections using standard AWS A 2.0 welding symbols. Indicate net weld lengths.

D. Submit manufacturer’s technical literature and test reports showing certified capacities for concrete anchors.

E. When foreign manufactured material is proposed for use, test material for conformance to ASTM Standards by a certified independent testing laboratory located in the United States. Certification from any other source outside the United States is unacceptable. Furnish copies of test reports to Project Manager for review. Do not begin fabrication until material has been approved. No additional payment will be made for this testing.

1.06 QUALIFICATIONS

A. Prepare shop drawings under direct supervision of a professional Structural Engineer experienced in design of this work and licensed in the State of Texas.

B. Welders' Certificates: Submit following Section 01330 - Submittal Procedures, certifying welders employed on the Work, verifying AWS D1.1, Structural Welding Code, using procedures, materials and equipment of type required for this work. Welder must have been qualified or re-certified within the previous 12 months of date welding is being performed.

1.07 FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on Drawings.

1.08 DELIVERY AND STORAGE

A. Materials stored at project site: Store above ground on platforms, skids, or other supports. Keep free of dirt, mud, grease, or oil. Protect from corrosion.

PART 2 PRODUCTS

2.01 MATERIALS

A. Steel Shapes and Plate: ASTM A 36.

B. Stainless Steel Sections: ASTM A 276, Type 316 for non-welded items and Type 316L for welded items.

C. Steel Tubing: ASTM A 500 or ASTM A 501, Grade B.

D. Pipe: ASTM A 53, Grade B Schedule 40.

E. Bolts, Nuts, and Washers: ASTM A 307 galvanized to ASTM A 153 for galvanized components. Provide anchor bolts for all equipment and machinery when anchor bolts are not furnished by manufacturer. Conform anchor size, length, projection, etc., to requirements of equipment and machinery manufacturer. Provide templates to accurately position anchor bolts in forms.

F. Stainless Steel Bolts and Nuts: Bolts in accordance with ASTM F 593, Type 316; nuts in accordance with ASTM F 594, Type 316; UNC coarse threads.

G. Concrete Anchors: Concrete anchors are inserted into holes drilled in hardened concrete. Use one of the following types:

1. Adhesive Anchors: For concrete anchors which are submerged, in splash zones, in enclosed spaces over liquids, or anchoring vibrating equipment, use epoxy adhesive anchors. Adhesive anchors may be used at all locations where concrete anchors are required. Epoxy systems shall be Sika/FI System with Sikadur Injection Gel Epoxy, Master Builders Concresive Epoxy Cartridge Dispensing System and Concresive Paste LPL, or equal. Threaded rods shall be ASTM F 593, Type 316 studs. Where adhesive anchors, or connected metal, are exposed to direct sunlight, the anchors shall be certified to maintain at least 90 percent of their rated strength (tested at 73 F) when tested at 160 F.

2. Expansion Anchors: Where concrete anchors are indicated and adhesive anchors are not required, wedge type anchors made with ASTM A 276, Type 316 Stainless Steel shall be used. Anchors shall be KWIK Bolt II By Hilti, Inc., or equal.

H. Welding Materials: AWS D 1.1; type required for materials being welded.

I. Shop and Touch-Up Primer: Same manufacturer as protective coating; compatible with protective coating; applied in accordance with manufacturer’s recommendation.

2.02 FABRICATION

A. Fit and shop-assemble in largest practical sections for delivery to site.

B. Fabricate items with joints tightly fitted and secured. Weld all shop connections except where welding is not practical, or unless otherwise shown on Drawings. Where screw bolts cannot be avoided, conceal fasteners where possible or countersink heads, screw up tight and nick threads to prevent loosening. Weld joints continuously except as shown on Drawings.

C. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints butt tight, flush, and hairline. Ease exposed edges to small uniform radius.

D. Exposed Mechanical Fastenings: Flush countersunk screws or bolts; unobtrusively located; consistent with design of component, except where specifically noted otherwise.

E. Supply components required for anchorage of fabrications. Fabricate anchors and related components of same material and finish as fabrication, except where specifically noted otherwise.

F. Welding shall conform to requirements of AWS D1.1, Structural Welding Code – Steel. Perform welding not governed by above in accordance with best modern practice for strength and durability.

2.03 FINISHES

A. Prepare surfaces to be primed in accordance with SSPC SP-2.

B. Do not prime surfaces in direct contact with concrete or where field welding is required.

C. Galvanize, after completion of welded fabrication, in accordance with ASTM A 123, structural steel members. Provide minimum 1.25 ounces per square foot galvanized coating.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that field conditions are acceptable and ready to receive work.

B. Beginning of installation means erector accepts existing conditions.

3.02 PREPARATION

A. Clean and strip primed steel items to bare metal where site welding is required.

B. Supply items required to be cast into concrete or embedded in masonry with setting templates, to appropriate sections.

C. Coat stainless steel threads with an anti-seizing compound prior to installing nuts.

3.03 INSTALLATION

A. Install items plumb and level, accurately fitted, free from distortion or defects.

B. Allow for erection loads, and for sufficient temporary bracing to maintain true alignment until completion of erection and installation of permanent attachments.

C. Field weld components indicated on shop drawings.

D. Perform field welding in accordance with AWS D 1.1.

E. Obtain Project Manager approval prior to cutting or making adjustments in the field.

F. After erection, prime welds, abrasions, and surfaces not shop primed except surfaces to be in contact with concrete.

3.04 ERECTION TOLERANCES

A. Maximum Variation from Plumb: 1/4-inch per story, non-cumulative.

B. Maximum Offset from True Alignment: 1/4-inch.

3.05 COATING REPAIRS

A. Thoroughly clean field welds, abrasions, and damaged or defective areas of galvanized surfaces to remove all loose, cracked or bruised splatter coating. After surface is prepared, for galvanized surfaces apply two coats of galvanizing repair coating, as approved by Project Manager. Repair other coated surfaces in accordance with manufacturer's recommendations, unless otherwise specified.

END OF SECTION

SECTION 09901

PROTECTIVE COATINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Preparing surfaces, providing adequate conditions for proper workmanship, and furnishing and applying the protective coating materials required for metallic, concrete, masonry and plastic surfaces.

B. Color code painting of piping and piping identification signs and markers.

C. Refer to Section 09900 – Painting for Decorative and Protective Coatings to be used on Interior and Exterior Architectural Surfaces, such as wood, gypsum board and masonry.

D. Refer to Section 09971 – Painting and Protective Coatings for Potable Water Storage Tanks for painting and protective coatings to be used on potable water storage tanks.

1.02 RELATED SECTIONS

A. Document 00410 – Bid Form

B. Document 00700 – General Conditions

C. Section 01270 – Measurement and Payment

D. Section 01330 – Submittal Procedures

E. Section 01630 – Product Substitution Procedures

F. Section 09900 – Painting for Decorative and Protective Coatings

G. Section 09971 – Painting and Protective Coatings for Potable Water Storage Tanks

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. No separate payment will be made for protective coatings unless specifically listed in Document 00410 – Bid Form. Include payment for protective coatings in unit prices for items to which coatings are applied.

2. Measurement for protective coatings, when included as a separate pay item, is on a square-foot basis for completed protective coating systems.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ANSI A13.1 – Color Schedule

B. ANSI/AWWA C213 – Fusion-bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines

C. ASTM D 412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.

D. ASTM D 624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.

E. ASTM D 638 - Standard Test Method for Tensile Properties of Plastics.

F. ASTM D 695 - Standard Test Method for Compressive Properties of Rigid Plastics.

G. ASTM D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

H. ASTM D 2240 - Standard Test Method for Rubber Property—Durometer Hardness.

I. ASTM D 2990 - Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics.

J. ASTM D 3960 - Standard Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings.

K. ASTM D 7234 - Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.

L. ASTM G 20 - Standard Test Method for Chemical Resistance of Pipeline Coatings.

M. Federal Specification TT-P-28 – Paint, Aluminum, Heat Resisting 1200 degrees F

N. Federal Standard 595A – Federal Standard Colors

O. Military Specification DOD-P-23236 – Paint Coating Systems, Steel Ship Tank, Fuel and Salt Water Ballast, Class 2

P. NSF Standard 61 – Drinking Water System Components – Health Effects

Q. SSPC-PA 1 – Paint Application Specification No. 1 - Shop, Field and Maintenance Painting

R. SSPC-PA 2 – Paint Application Specification No. 2 – Measurement of Dry Paint Thickness with Magnetic Gages

S. SSPC-Paint 16 – Coal Tar Epoxy-Polyamide Black (or Dark Red) Paint

T. SSPC-SP 1 – Solvent Cleaning

U. SSPC-SP 2 – Hand Tool Cleaning

V. SSPC-SP 3 – Power Tool Cleaning

W. SSPC-SP 5/NACE 1 – White Metal Blast Cleaning

X. SSPC-SP 6/ NACE 3 – Commercial Blast Cleaning

Y. SSPC-SP 7/NACE 4 - Brush-Off Blast Cleaning

Z. SSPC-SP 10/NACE 2 – Near White Metal Blast Cleaning

AA. SSPC-SP 11 – Power Tool Cleaning to Bare Metal

BB. SSPC-VIS 1-89 – Visual Standard for Abrasive Blast Cleaned Steel

CC. SSPC-VIS 3 – Visual Standard for Power-and Hand-Tool Cleaned Steel

DD. SSPC-QP 1 – Standard Procedure for Evaluating Qualifications of Painting Contractors

EE. SSPC-QP 2 - Standard Procedure for Evaluating Qualifications of Painting Contractors to Remove Hazardous Paint

FF. SSPC-SP12/NACE 5 – Surface Preparation and Cleaning of Steel and Other Hard Materials by High-and Ultrahigh-Pressure Water Jetting Prior to Recoating

1.05 DEFINITIONS

A. Paint, coatings, or finishes as used in this Section include surface treatments, emulsions, enamels, paints, epoxies, polyurethanes, acrylics, zincs, and other protective coatings with the exceptions of galvanizing or anodizing, whether used as a pretreatment, primer, intermediate coat, or finish coat.

B. DFT means minimum dry film thickness.

C. VOC means Volatile Organic Components

1.06 PERFORMANCE REQUIREMENTS

A. See the Drawings and other Specifications to determine how coatings under this Section will be applied. Paint or coat new and modified surfaces in conformance with this Section.

B. Coating system schedules summarize surfaces to be coated, required surface preparation, and coating systems to be applied. Coating notes on Drawings are used to show exceptions to schedules, to show or extend limits of coating systems, or to clarify or show details for application of coating systems.

C. Do not apply protective coatings to the following surfaces unless specifically named or shown to be coated:

1. Concrete
2. Stainless steel, bronze, or brass
3. Machined surfaces
4. Grease fittings
5. Glass
6. Equipment nameplates
7. Platform gratings, stair treads, door thresholds, and other walk surfaces
8. Galvanized steel electrical conduit and associated galvanized and factory-coated junction boxes and electrical panels
9. Galvanized surfaces inside buildings and not exposed to view
10. Manhole and valve covers and rings, storm water inlet gratings, covers, and frames

D. Provide decorative and protective coatings for interior architectural surfaces such as wood, gypsum board, and masonry in accordance with Section 09900 – Painting.

1.07 SUBMITTALS

A. Make submittals in accordance with Section 01330 – Submittal Procedures.

B. Submit the following information at least 10 days prior to protective coating work:

1. Coating Materials List: Eight copies of a coating materials list naming the manufacturer and the coating number, keyed to the coating systems described in this Section. Submit the list prior to or at the time of sample submittal.
2. Paint Manufacturer's Information: For each coating system to be used, submit the following data:
    a. Paint manufacturer's Product Data Sheet for each product proposed, including statements on the suitability of the material for the intended use.
    b. Technical and performance information that demonstrates compliance with the system performance and material requirements.
    c. Paint manufacturer's instructions and recommendations on surface preparation, application and curing.

d. Colors available for each product, where applicable.

e. Compatibility of shop and field applied coatings, where applicable.

f. Material Safety Data Sheets for each product used.

g. VOC of each paint or coating proposed, stated in grams per litre.

3. Samples

a. Submit color samples of paint, finishes, and other coating materials on 8-1/2 inch by 11-inch sheet metal or heavy cardstock. Have each sheet completely coated over its entire surface with one protective coating material, type, and color.

b. Provide two sets of color samples to match each color selected by the City Engineer from the manufacturer's standard color sheets. If custom-mixed colors are indicated, prepare color samples using color formulations prepared to match the color samples furnished by the City Engineer.

c. Submit one 15-pound sample of each abrasive proposed to be used for surface preparation for submerged and severe service coating systems.

1.08 QUALIFICATIONS

A. Submit five (5) references which show that the painting Contractor has previous successful experience with the indicated or comparable coating systems. Include the name, address, and the telephone number for the owner of each installation for which the painting Contractor provided the protective coating. As an alternative, submit proof of certification in accordance with SSPC-QP 1.

B. For any project which involves removal or repair of lead based paints, submit proof of certification in accordance with SSPC-QP 2.

1.09 ENVIRONMENTAL RESTRICTIONS

A. Ventilate area where coating is being applied. Post and enforce NO SMOKING OR OPEN FLAME signs until coating has cured.

B. Provide lighting level of 80-foot candles (860 1x) measured mid-height at substrate surface.

C. Restrict worker access and construction traffic from area where coating is being applied or is curing.

D. Comply with City of Houston and all applicable OSHA confined space entry regulations including but not limited to OSHA Permit-Required Confined Space Standard 1910.146.

1.10 WARRANTY INSPECTION AND MAINTENANCE

A. Warranty Inspection:

1. A warranty inspection may be conducted during the eleventh month following completion of coating and painting. The Contractor and a representative of the coating material manufacturer must attend the inspection. At the option of the City, the City may be represented by a NACE certified coating inspector.

2. The City Engineer may, by written notice to the Contractor, reschedule the warranty inspection to another date within the one-year correction period, or may cancel the warranty inspection altogether. Cancellation of the warranty inspection does not relieve the Contractor of the Contractor's responsibilities under the Contract Documents.

3. Repair defective work discovered during the warranty inspection in accordance with these Specifications.

B. Extended Maintenance of Chemical Tank Lining Systems: Promptly repair defects in the chemical resistant sheet lining system for a period of 2 years after the lining has been placed into service. Such maintenance includes repair of the chemical tank and any equipment or facilities damaged by the corrosive action of the chemicals.

PART 2 PRODUCTS

2.01 COATINGS CRITERIA

A. Suitability: Use suitable coating materials as recommended by the manufacturer. Recommendations must be accompanied by test methods used to determine suitability and results of these tests.

B. Compatibility: In any coating system, use only compatible materials from a single manufacturer. Give particular attention to compatibility of primers, intermediate coats and finish coats. If necessary, apply a barrier coat or tie coat between existing prime coat and subsequent field coats to ensure compatibility.

C. Containers: Supply coating materials in sealed containers that plainly show the designated name, formula or specification number, batch number, color, date of manufacture, and name of manufacturer, all plainly legible at the time of use.

D. Colors: Use colors and shades of colors of all coats of paint as indicated on the coating schedules or as selected by the City Engineer. Make each coat a contrasting shade to the previous and following coats to facilitate inspection of surface coverage of each coat. The City Engineer will select finish colors from the manufacturer's standard color samples.

E. Substitute or Equal Products:

1. To establish equality under Section 01630 – Product Substitution Procedures, furnish satisfactory documentation from the manufacturer of the proposed substitute product that the material meets the indicated requirements and is equivalent to or better in the following properties:

    a. Resistance to abrasion and physical damage.

    b. Resistance to chemical attack.

    c. Life expectancy.

    d. Ability to recoat in the future.

    e. Solids content by volume.

    f. Dry film thickness per coat.

    g. Compatibility with other coatings.

    h. Suitability for the intended service.

    i. Temperature limitations in service and during application.

    j. Type and quality of recommended undercoats and topcoats.

    k. Ease of application.

    l. Ease of repairing damaged areas.

    m. Stability of colors.

    n. VOC content expressed in grams per liter.

2. For substitutions, submit protective-coating materials which are standard products produced by recognized manufacturers who are regularly engaged in production of such materials for essentially identical service conditions. Where requested, provide the City Engineer with the names of not less than 10 successful applications of the proposed manufacturer's products, which comply with these requirements. Applications must be in similar service environments to the job being contracted.

2.02 INDUSTRIAL COATING SYSTEMS

A. Material Sources: Each of the following manufacturers is capable of supplying many of the specified industrial coating materials. Manufacturers and specific paint designations (numbers) are listed to indicate the required type and quality of coating. Contractors are to base their bid on the use of products supplied by one of the named manufacturers. These named manufacturers are designated to establish a level of acceptable product quality or manufacturing experience and are not to be construed as the only manufacturers of products acceptable for use. Other manufacturers will be considered on an individual basis, and may be submitted for consideration in accordance with Document 0700 General Requirements, Article 3.8, Product Options and Substitutions (excluding 3.8.3), Section 01330 – Submittal Procedures, Section 01630 – Products Substitution Procedures, and this Section.

1. AKZO/International Coatings
2. Ameron International
3. Carboline Coatings Company
4. Hempel Coatings USA, Inc.
5. ICI/Devoe Coatings
6. Sigma Coatings USA, Inc.
7. Tnemec Company
8. Sherwin Williams Co.

B. System 1 – Aliphatic Polyurethane Finish Coat: Use a two-component aliphatic acrylic polyurethane coating that provides superior color and gloss retention, resistance to splash from acid and alkaline chemicals, resistance to chemical fumes and severe weathering, and has a minimum solids content of 58 percent by volume. As primer, use a rust inhibitive 2- component epoxy coating with minimum solids content of 66 percent by volume.

1. Prime Coat:
   a. DFT = 4-6 mils (100-150 microns).
   b. Products: Ameron 385, Carboline 893, Tnemec 69, VyGuard V75, SW Macropoxy 646 FC Epoxy, or equal.
2. Finish Coats (one or more):
   a. DFT = 2-4 mils (50-100 microns).
   b. Products: Ameron 450 GL, Carboline 134 HG, Tnemec 74, VyGuard V54, Sherwin Williams Hi-Solids Polyurethane, or equal.

3. Total System = 6-10 mils (150-250 microns).

4. Apply more than one finish coat as necessary to produce a finish with uniform color and texture.

C. System 2 – Inorganic Zinc/Epoxy Polyurethane: For prime coat, use a 2-component water or solvent-based inorganic zinc silicate which contains at least 85 percent of metallic zinc by weight in the dried film, and is recommended by the coating manufacturer as a primer for this system. As intermediate coat, use a high-build, 2-component epoxy with a solids content of at least 70 percent by volume. For finish coat, use a 2-component aliphatic acrylic or polyester polyurethane coating material that provides superior color and gloss retention, resistance to chemical fumes and severe weathering, and has a minimum solids content of 58 percent by volume.

1. Prime Coat:

   a. DFT = 2.5-4.0 mils (65-100 microns).

   b. Products: Ameron Dimetcote 21-5 or 21-9, Carbozinc 11 or D7WB, VyGuard 13F6 or 13F7, SW Zinc Clad II L.V. or equal.

2. Intermediate Coat:

   a. DFT = 4-6 mils (100-150 microns).

   b. Ameron 385, Carboline 893, VyGuard V75, or equal.

3. Finish Coats (one or more):

   a. DFT = 2.5 to 4.0 mils (65-100 microns).

   b. Ameron 450 GL, Carboline 134 HG, VyGuard V54, Sherwin Williams Hi-Solids Polyurethane, or equal.

4. Total System DFT = 9-14 mils (225-600 microns).

5. Apply intermediate coat in excess of 4 mils (100 microns) DFT using the mist coat/full coat technique to completely cover the inorganic zinc primer and prevent bubbling of the epoxy or polyurethane finish coat.

6. Apply more than one finish coat as necessary to produce a finish with uniform color and texture.

7. If inorganic zinc primer is used as a pre-construction or shop-applied primer, and there are damaged or uncoated areas, spot blast the damaged areas with abrasive to an SSPC-SP 10 Near White Metal Standard and then coat with the specified material.

D. System 3 – Inorganic Zinc: Use a 2-component water-based inorganic zinc silicate which contains at least 85 percent of metallic zinc by weight in the dried film.

1. Prime Coat and Finish Coat (one).

a. DFT = 2.5 to 4.0 mils (65-100 microns).

b. Products: Ameron Dimetcote 21-5, Carbozinc D7WB, VyGuard 13F6 or 13F7, S.W. Zinc Clad XI, or equal.

2. Total System DFT = 2.5 to 4.0 mils (65-100 microns).

E. System 4 – Acrylic Latex: Use a single component, water-based acrylic latex with a fungicide additive having a minimum solids content of 35 percent by volume. Apply a prime coat as recommended by manufacturer. Select coating material, which is available in ANSI safety colors.

1. Prime Coat

a. DFT = 2-3 mils (50-75 microns).

b. Products: Carboline D3358, Ameron 148, Hemucryl 1803, Sherwin Williams DTM Primer/Finish.

2. Finish Coats (2 or more):

a. DFT = 6-8 mils (150-200 microns).

b. Products: Carboline D3359, Ameron 220, Hemucryl 4803, Sherwin Williams DTM Acrylic Coating or equal.

3. Total System DFT = 8-11 mils (200-275 microns).

F. System 5 – Epoxy: Use a two-component, rust inhibitive, polyamide-cured epoxy coating material with a recoatable finish that is available in a wide selection of colors. Use a coating with a minimum solid content of 66 percent by volume and resistant to service conditions of condensing moisture, splash and spillage of lubricating oils, and frequent washdown and cleaning.

1. Prime Coat:

a. DFT = 3-5 mils (75-125 microns).

b. Products: Ameron 385PA, Carboline 193, Tnemec 69, VyGuard V75, Sherwin Williams Macropoxy 646 FC, or equal.

2. Prime Coat (where shop applied):

a. DFT = 3-5 mils (75-125 microns).

b. Products: Ameron 370, Carboline 193, Tnemec 161, VyGuard V75, Sherwin Williams Recoatable Epoxy Primer, or equal.

3. Finish Coats (2 or more):

a. DFT = 5- 7 mils (125-175 microns).

b. Products: Ameron 385, Carboline 893, Tnemec 69, VyGuard V75, Sherwin Williams Macropoxy 646 FC, or equal.

4. Total System DFT = 8-12 mils (200-300 microns).

G. System 6 – Aliphatic Polyurethane, Fiberglass: Use a two-component aliphatic polyurethane coating material with superior color and gloss retention, resistance to splash from acid and alkaline chemicals, and resistance to chemical fumes and severe weathering. Use a primer, tie coat, or mist coat as recommended by the manufacturer.

1. Prime Coat (Tie Coat): Ameron 385, Carboline 893, Tnemec P66, VyGuard V75, Macropoxy 646 FC, or equal.

2. Finish Coats (2 or more):

a. DFT = 2-4 mils (50-75 microns).

b. Products: Ameron Amershield, Carbothane 134 HG, Tnemec 74, VyGuard V54, or equal.

H. Section 7 – Alkyd Enamel: Use a high quality, gloss, or semi-gloss, medium long oil alkyd finish with a minimum solids content of 49 percent by volume. Apply primer as recommended by manufacturer.

1. Prime Coat:

a. DFT = 2-3 mils (50 to 75 microns).

b. Products: Ameron 5105, Carboline AD29, Tnemec P4-55, VyGuard 13R29, kem Kromik Universal, or equal.

2. Finish Coats (2 or more):

a. DFT = 2-4 mils (50-75 microns).

b. Products: Ameron 5401HAS, Carboline GP62, Tnemec 2H, VyGuard V20, Sherwin Williams Indusrial Enamel, or equal.

3. Total System DFT = 4-7 mils (100-175 microns).

I. System 8 – Aluminum Metal Isolation: Use one coat of a high-build polyamide epoxy paint.

1. Products: Tnemec P66, Ameron 385, Carboline 893, Tnemec P66, VyGuard V75, Sherwin Williams Macropoxy 646 FC, or equal.

2. Total System DFT = 6-8 mils (150-200 microns).

J. System 9 – Aluminum Silicone Resin: Use an aluminum silicone resin material suitable for a service temperature of up to 1000 degrees F (538 degrees C). Coating must comply with Federal Specification DOD-P-28.

1. Prime Coat and Finish Coat (2 or more):

a. DFT = 2-4 mils (50-100 microns)

b. Products: Tnemec 39-1061, Ameron 878, Carboline 4631, VyGuard V437A1, Sherwin Williams Steel Master 9500, or equal

c. Total System DFT = 2-4 mils (50-100 microns)

K. System 10 – Zinc Rich Epoxy: Use a polyamide Epoxy resin material that contains at least 76 percent zinc in the dried film.

1. Prime Coat and Finish Coat (2 or more):

a. DFT = 3-5 mils (75-125 microns)

b. Products: Ameron 68HS, Carboline 858, VyGuard 13F4, Sherwin Williams Zinc Clad III, or equal

c. Total System DFT = 3-5 mils (75-125 microns)

2.03 SUBMERGED AND SEVERE SERVICE COATING SYSTEMS

A. Material Sources: The manufacturers listed in this paragraph are materials, which satisfy the material descriptions of this paragraph and have a documented successful record for long- term submerged or sever service conditions. Proposed substitute products will be considered as indicated under paragraphs 2.01.5.

B. System 100 – Amine-Cured Epoxy: Use a high-build amine-cured epoxy with a solids content of at least 80 percent by volume. Use a coating suitable for long-term immersion in potable water. For potable water service, select a coating material listed in the NSF 61 Standard.

1. Prime Coat and Finish Coats (3 or more):

a. DFT = 16-19 mils (400 to 475 microns).

b. Products: Ameron Amercoat 395, Carboline 891, Tnemec 139, Sherwin Williams Tank Clad H.S,or equal.

2. For coating of valves and non-submerged equipment, DFT = 12-14 mils (300-350 microns).

C. System 101 – Polyamide Cured Epoxy: Use a high-build, polyamide epoxy resin with a solids content of at least 56 percent by volume. Use a coating suitable for long-term immersion in potable water. For potable water service, select a coating material listed under NSF 61 Standard.

1. Prime Coat and Finish Coats (3 or more):

a. DFT = 12-14 mils (300-350 microns).

b. Products: Tnemec 20, VyGuard 78PR, Sherwin Williams Macropoxy 646 NSF,or equal.

D. System 102 – Coal Tar Epoxy: Use a high-build, 2-component amine or polyamide-cured coal tar epoxy with a solids content of at least 68 percent by volume. Use a coating suitable for long-term immersion in wastewater or for coating of buried surfaces. Coating must conform to Mil Spec DOD-P-23236, or to SSPC Paint 16. Prime coats are for use as a shop primer only. Omit prime coat when both surface preparation and coating are performed in the field.

1. Prime Coat: DFT = 1.5-2.5 mils (38-65 microns).

a. Products: Ameron Amercoat 83HS, Tnemec P66, VyGuard V75, Sherwin Williams Copoxy Primer, or equal.

2. Finish Coats (2 or more):

a. DFT = 14-18 mils (350-450 microns).

b. Products: Ameron 78HB, Carbomastic 14, Tnemec 46H413, VyGuard 64, Sherwin Williams Targuard Coal Tar Epoxy,or equal.

c. Total System DFT = 15.5-20.5 mils (387-513 microns).

E. System 103 – Fusion Bonded Epoxy: Use a 100 percent powder epoxy applied in accordance with ANSI/AWWA C213, except prepare surface as specified in the coating system schedule in this Section. Apply the coating using the fluidized bed process.

1. Liquid Epoxy: For field repairs, use a 100 percent solids liquid epoxy as recommended by the powder epoxy manufacturer to provide a DFT of 15-17 mils (375-425 microns).

2. Powder Coating:

a. DFT = 15-17 mils (375-425 microns).

b. Products: Scotchkote 134 or 206N, Napgard 7-0008 or 7-2500, or equal.

c. Total System DFT = 15-17 mils (375-425 microns).

d. For coating of valves, DFT =11-12 mils (275-300 microns).

F. System 104 – Chemical Resistant Sheet Lining:

1. Materials: Use natural rubber, chlorobutyl rubber, ethylene propylene diene monomer (EPDM) rubber, chloroprene polymer (neoprene) rubber, or chlorosulfonated polyethylene (Hypalon) rubber sheet lining material. Submit shop drawings containing technical information that confirms the suitability of the lining material system for long-term immersion in each chemical to be stored. Service temperatures are expected to be up to 1500 F (650 C).

a. Neoprene Sheet Lining Material: Use a synthetic rubber formulated for steam curing at atmospheric pressure. Provide a minimum lining thickness of 3/16 inch. Supply B.F. Goodrich compound 59688, or equal.

b. Chlorobutyl Sheet Lining Material: Use a synthetic rubber formulated for steam curing at atmospheric pressure. Supply B.F. Goodrich compound 60924, or equal.

c. Natural Rubber (soft) Sheet Lining Material: Use a soft natural rubber formulated for steam curing at atmospheric pressure. Provide a minimum lining thickness of 3/16 inch. Supply B.F. Goodrich compound 83160, or equal.

d. Natural Rubber (hard) Sheet Lining Material: Use a hard, natural rubber resistant to oxidizing agents and formulated for autoclave curing. Provide a minimum lining thickness of 3/16 inch. Supply B.F. Goodrich compound 8631, or equal.

e. EPDM Sheet Lining Material: Use synthetic rubber suitable for use as a lining for 50 percent sulphuric acid solution and formulated for autoclave or steam curing under pressure.

f. Hypalon Sheet Lining Material: Use synthetic rubber suitable for use as a lining for 50 percent sulfuric acid solution.

2. Primers: Use primers, adhesives, activators, accelerators, and other necessary materials as recommended by the sheet material manufacturer.

3. Metal Surface Preparation: Prior to abrasive blast cleaning, prepare the base metal as required by the sheet lining material manufacturer's installation instructions. If the instructions differ from these specifications, provide the highest degree of cleaning and surface preparation required by either instructions or specifications. Perform abrasive blast cleaning in accordance with this section.

4. Installation: Install lining materials in accordance with the material manufacturer's written installation instructions. Line interior surfaces including piping, vents, fittings, flange faces, manhole covers, and blind flanges.

5. Testing: Test the lining system for holidays in accordance with this Section before and after curing.

6. Curing: Cure the lining system by steam using the time and temperature as required by the material manufacturer.

G. System 105 – Vinyl Ester: Use vinyl ester resin coating material with an inert flake pigment that is suitable for immersion service in 30 percent hydrochloric acid and 30 percent sulfuric acid solutions.

1. Coating (2 or more coats):

a. DFT = 40-45 mils (1000-1125 microns).

b. Products: Plasite 4100, Sherwin Williams Magnalux 304 FF,or equal.

c. Prime Coat: As recommended by the material manufacturer.

H. System 106 – 100% Solids Epoxy: Use a solventless epoxy resin coating suitable for severe service areas subject to splash, spillage or intermittent immersion in wide range of industrial chemicals and wastewater. Coating to resist normal abrasion from rolling vehicles.

1. Coating (2 or more coats):

a. DFT = 15-20 mils (325-500 microns).

b. Products: Ameron, Carboline, Sherwin CorCote HCR.

c. Prime Coat: As recommended by manufacturer.

I. System 107 – 100% solids Epoxy Sealer: Use a clear, unpigmented solventless epoxy suitable for application over marginal surfaces, including damp surfaces, tight rust and tight old coatings. Coating serves as primer for alkyd, acrylic, epoxy, and polyurethane finish coats.

1. Coating (1 coat only):

a. DFT = 1-2 mils (25-50 microns).

b. Products: ICI/Devoe 167 PrePrime, Carboline Rust Bond, Sherwin Williams 920 PrePrime, or equal.

J. System 108 - 100% Solids, Isocyanate-Free, Solvent-Free, High Build Epoxy Coating for Wastewater applications only, to be spray applied in one or more coats to all interior surfaces of exposed concrete above the spring line or as otherwise detailed.

1. Product Characteristics:

a. Product: 100% solids, solvent-free high-build epoxy system

b. Product Type: amine cured epoxy

c. VOC Content (ASTM D3960): 0%

d. Compressive Strength, psi (ASTM D695): 10,500 (minimum)

e. Tensile Strength, psi (ASTM D638): 4,500 (minimum)

f. Flexural Strength, psi (ASTM D790): 7,500 (minimum)

g. Adhesion to Concrete, psi/mode of failure (ASTM D7234): 350 psi (minimum)/with substrate (concrete) failure

h. Chemical Resistance, pH>0.5 (ASTM G20): 60% Sulfuric Acid

2. In all cases the coating product(s) shall be applied to a minimum dry film thickness of 80 mils to surface profiles of CSP-4 to CSP-5 or 125 mils minimum DFT to surface profiles of CSP-6 or greater.

3. When the wall of the liner is to be structurally designed to withstand the hydraulic load generated by the groundwater table the long-term (50yr) value of the flexural modulus of elasticity will be utilized to calculate the thickness of the structural line. The initial flexural modulus of elasticity (short term) of the submitted resin material will be utilized with the long-term deformation percentage as determined by ASTM D2990 in the design equation outlined in ASTM 1216-09, Appendix XI. The value of the long-term flexural modulus of the proposed product will be certified by an independent, certified, third party testing lab, independent of the Manufacturer. [The definition of long-term value will be identified as initial flexural modulus of elasticity less the reduction in value caused by Creep over a fifty (50) year minimum period and verified by third party testing (ASTM D2990).]

4. Subsequent top-coating or additional coats of the coating product(s) shall occur within the product recoat window or 24 hours whichever is less. Additional surface preparation procedures will be required if this recoat window is exceeded.

K. System 109 - 100% Solids, Solvent-Free, Multi-Layered Polymer Lining System (Polyurea and Polyurethane) for Wastewater applications only, to be spray applied in three layers to all interior surfaces of exposed concrete above the spring line or as otherwise detailed.

1. Product Characteristics:

a. Product: 100% solids, solvent-free, polyuria (two layers) and polyurethane (one layer) system

b. Product Type: Self-curing polymer lining

c. VOC Content (ASTM D3960): 0%

d. Tensile Strength, psi (ASTM D412): 2,400 (minimum)

e. Elongation % (ASTM D412): 200 (minimum)

f. Tear Strength, pli (ASTM D624): 300 (minimum)

g. Shore D Hardness, (ASTM 2240): 45 (minimum)

h. Adhesion to Concrete, psi/mode of failure (ASTM D7234): 350 psi (minimum)/with substrate (concrete) failure

i. Chemical Resistance, pH>0.5 (ASTM G20): 30% Sulfuric Acid

2. In all cases the coating product(s) shall be applied to a minimum thickness of 500 mils total.

3. For resistance to ground water head pressure the coating shall be a minimum of 500 mils thick for depths up to 32 feet. For depths greater than 32 feet consult the coating manufacturer for recommendations.

4. Subsequent top-coating or additional coats of the coating product(s) shall occur within the product recoat window or 24 hours whichever is less. Additional surface preparation procedures will be required if this recoat window is exceeded.

L. System 110 – 100% Solids, High Build Polyurethane Coating for Wastewater applications, to be spray applied in one or more coats to all interior surfaces of exposed concrete above the spring line or as otherwise detailed.

1. Product Characteristics:

a. Product: 100% solids, high-build polyurethane system

b. Product Type: Catalyzed, two component, polyurethane

c. VOC Content (ASTM D3960): 0%

d. Compressive Strength, psi (ASTM D695): 18,000 (minimum)

e. Tensile Strength, psi (ASTM D638): 7,450 (minimum)

f. Flexural Strength, psi (ASTM D790): 14,000 (minimum)

g. Flexural Modulus, psi (ASTM D790): 735,000 (minimum)

h. Adhesion to Concrete, psi/mode of failure (ASTM D7234): 200 psi (minimum) with substrate (concrete) failure

i. Chemical Resistance, pH 0.5 (ASTM G20): 20% Sulfuric Acid

2. In all cases the coating product(s) shall be applied to a minimum dry film thickness of 80 mils to surface profiles of CSP-4 to CSP-5 or 125 mils minimum DFT or surface profiles of CSP-6 or greater.

3. When the wall of the resin based liner is to be structurally designed to withstand the hydraulic load generated by the groundwater table the long-term (50yr) value of the flexural modulus of elasticity will be utilized to calculate the thickness of the structural line. The initial flexural modulus of elasticity (short term) of the submitted resin material will be utilized with the long-term deformation percentage as determined by ASTM D2990 in the design equation outlined in ASTM 1216-09, Appendix XI. The value of the long-term flexural modulus of the proposed product will be certified by an independent, certified, third party testing lab, independent of the Manufacturer. [The definition of long-term value will be identified as initial flexural modulus of elasticity less the reduction in value caused by Creep over a fifty (50) year minimum period and verified by third party testing (ASTM D2990).]

4. Polyurethane product characteristics allow high build thicknesses to be achieved in one application without additional surface preparation. However, if installation requires applications outside of the recoat window, additional surface preparation may be necessary by using a primer or abrading the previously coating surface area.

PART 3 EXECUTION

3.01 MANUFACTURER'S SERVICES

A. Require the protective coating manufacturer to furnish a qualified technical representative to visit the project site for technical support as may be necessary to resolve field problems attributable to or associated with manufacturer's products.

B. For submerged and severe service coating systems, require the paint manufacturer to furnish the following services:

1. Provide at least 6 hours of on-site instruction on the proper surface preparation, use, mixing, application, and curing of the coating systems.

2. Observe the start of surface preparation, mixing, and application and curing of the coating systems.

3. Provide the services of a NACE Certified Coating Inspector at all times during the surface preparation, mixing, application, curing and testing of all coatings applied in submerged or acid spill areas.

3.02 WORKMANSHIP

A. Use skilled craftsmen and experienced supervision. For all jobs involving lead based paint removal or repair, require the presence of a certified Competent Person, Lead per OSHA requirements.

B. Apply coating to produce an even film of uniform thickness. Give special attention to edges, corners, crevices, and joints. Ensure thorough cleaning and an adequate thickness of coating material. Apply coatings to produce finished surfaces free from runs, drips, ridges, waves, laps, brush marks, and variations in color, texture and finish. Effect complete hiding so that the addition of another coat would not increase the hiding. Give special attention to ensure that edges, corners, crevices, welds, and similar areas receive a film thickness equivalent to adjacent areas. Apply a brushed stripe coat to all edges and welds after priming submerged or severe service areas.

C. Remove, mask or otherwise protect hardware, lighting fixtures, switch plates, machined surfaces, couplings, shafts, bearings, name plates on machinery, and other surfaces not to be painted. Provide drop cloths to prevent coating materials from falling on or marring adjacent surfaces. Protect the working parts of mechanical and electrical equipment from damage during surface preparation and coating operations. Mask openings in motors to prevent entry of coating or other materials.

D. Do not damage adjacent work during blast cleaning operations. Perform spray painting under carefully controlled conditions. Promptly repair any damage to adjacent work or adjoining property occurring from blast cleaning or coating operations.

E. Coordinate cleaning and coating so that dust and other contaminants from the cleaning process will not fall on wet, newly-coated surfaces.

3.03 SURFACE PREPARATION STANDARDS

A. The following referenced surface preparation standards of the Society for Protective Coatings (SSPC) form a part of this Specification:

1. Solvent Cleaning (SSPC-SP1): Removal of oil, grease, soil, drawing and cutting compounds, and other soluble contaminants from steel surfaces by cleaning with solvent, vapor degreasing, emulsion or alkaline cleaners, or steam.

2. Hand Tool Cleaning (SSPC-SP2): Removal of all loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter by hand chipping, scraping, sanding, and wire brushing.

3. Power Tool Cleaning (SSPC-SP3): Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, by rotary or impact power tools, power wire brushing, or power abrading.

4. White Metal Blast Cleaning (SSPC-SP5/NACE 1): Removal of all visible oil, grease, soil, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter by blast cleaning.

5. Commercial Blast Cleaning (SSPC-SP6/NACE 3): Removal of all visible oil, grease, dust, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter, except limit random staining to no more than 33 percent of each unit area of surface.

6. Brush-Off Blast Cleaning (SSPC-SP7/NACE 4): Removal of all visible oil, grease, dirt, dust, loose mill scale, loose rust, and loose coating, all of which are considered tightly adherent if they cannot be removed by lifting with a dull putty knife.

7. Near-white Blast Cleaning (SSPC-SP10/NACE 2): Removal of all visible oil, grease, dirt, mill scale, rust, coating, oxides, corrosion products, and other foreign matter, except limit random staining to no more than 5 percent of each unit area of surface.

3.04 METAL SURFACE PREPARATION (UNGALVANIZED)

A. Provide the minimum abrasive-blasted surface preparation as indicated in the coating system schedules at the end of this Section. Where there is a conflict between these specifications and the coatings manufacturer’s printed recommendations for the intended service, the higher degree of cleaning applies.

B. Perform metal surface preparation in conformance with the current SSPC/NACE Standards and this Section. Blast cleaned surfaces must match standard samples in SSPC-VIZ 1.

C. Remove oil, grease, welding fluxes, and other surface contaminants prior to blast cleaning using solving cleaning as per SSPC-SP1.

D. Round or chamfer sharp edges. Grind to smooth finish burrs, surface defects, and weld splatter prior to blast cleaning.

E. Select the type and size of abrasive to produce a surface profile that meets the coating manufacturer's recommendation for the particular coating and service conditions. As abrasives for submerged and severe service coating systems use clean, hard, sharp cutting crushed slag. Do not use automated blasting systems and metal shot or grit for surfaces that will be in submerged service, even if subsequent abrasive blasting is planned with hard, sharp-cutting slag.

F. Do not reuse abrasive except when an automated blasting system is used for surfaces that will be in non-submerged service. For automated blasting systems, use clean, oil-free abrasives. In the abrasive mix, use at least 50 percent steel grit. Replenish abrasive mix with new shot/grit combination as necessary to maintain the anchor profile within ½ mil (13 microns) of the specified profile.

G. Comply with the applicable federal, state, and local air pollution control regulations for blast cleaning.

H. For air-blast cleaning, supply compressed air at adequate pressure from well-maintained compressors equipped with oil and a moisture separator which delivers oil and water-free air as checked with white blotter, white cloth, or plastic sheets at the beginning of each blasting sequence.

I. Clean surfaces of dust and residual particles of the cleaning operation using dry air-blast cleaning, vacuuming, or another approved method prior to painting. Vacuuming must be the final cleaning method immediately prior to painting areas that will go into submerged service.

J. In enclosed areas and other areas where dust may settle, vacuum the surface clean and wipe it with a tack cloth.

K. Remove damaged or defective coating by the specified blast or power tool cleaning to meet the clean surface requirements before recoating.

L. If the specified abrasive blast cleaning will damage adjacent work, the area to be cleaned is less than 100 square feet, and the coated surface will not be in submerged service, then SSPC-SP2 – Hand Tool Cleaning or SSPC-SP3 – Power Tool Cleaning, may be used. If the coated area to be cleaned is less than 100 square feet, and will be in submerged service, then SSPC-SP11 Power Tool Cleaning to Bare Metal may be used.

M. Completely remove shop-applied coatings of unknown composition before the specified coatings are applied. Examine valves, castings, ductile or cast iron pipe, and fabricated pipe or equipment for the presence of shop-applied temporary coatings. Completely remove temporary coatings by solvent cleaning per SSPC-SP1 method before starting abrasive blast cleaning. Alternate cleaning methods such as Baking Soda Blasting or Sponge Jet Blasting may be used as appropriate.

N. Use the solvent cleaning method (SSPC-SP1) to clean shop-primed equipment in the field before finish coats are applied.

3.05 SURFACE PREPARATION FOR GALVANIZED FERROUS METAL

A. For galvanized ferrous metal, use the alkaline cleaning method per SSPC-SP1 to remove oil, grease, and other contaminants detrimental to adhesion of protective coatings. Alternate methods with biodegradable surfactant type cleaners followed by fresh water washing may be used as appropriate.

B. Apply pretreatment coatings of surfaces in accordance with the printed recommendations of the coating manufacturer.

3.06 SURFACE PREPARATION OF FERROUS SURFACES WITH EXISTING COATINGS

A. Remove grease, oil, heavy chalk, dirt, or other contaminants by solvent or detergent cleaning prior to abrasive blast cleaning. Determine the generic type of the existing coatings by laboratory testing.

B. Provide the degree of cleaning specified in the coating system schedule for the entire surface to be coated. If the degree of cleaning is not indicated in the schedule, remove deteriorated coatings by abrasive blast cleaning to meet the requirements of SSPC-SP6 Commercial Blast Cleaning. Clean areas of tightly adhering coatings to meet the requirements of SSPC-SP7 Brush-Off Blast Cleaning, with the remaining thickness of pre-existing coating not to exceed 3 mils.

C. If coatings to be applied are not compatible with existing coatings, apply intermediate coatings conforming to the paint manufacturer's recommendation for the indicated coating system or completely remove the existing coating prior to abrasive blast cleaning. Make a small trial application for compatibility prior to painting large areas. Allow the trial application to cure for 7 days at 50º F (10º C) or higher before determining compatibility.

D. Completely remove coatings of unknown composition prior to application of new coatings.

E. Where specified or where job site conditions do not permit dry-abrasive blasting for industrial coating systems due to dust or air pollution considerations, water jetting or wet- abrasive blasting may be used. In both methods, use inhibitors approved by the manufacturer of the coating system, which will be applied over the cleaned area. Begin the coating application as soon as the surface has dried, and before the formation of any flash rusting. Perform water jetting with or without abrasive injection, as appropriate, to achieve the specified degree of surface cleanliness. Do not use water-jetting methods for submerged or severe-service coating systems, unless specified for that area.

3.07 PLASTIC, FIBERGLASS, AND NONFERROUS METALS SURFACE PREPARATION

A. Unless otherwise indicated, for equipment or parts of equipment which are not submerged in service, shop-prime, and then finish-coat in the field after installation. For methods, materials, application equipment, and other details of shop painting, comply with this Section. If the shop primer requires topcoating within a specified period of time, apply the finish coating in the shop and then touch-up the paint after installation.

B. Perform surface preparation and coating work in the field for equipment, or parts and surfaces of equipment which are submerged or inside an enclosed hydraulic structure when in service, with the exception of pumps and valves.

C. For certain pieces of equipment, it may be undesirable or impractical to apply finish coatings in the field. Such equipment may include engine generator sets, equipment such as electrical control panels, switch gear or main control boards, submerged parts of pumps, ferrous metal passages in valves, or other items where it is not possible to obtain the required quality in the field. For such equipment, prime and finish-coat in the shop and touch-up in the field after installation. Use the identical material for touch-up that was used for shop painting. Require the manufacturer of each such piece of equipment to certify as part of its shop drawings that the surface preparation is in accordance with these specifications. Submit the coating material product data sheet with the shop drawings for the equipment.

D. For certain small pieces of equipment, the manufacturer will have a standard coating system, which is suitable for the intended service conditions. In such cases, the final determination of suitability will be made during review of the shop drawing submittals. Equipment of this type generally includes only indoor equipment such as instruments, small compressors, and chemical metering pumps.

E. Protect shop-painted surfaces during shipment and handling. Protect surfaces with padding or blocking. Lift equipment with canvas or nylon slings. Before being topcoated, do not expose primed surfaces to the weather for more than 2 months or less when recommended by the coating manufacturer.

F. Repair damage to shop-applied coatings in accordance with this Section and the coating manufacturer's printed instructions.

G. Make certain that the shop primers and field topcoats are compatible and meet the requirements of this Section. Submit copies of applicable coating manufacturer's product data sheets with equipment shop drawings.

3.08 APPLICATION OF COATINGS

A. Apply protective coatings to steel substrates in accordance with SSPC-PA1 – Paint Application Specification No. 1. Shop, Field and Maintenance Painting.

B. Inspect cleaned surfaces and each coat prior to succeeding coats. Schedule inspections with the City Engineer in advance.

C. Paint blast-cleaned ferrous metal surfaces before rusting or other deterioration of the surface occurs. Limit blast cleaning to only those surfaces that can be coated in the same working day unless the area to be coated is protected by humidity control equipment set to maintain humidity below 50 percent at all times.

D. Apply coatings in accordance with the manufacturer's instructions and this Section, whichever has the most stringent requirements.

E. Give special attention to edges, angles, weld seams, flanges, nuts and bolts, and other places where insufficient film thickness is likely to occur. Use stripe painting by brush, after application of the primer, for these areas.

F. Give special attention to materials, which will be joined so closely that proper surface preparation and application are not possible. Coat such contact surface prior to assembly or installation. Use only inorganic zinc primers on faying surfaces.

G. Apply finish coats, including touch-up and damage repair coats, in a manner which will present uniform texture and color-matched appearance.

H. Do not apply coatings under the following conditions:

1. Temperature outside of the manufacturer's recommended minimum and maximum range.

2. Dust or smoke laden atmosphere.

3. Substrate or air temperature less than 5º F (3º C) above the due point.

4. Air temperature is expected to drop below 40ºF (14º C) or less than 5º F (3º C) above the dew point within 8 hours after application of the coating.

5. Wind conditions in excess of 15 MPH or dust laden.

I. Determine the dew point by use of a sling psychrometer in conjunction with the U.S. Department of Commerce, Weather Bureau psychometric tables.

J. For steel piping which will not be buried, have the surface abrasive blast cleaned and primed before installation.

K. Apply finish coats after concrete, masonry, and equipment installation is complete and the work areas are clean and dust free. Concrete must have cured for a minimum of 28 days @ 75º F (24º C) unless an approved epoxy sealer has been applied to green concrete within 12 hours of finishing the concrete.

3.09 CURING OF COATINGS

A. Maintain curing conditions in accordance with the recommendations of the coating material manufacturer and this Section, whichever is the most stringent. Complete curing before placing the coating systems into service.

B. In the case of enclosed areas, forced air ventilation using heated air may be required until the coatings have fully cured.

C. Forced air ventilation is required for the application and curing of coatings on the interior surfaces of enclosed hydraulic structures. During application and curing periods, continuously exhaust air from the lowest level of the structure using portable ducting to force air into all compartments and around baffles. After interior coating operations have been completed, provide a final curing period that meets the minimum temperature and time requirements of the manufacturer of the coating system being applied, while operating the forced air ventilation system continuously.

3.10 SHOP AND FIELD INSPECTION AND TESTING

A. Give the City Engineer a minimum of 3 days advance notice of the start of any field surface preparation work or coating application work, and a minimum of 7 days advance notice of the start of any shop surface preparation work.

B. Perform surface preparation and coating applications in the presence of the City Engineer, or City Engineer's appointed NACE certified coating inspector, unless the City Engineer has granted prior approval to perform the work in their absence.

C. Inspection by the City Engineer or the NACE certified inspector, or the waiver of inspection of any particular portion of the work, does not relieve the Contractor of the Contractor's responsibility to perform the Work in accordance with these Specifications.

D. Erect and move scaffolding where requested by the City Engineer to facilitate inspection. Provide additional illumination to light areas to be inspected. Remove or grind smooth all scaffolding clips welded to the structure prior to surface preparation of the structure.

E. Until final acceptance of the coatings, furnish inspection devices in good working condition for the detection of holidays and measurement of dry-film thickness (DFT) of protective coatings. Make DFT gauges available for the City Engineer's use throughout the coating process until final acceptance of the coatings. Provide the services of a NACE certified coating inspector for all holiday detection work until the final acceptance of the coatings. Operate holiday inspection devices in the presence of the City Engineer.

F. Perform holiday tests on coated ferrous surfaces inside a steel reservoir, other surfaces that will be submerged in water or other liquids, or surfaces which are enclosed in a vapor space in such structures. Perform holiday tests on surfaces coated with any of the submerged and severe service coating systems. Mark and repair or recoat areas which contain holidays in accordance with the coating manufacturer's printed instructions and then retest. DO NOT PERFORM HOLIDAY TESTING AFTER STRUCTURE HAS BEEN SUBMERGED.

1. Coatings with Thickness Exceeding 20 mils (500 microns): For surfaces having a total DFT exceeding 20 mils (500 microns); use a pulse-type holiday Detector such as Elcometer 136, or equal. Adjust and operate in accordance with NACE RP0188.

2. Coatings with Thickness of 20 mils (500 microns) or Less: For surfaces having a total DFT of 20 mils or less, use Elcometer 269 non-destructive type holiday detector, or equal. Instrument must operate at less than 75 volts. For thicknesses between 10 and 20 mils (250 and 500 microns), a non-sudsing type wetting agent such as Kodak Photo-Flo, or equal, may be added to the water prior to wetting the detector sponge. For submerged or severe service areas, the residue of the wetting agent must be removed with clean, fresh water prior to application of any additional coats.

G. On ferrous metals, measure the DFT in accordance with SSPC-PA2 Measurement of Dry Film Thickness with magnetic gauges using either a pull-off type gauge (Elcometer 211) or constant pressure gauge (Elcometer 345F), or equal. Test each coat for the correct thickness. Calibrate the DFT gauge at the beginning of each workday or shift in accordance with the directions of the manufacturer of the gauge. Do not take measurements until at least 8 hours after coating application. On non-ferrous metals, measure the DFT with positive pressure eddy current gages (Elcometer 345N) or equal.

H. Evaluation of blast-cleaned surface preparation work will be based upon comparison with photographic samples contained in SSPC-VIZ 1.

I. Evaluation of surface profile will be based upon the use of TesTex pressure sensitive tapes.

3.11 PAINTING AND IDENTIFICATION OF PIPING

A. Painting and Color Coding:

1. Use colors and signs to identify all piping which is exposed to view in buildings or tunnels, above suspended ceilings or exposed above grade, and all outdoor piping. Identify each pipe by a color complying with the following schedule of colors and by applied markers.

2. Coat pipes with the number of coats and type of material specified. Base coats for pipeline painting may be a neutral color. Make each succeeding base coat a contrasting color. For the final coat, comply with the pipe identifying color schedule.

3. Apply pipe identification markers to exposed piping, except for the following pipe at wastewater lift stations:

   a. Discharge piping for wastewater pumps.

   b. Vent piping.

c. Any piping inside wet wells.

B. Pipe Identification Markers:

1. Identify all pipes with applied signs or markers at 15-foot centers, at both sides of penetrated walls or floors, adjacent to valves, at connected equipment, at branch fittings, and in congested pipe layouts.

a. Apply markers consisting of signs with legends as follows:

OUTSIDE DIAMETER OF PIPE OR COVERING (INCHES)	LENGTH OF COLOR FIELD (INCHES)	SIZE OF LETTERS (INCHES)
3/4 to 1- 1/4	8	1/2
1- 1/2 to 2- 3/8	8	3/4
2- 1/2 to 5- 7/8	12	1- 1/4
6 to 7- 7/8	12	1- 1/4
8 to 10	24	2- 1/2
Over 10	32	3- 1/2

b. As pipe markers, use semi-rigid outdoor grade acrylic plastic, Seton Name Plate Corp., SetMark, or equal. Use Type SNA for outside diameters 3/4 through 5- 7/8 inches and Type STR for 6-inch outside diameter or larger. For pipes less than 3/4-inch in diameter, use applied marker of brass identification tags 1-1/2 inches square with depressed letters 1/4-inch high, black-filled. Apply tightly to pipeline with metal or plastic straps.

C. Pipe Identification Color Schedule:

1. For wastewater facilities refer to current version of TCEQ chapter 217. For piping systems not found in TCEQ chapter 217, use the colors listed in the following pipe identification color schedule for facilities:

PIPE IDENTIFICATION COLOR SCHEDULE

PIPING SYSTEM	COLOR	FED. STD. NO.
Fire Mains	Red	11105
Oxygen	Orange	12246
Sodium Hypochlorite	Yellow	13655
Raw Polymer	Pink	11156
Diluted Polymer	Purple	17142
Natural Gas	Yellow	13655
Heating Water	Pink	11158
Domestic Hot	Light Pink	11668
Potable Water	Blue	15102
Non-Potable Water	White	17875
Instrument Air	Green	14187
Plant Air	Dark Green	14110
Raw Sewage	Gray	16473
Grit	Dark Gray	16187
Cyclone Return	Gray	16473
Classifier Return	Gray	16473
Heavy Solids	Dark Brown	10080
Return Sludge	Brown	10091
Waste Sludge	Yellow-Brown	10266
Scum	Light Brown	10334
Chilled Water Supply (CWS)	Blue-Green	14329
Chilled Water Return (CWR)	Blue-Green	14325
Condensing Water Supply (Cond-WS)	Light Green	14533
Condensing Water Return (Cond-WR)	Light Green	14533
Deionized Water (DW)	Light Blue	15526
Vacuum (Vac)	White	17875
Vent	Light Gray	16492

2. For pipe identification colors not listed above, follow American National Standard (ANSI A13.1-81) Color Schedule:

   a. Materials inherently hazardous, flammable or explosive; chemically active or toxic; extreme temperature or pressure; radioactive: Yellow Field with Black Letters.

   b. Material of inherently low hazard – liquid or liquid admixture: Green Field with White Letters; gas or gaseous admixture: Blue Field with White Letters.

   c. Fire quenching materials, water, foam, carbon dioxide, Halon, etc.: Red Field with White Letters.

3.12 COATING SYSTEM SCHEDULES – FERROUS METALS

A. Coating System Schedule, Ferrous Metal – Not Galvanized

SCHEDULE NO. AND APPLICATION	SURFACE PREPARATION	SYSTEM NO./ DESCRIPTION
FM-1: Surfaces indoors and outdoors, exposed or covered, except those listed below.	Near White Metal blast cleaning SSPC-SP10/NACE 2	(2) Inorganic zinc/epoxy/ polyurethane
FM-2: Surfaces in chlorination room, chlorine storage room, sodium hypochlorite storage room	Near White Metal blast cleaning SSPC-SP10/NACE 2	(100) Amine-cured epoxy
FM-3: Surfaces of pumps and equipment and other ferrous surfaces submerged or intermittently submerged in potable water, utility water, and wastewater; including surfaces lower than 2 feet above high-water level in hydraulic structures, and surfaces inside enclosed hydraulic structures, pump state wet wells, and vents (excluding shop-coated valves, couplings, and pumps).	White Metal Blast Cleaning SSPC-SP5/ NACE 1	(100) Amine-cured epoxy
FM-4: Surfaces exposed to high temperature between 1500 and 6000 F (650 and 3150 C).	Near White Metal blast cleaning SSPC-SP10/NACE 2	(3) Inorganic Zinc, water-based
FM-5: Surfaces exposed to high temperature between 6000 and 10000 F.	Near White Metal blast cleaning SSPC-SP10/NACE 2	(9) Aluminum silicon resin
FM-6: Where indicated, ferrous surfaces in water passages of valves 4-inch size and larger, exterior surfaces of submerged valves.	White Metal Blast Cleaning SSPC-SP5/ NACE 1	(101) Polyamide-cured epoxy
FM-7: Where indicated, ferrous surfaces in water passages of pumps which have discharge size of 4 inches or larger; exterior, submerged surfaces of pumps.	White Metal Blast Cleaning SSPC-SP5/ NACE 1	(101) Polyamide-cured epoxy
FM-8: Ferrous surfaces of sleeve couplings.	White Metal Blast Cleaning SSPC-SP5/ NACE 1	(103) Fusion-bonded epoxy
FM-9: Ferrous surfaces of sluice gates, flap gates, and shear gates, including wall thimbles.	White Metal Blast Cleaning SSPC-SP5/ NACE 1	(101) Polyamide-cured epoxy
FM-10: Structural steel, miscellaneous metal work, and supports for prefabricated metal buildings, not exposed to view in finished building.	Commercial Blast Cleaning (SSPC-SP6/NACE 3	(10) Zinc Rich Epoxy
FM-12: Ferrous metal exposed to view, inside and outside of buildings.	Near White Metal blast cleaning SSPC-SP10/NACE 2	(2) Inorganic zinc/ epoxy/polyurethane

SCHEDULE NO. AND APPLICATION	SURFACE PREPARATION	SYSTEM NO./ DESCRIPTION
FM-13: Surfaces of indoor equipment not submerged.	Commercial Blast Cleaning SSPC-SP6/ NACE 3	(5) Epoxy, equipment
FM14: Exterior (exposed) surfaces shop-coated with fusion-bonded epoxy.	Light abrasive blast to roughen surface	(6) Aliphatic polyurethane

B. Coating System Schedule, Ferrous Metal – Galvanized: Apply pretreatment coatings, barrier coatings, or washes as recommended by the coating manufacturer.

SCHEDULE NO. AND APPLICATION	SURFACE PREPARATION	SYSTEM NO./ DESCRIPTON
FMG-1: Exposed surfaces indoors and outdoors, except those listed below.	Alkaline cleaning SSPC-SP1	(1) or (4) Aliphatic Polyurethane, or Acrylic
FMG-2: Surfaces in chlorination room, chlorine storage room, and sodium hypochlorite storage room.	Alkaline Cleaning SSPC-SP1	(100) Amine-cured epoxy
FMG-3: Surfaces submerged in water or wastewater, including surfaces lower than 2 feet above high-water level and surfaces inside hydraulic structures and vents	Alkaline cleaning SSPC-SP1 followed by Brush-Off blast cleaning SSPC-SP7/ NACE 4	(100) Amine-cured epoxy
FMG-4: Surface exposed to view, inside and outside of building.	Alkaline Cleaning SSPC-SP1	(1) or (4) Aliphatic polyurethane, or Acrylic

C. Coating System Schedule, Interior Surface of Welded Steel Tanks: Coat interior surfaces, including tank nozzles, manholes, nozzle necks, and flange faces. For steel tank exterior coating systems, see paragraph 3.15.1, Coating System Schedule, Ferrous Metal – Not Galvanized.

PRODUCT STORED	SURFACE PREPARATION	SYSTEM NO. /DESCRIPTION
Zinc Orthophosphate	White metal blast cleaning SSPC-SP5/NACE1	(104) Natural rubber (soft) or neoprene
Liquid Alum	White metal blast cleaning SSPC-SP5/NACE1	(104) Natural rubber (soft) or neoprene
Polymer	White metal blast cleaning SSPC-SP5/NACE1	(104) Natural rubber (soft) or neoprene
Sodium Bisulfite	White metal blast cleaning SSPC-SP5/NACE1	(104) Natural rubber (soft) or neoprene
Ferric Chloride	White metal blast cleaning SSPC-SP5/NACE1	(104) Natural rubber (hard)
Aqueous Ammonia	White metal blast cleaning SSPC-SP5/NACE1	(104) Chlorobutyl rubber
Caustic Soda	Commercial Blast Cleaning SSPC-SP6/NACE 3	No Coating
Sodium Hypochlorite	White metal blast cleaning SSPC-SP5/NACE1	(104) Chlorobutyl Rubber
Sulfuric Acid (max. 45% concentration)	White metal blast cleaning SSPC-SP5/NACE1	(107) Hypalon
Sulfuric Acid (above 40% concentration)	White metal blast cleaning SSPC-SP5/NACE1	(107) Viton
Hydrofluosilicic Acid	White metal blast cleaning SSPC-SP5/NACE1	(107) Chlorobutyl Rubber
Water, Potable Water, Utility Water	White metal blast cleaning SSPC-SP5/NACE1	(100) Amine-Cured Epoxy

3.13 COATING SYSTEM SCHEDULES, NONFERROUS METAL, PLASTIC, FIBERGLASS

A. Where isolated non-ferrous parts are associated with equipment or piping, use the coating system for the adjacent connected surfaces. Do not coat handrails, gratings, frames, or hatches. Use primers recommended by coating manufacturer.

SCHEDULE NO. AND APPLICATIONS	SURFACE PREPARATION	SYSTEM NO./ DESCRIPTION
NFM-1: Exposed surfaces, indoors and outdoors, except those listed below.	Solvent cleaned SSPC-SP1	(1) Aliphatic Polyurethane
NFM-2: Chlorination room, chlorine storage room, sodium hypochlorite storage room.	Solvent cleaned SSPC-SP1	(100) Amine-Cured Epoxy
NFM-3: Aluminum surfaces in contact with concrete, or with any other metal except galvanized ferrous metal.	Solvent cleaned SSPC-SP1	(8) Aluminum Metal Isolation
NFM-4: Polyvinyl chloride plastic, indoors and outdoors, not submerged.	Solvent cleaned SSPC-SP1	(4) Acrylic
NFM-5: Fiberglass surfaces.	Per paragraph 3.09, Plastic, Fiberglass, and Non-Ferrous Metals Surface Preparation	(6) Aliphatic Polyurethane Fiberglass

END OF SECTION

SECTION 09971

PAINTING AND PROTECTIVE COATINGS FOR POTABLE WATER STORAGE TANKS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Surface preparation and application of paints and/or protective coating materials in a safe manner with proper handling and removal and disposal of all waste materials.

1.02 RELATED SECTIONS

A. Document 00700 – General Conditions

B. Section 01330 – Submittal Procedures

C. Section 01351 – Environmental Safety and Worker Protection

D. Section 02136 – Waste Material Handling, Testing and Disposal

1.03 MEASUREMENT AND PAYMENT

A. There is no separate measurement and payment for work performed under this Specification Section. Include the cost for this work in the contract bid price for work of which this is a component part.

1.04 REFERENCE STANDARDS

A. American Society for Testing of Materials (ASTM)

1. ASTM A 123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

2. ASTM A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

3. ASTM A 385 - Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)

4. ASTM E 376 - Standard Practice for Measuring Coating Thickness by Magnetic-Field or Eddy Current (Electromagnetic) Testing Methods.

5. ASTM D 4285 - Standard Test Method for Indicating Oil or Water in Compressed Air.

6. ASTM D 4940 - Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blast Cleaning Abrasives.

7. ASTM D 4417 - Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel.

B. NACE International "Book of Standards"

1. Field Measurement of Surface Profile of Abrasive Blast Cleaned Steel Surfaces Using Replica Tape: RP0287-91

2. Discontinuity (Holiday) Testing of Protective Coatings: RP0188-90

3. Visual Standard for Surfaces of New Steel Centrifugally Blast Cleaned with Steel Grit and Shot TM0175-75

C. NACE International Publication 6A192, "Dehumidification Equipment in Lining Application"

D. Society for Protective Coatings (SSPC), "Steel Structures Painting Manual, Vol. 1, Good Painting Practice"

E. Society for Protective Coatings (SSPC), "Steel Structures Painting Manual, Vol. 2, Systems and Specification"

1. Solvent Cleaning: SSPC-SP-1-82

2. Hand Tool Cleaning: SSPC-SP-2-95

3. Power Tool Cleaning: SSPC-SP-3-95

4. Power Tool Cleaning to Bare Metal: SSPC-SP-11-95

5. White Metal Blast Cleaning: SSPC-SP-5/NACE 1-94

6. Commercial Blast Cleaning: SSPC-SP-6/NACE 3-94

7. Brush-Off Blast Cleaning: SSPC-SP-7/NACE 4-94

8. Near-White Blast Cleaning: SSPC-SP-10/NACE 2-94

9. Mineral and Slag Abrasives: SSPC-AB 1-91

10. Visual Standard for Abrasive Blast Cleaned Steel: SSPC-Guide to Vis 1-89

11. Measurement of Dry Paint Thickness with Magnetic Gages: SSPC-PA 2

F. NSF International Standard 61 - Drinking Water System Components.

G. If there is a conflict between cited reference standards and this specification, this specification prevails unless otherwise indicated in the procurement documents.

1.05 SUBMITTALS

A. Submittals for materials and/or systems proposed for use on this project must conform to requirements included in Section 01330 and include, but not be limited to, those items listedfor each product/system below. Provide submittals to the Engineer for review.

B. Paint and Protective Coatings:

1. Manufacturer Technical Data Sheets for all paints, coatings, solvents, detergents and degreasers proposed.

2. Manufacturer Material Safety Data Sheets (MSDS) for all paints, coating and thinners proposed.

3. Color name and/or number with color chart for each specific coating product. Exterior topcoat color shall be City of Houston Barr Blue.

4. Manufacturer’s statement of conformance with ANSI/NSF 61 (NSF International) requirements for use on potable water tank interior surfaces.

5. Manufacturer's specific ventilation requirements for products used on interior surfaces. Provide ventilation requirements to ensure adequate evacuation of solvents to prevent solvent entrapment, worker exposure to solvents above the OSHAPEL, and timely coating system cure.

C. Abrasive Blast Products

1. Use abrasive blast products which conform to the Society for Protective Coatings (SSPC) Abrasive Specification No. 1. "Mineral and Slag Abrasives", except that copper slag is not permitted. Abrasive blast product submittals to include, but not be limited to, the following:

2. Manufacturer's certification or laboratory analysis that the product proposed contains less than 1% free crystalline silica.

3. Laboratory analysis of blast material presenting results of blast material testing as required in SSPC-AB 1, Table 1 requirements for Chemical and Physical Properties of Abrasives, except that the conductivity test for water soluble contaminants in accordance with ASTM D-4940 shall not exceed 500 microsiemens (micromhos).

4. Material Safety Data Sheets.

5. Composition, mesh size, and bulk density.

6. Recommended application nozzle, air requirements, and pressure.

D. Containment System

1. Include a sample or samples of containment materials including screens, tarpaulins, sheets, films and ground covers. Include manufacturer technical data sheets for the proposed containment system. In addition, include the following:

2. Outrigger/containment structural support system layout and details.

    a. For ground storage tanks, submit proposed arrangement of scaffolds and/or A-frames to support containment materials. Do not support containment from existing tank handrails or ladders. The scaffolding must be designed to support the weight of the containment materials and provide a safe working environment for workers.

    b. For elevated storage tanks, submit proposed layout of outrigger system, containment hoisting system, details of proposed method of connection to tank shell, list of structural members including, but not limited to, size of member, maximum allowable wind velocity before system must be lowered to prevent structural damage to the system and/or tank, method of determining wind velocity and proposed location of wind velocity measuring device. The outrigger system layout must be reviewed and sealed by a licensed Professional Engineer registered in the State of Texas.

3. Manufacturer’s technical data sheets for the proposed containment system.

4. Manufacturer's certification that proposed containment materials are fire resistant.

5. Provide a minimum shade factor for proposed containment materials of 95%, except for a minimum shade factor of containment materials used with chemical stripping agents of 85%.

E. Chemical Stripping Agents - For Rehabilitation of an Existing Tank

1. Manufacturer's Technical Data Sheet for the materials proposed.

2. Material Safety Data Sheets (MSDS).

3. Proposed method of application.

4. Waste material containment and retrieval system.

F. Dehumidification Equipment

1. Manufacturer and Supplier

2. Support Equipment (i.e. generator)

3. Equipment capacity, sized per NACE Publication 6A192

PART 2 PRODUCTS

2.01 COATINGS

A. Painting and Coatings

1. The following paint/coating manufacturers are known to have products of acceptable quality for this project: ACRO, Raven Lining Systems, Carboline, Sherwin - Williams, Tnemec, Valspar and Devoe (for exterior wash only). Bid based upon the use of products supplied by one of these named manufacturers. These named manufacturersare designated to establish a level of acceptable product quality or manufacturing experience and are not to be construed as the only manufactures of products acceptable for use on this project. Other manufacturers and products will be considered on an individual basis, and may be submitted for consideration in accordance with Document 00700, Article 3.10, Product Options and Substitutions (excluding 3.10.3), Section 01330, and this Section.

2. Specific products of the named manufacturers acceptable for use and to be bid for this project are contained in Table 1, "Coating Product," included in this section.

3. Use non-lead containing coatings which comply with all laws, regulations and ordinances of the Federal, State, and Local government including V.O.C. regulations.

4. Properly store and handle materials according to manufacturer's requirements and in compliance with applicable government regulations.

5. Color: Generally, colors are to be as follows:

   a. When multiple coats are required, use coatings alternating colors.

   b. Use white for the interior final coat.

   c. Use City of Houston Barr Blue for exterior final coat.

6. Obtain all coating materials and required thinners for each tank from the same single source coating manufacturer.

7. The schedule for painting and coating for specific tanks is contained in Table 2 "Surface Preparation and Finish Schedule" included in this Section.

B. Hot Dip Galvanized Surfaces

1. If specified, hot dip galvanize in accordance with ASTM A 123, ASTM A 385 and/or ASTM A 153.

2. The completed galvanized sections to have a minimum of 2 ounces per square foot. Two ounces of galvanizing per square foot equals approximately 3.4 mils.

3. Estimate weight of galvanizing by use of magnetic dry film thickness gage in accordance with ASTM E 376-89.

4. Galvanizing (zinc) in contact with potable water must be NSF classified for contact with potable water.

2.02 EPOXY CAULKING

A. Use flexible, NSF classified epoxy caulking for use in contact with potable water and compatible with the epoxy lining system used in the tank.

B. Caulk to be 100% solids, two component, polyamine or polyamide cured.

C. The coating manufacturer and caulk material manufacturer to confirm, in writing, that the internal epoxy coating system is compatible with the 100% solids epoxy caulk material.

D. Include in the written confirmation of material compatibility, any conditions for or surface preparation requirements of the epoxy caulk material.

E. An acceptable product for this Project is "Aquatapoxy A7", manufactured by Raven Lining Systems, Tulsa, Oklahoma.

2.03 CHEMICAL PAINT STRIPPER (FOR REHABILITATION OF AN EXISTING TANK)

A. Use of chemical paint stripper for removal of exterior paint is allowed, if approved by the Engineer and used in strict accordance with manufacturer’s recommendations.

B. Propose a chemical stripping system such as "Peel Away", manufactured by Dumond Chemicals, Inc. of New York, NY, or approved equivalent.

2.04 CONTAINMENT SYSTEM

A. Provide a containment system which allows for the containment of the environmentally sensitive waste, dust and paint over spray that will be generated during the blasting and painting operations.

B. When a tank is to be rehabilitated and the coatings to be removed contain lead, containment to conform at a minimum to the requirements of TNRCC Texas Air Control Board Regulation I, 31 TAC Chapter 111 Sections 131 through 139 and meet the performance requirements of Section 01351 "Environmental Safety and Worker Protection" of this specification.

C. When chemical stripping agents are used, provide for containment of debris, aerosols, strippings and other emissions or releases. In addition, manage contained waste in accordance with Section 02136 "Waste Material Handling, Testing and Disposal" and Contractor waste handling procedure.

D. Determine by the Engineer, the containment system requirements, if any, for wet abrasive blast or vacuum abrasive blast, and roller applied or brush-on coatings. Use impervious ground coverage as noted in Item 2.04.F.6 at all times.

E. Containment system proposed by the Contractor must assure the protection of the surrounding environment and must provide sufficient protection to meet: TNRCC Texas Air Control Board regulations for the Control of Air Pollution and Visible Emissions of Particulate Matter; Texas Water Commission regulations applicable to protection of the soil and water; and Sections 01351 - "Environmental Safety and Worker Protection" and 02136 "Waste Material Handling, Testing and Disposal" of this Specification.

F. Construct containment system with wind screens of a minimal shade factor as specified in section 1.05.D of this section, or as required below, with no emission from edges, rips, or tears. The containment system must be designed for the purpose of containing and controlling emissions, debris and protecting the air, ground and soil from contaminants resulting from lead paint removal, surface preparation and painting operations.

1. Containment System to provide a safe working environment and provide for control of emissions as required in Section 01351 "Environmental Safety and Worker Protection" of this Specification.

2. For rehabilitating an existing tank, employ a Containment System meeting the requirements of an SSPC Class 2 containment, per SSPC Guide 6 (CON), when lead containing paint is to be removed by abrasive blast cleaning methods.

3. The containment materials must provide for performance which will comply with the following:

    a. Protection of the environment, including air, water and soil, from abrasive blast media, process water, dust particles and paint debris.

    b. Air movement within containment.

    c. Secure edges and seams.

    d. Permeable to natural lighting, unless alternate lighting is to be provided.

    e. Tarp overlap to provide for maximum containment of spent debris.

4. Maintain the containment system free of defects through the course of the project. In the event that emissions or releases occur which exceed the requirements established in Section 01351, "Environmental Safety and Worker Protection," stop work until all defects are repaired.

5. Prior to installation, the containment system design must be submitted and reviewed by the Engineer. In addition, for work on elevated water storage tanks, design the containment enclosure to be raised and lowered within 15 minutes to prevent damage to the enclosure, the tank, personnel, and excessive loading to the tank and tank appurtenances in the event of high winds and foul weather.

6. Place membranes that are impervious to the abrasive blast media, paint debris dusts, and process water on the ground around the tank to prevent contamination of the ground storm waters and surface waters due to run-off. Use chemically resistant membranes when chemical stripping is employed. Contain the debris within 30 feet of the base of the tank.

7. Prior to any changes or modifications in the containment system during the course of the work, submit in writing and review by the Engineer, proposed changes and modifications. Address the operational and technical reasons for containment modifications in the submittal.

G. Eagle Industries, Reef Industries, or equivalent are acceptable suppliers.

2.05 ABRASIVE BLAST MATERIALS

A. Mineral and slag abrasive materials are to conform to the requirements of the Society for Protective Coating's Abrasive Specification No. 1, SSPC-AB1. Abrasives are to be Class A, less than 1% crystalline silica. The conductivity of the abrasive (indicative of water soluble contaminants) is not to exceed 500 microsiemen (micromhos) when tested in accordance with ASTM-D4940. Prior to use, provide the Engineer qualifications and conformance testing performed and documented in accordance with Section 5 of SSPC-AB1. Abrasive materials expressly prohibited from use include sand and copper slag.

2.06 PRODUCT HANDLING

A. Delivery and Storage

1. Deliver all paints, coatings and related materials to the job site or fabrication shop in original unopened containers with the product name, type and batch number, color, and manufacture date clearly marked on each container.

2. Store all materials used on the job in a single place provided by the Contractor or designated by the Engineer at the job site. Comply with OSHA requirements, recommendations of the National Fire Protection Association, City Fire Codes, and manufacturer recommendations for on site and fabrication shop storage.

3. Remove oily or solvent-soaked rags and all waste from the job site every night, and take all necessary precautions to reduce fire hazards to a minimum.

4. If the storage space was a fixed part of the project, leave clean upon completion of the work. Repair any damage to storage space or its surroundings.

PART 3 EXECUTION

3.01 COATING OPERATION ENVIRONMENTAL REQUIREMENTS

A. Tank Interior Humidity and Temperature

1. During abrasive blast cleaning and painting operations, the relative humidity of the interior air is not to exceed fifty percent (50%). Measure relative humidity by a sling psychrometer or other appropriate psychometric measuring equipment.

2. Maintain the interior air temperature and surface temperature of surfaces to be coated between 50˚F and 120˚F and at least 5˚F above the dew point or as otherwise required by the manufacturer. (Note, that for use of Aquatapoxy, the maximum surface temperature is 100˚F.)

3. Achieve the required conditions for interior air conditions through the use of dehumidification equipment.

   a. Submit for review by the Engineer, proposed dehumidification equipment. Provide a minimum of three air changes per hour unless dehumidification equipment manufacturer's calculations substantiate fewer air changes.

   b. Supply dry, fresh (not recirculated) air within 12 inches of the tank bottom from a system of duct work and blowers with the dehumidification equipment. Operate the ventilation system 24 hrs/day throughout the entire coating cure process.

   c. Maintain dehumidification until abrasive cleaning operations, coating operations and cure are complete, but not less than ten (10) days.

B. Tank Exterior Humidity and Temperature

1. Do not apply a coating to wet or damp surfaces or in rain, snow, fog or mist.

2. Do not apply any coatings when it is expected that the ambient air temperature will fall below 50˚F or within 5˚F of the dew point within 6 hours after application of coatings or paints.

3. Do not apply a coating when the relative humidity is above 85%, or as specified in the coating manufacturer's product data sheet. Measure relative humidity and dew point by use of a Sling Psychrometer in conjunction with US. Department of Commerce Weather Bureau Psychometric Tables. If the above conditions are exceeded, delay coating or painting operations until conditions are favorable.

4. The ambient conditions and surface temperature of the surfaces being coated must be between 50˚F and 120˚F and at least 5˚F above the dew point in accordance with the manufacturer's recommendations. The maximum surface temperature during application of urethane coatings is 100˚F.

3.02 WORKMANSHIP

A. Good workmanship is required for all work as defined by the latest edition of the "Manual of Good Painting Practices" published by the Society for Protective Coatings (SSPC), 40 24th Street, Pittsburgh, Pennsylvania 15222.

B. These specifications do not cancel or supersede the directions of the manufacturer regarding the warranty or applicability of the product. In instances of variations between manufacturer's recommendations and this specification, the more stringent requirement governs.

C. The Contractor to furnish trained personnel experienced in the work to be performed. Contractor to ensure work is performed in accordance with these specification requirements including, but not limited to: surface cleanliness; anchor profile; ambient conditions; film thickness (wet and dry) and holiday detection. Provide and use such inspection instruments, gauges or other equipment as may be required to verify compliance with manufacturer's instructions and these specifications. Assure proper operating condition and calibration of equipment and instrumentation before and after use.

D. Provide tools and equipment in good working order including moisture traps in air lines to pressure pot and spray gun when air atomization is used. Set moisture trap for continuous bleed during spraying operation. Place moisture traps as close to spray gun as practical. Process air to be free from oil and moisture when tested in accordance with ASTM D 4285.

E. Do not apply primer closer than four inches (4") to any surface scheduled for subsequent blasting or to be field welded.

F. Apply a brush stripe coat of primer, subsequent to surface preparation, but prior to full primer coat application to welds, rivets, corners, crevices, and other default to coat surfaces.

G. Apply all caulk and/or sealant materials smooth and continuous.

3.03 SURFACE PREPARATION

A. Remove visible deposits of oil or grease prior to surface preparation in accordance with SSPC-SP- 1 or other methods approved by the Engineer, remove visible deposits of oil or grease.

B. Prior to abrasive blast cleaning, remove all surface imperfections such as sharp fins, sharp edges, weld spatter, or burning slag. Grind sharp corners and edges to a smooth round edge with a radius of not less than 1/16 inch.

C. Abrasive blast cleaned surfaces to meet the requirements of this specification when examined in accordance with Society for Protective Coatings "Guide to SSPC-VIS 1-89". This applies to all exposed surfaces, including difficult to access areas (e.g. behind stiffener rings). When a tank is to be rehabilitated and the coatings to be removed contain lead, acceptable coating removal methods include wet abrasive blast cleaning, water jetting with or without abrasives, vacuum abrasive blast cleaning, and chemical stripping. Certain coating removal methods require subsequent dry abrasive blasting to achieve the specified surface preparation. Should these methods be selected, ensure that no fugitive dust escapes the containment system during dry abrasive blasting. This is to be accomplished by the use of negative air and/or dust collection systems adequately sized to effectively control dust.

D. For rehabilitation of an existing tank, Moderately Pitted Surface is defined as a surface having pits less than 1/16-inch deep with a frequency of 4 to 5 pits per square foot. Prior to application of the specified coating system, blast the pitted surface to SSPC-SP10. The first coat may be thinned (not to exceed manufacturer's published recommendations) and applied by stiff bristle brush or roller to all pitted surfaces.

E. For rehabilitation of an existing tank, Badly Pitted Surface is defined as a surface having pits greater than 1/16-inch deep and less than 1/2 of the metal thickness with a frequency of 8-12 pits per square foot. Prior to application of the specified coating system, blast the pitted surface to SSPC-SP10. Prior to applying the specified system, fill the pits with an epoxy caulk seam sealer applied by putty knife or stiff bristle brush.

F. Prior to painting, remove dust by vacuuming from all prepared interior surfaces to be coated.

G. Subsequent to achieving the specified surface preparation and prior to coating application, interior wetted surfaces must be free from surface contaminants, visible and non-visible, to a level of less than 7µg/cm2 as sodium chloride. Surfaces will be tested by the City's laboratory for evidence of surface contaminants including soluble iron and salts such as chlorides. A minimum of one test for every 2500 square feet of shell and floor area will be performed. Ensure tank interior is dust free at the time of the test and that the surfaces to be tested are clean.

H. Prepared exterior surfaces may be vacuumed or cleaned by an alternative method acceptable to the Engineer. (For rehabilitation of an existing tank, note that use of compressed air during lead paint removal operations is only allowable under full containment.)

I. Prepared and approved surfaces must be coated before contamination, including rust bloom. Surfaces shown to be contaminated or exhibiting rust are to be recleaned to the requirements of the specifications at Contractor's expense.

J. Repair abraded or otherwise damaged areas of existing paint using comparable materials and procedures, as approved by the Engineer.

K. Treat areas of visible mildew with an approved mildewcide, compatible with the coating system to be applied.

3.04 CHEMICAL STRIPPER (FOR REHABILITATION OF AN EXISTING TANK)

A. After application of chemical stripper and prior to recoating of the exterior surface of the tank, evaluate the anchor profile and surface cleanliness. If the surface cleanliness and anchor profile meet specification requirements, recoating of the tank can be performed. If surface cleanliness and/or anchor profile do not meet the requirements of this specification, prepare the surface in the manner specified to obtain the required anchor profile and freedom from surface contaminants.

B. For caustic based strippers, use pH paper to check the tank surface after removal of the chemical stripper and existing coating system. Failure to properly clean and neutralize the surface can result in an alkaline residue remaining on the tank surface. If the surface pH is not neutral (pH of 7.0 to 7.5), flush the surface with potable water or approved neutralizing agent until a neutral surface pH is achieved.

C. Notify the Engineer a minimum of 48 hours in advance of the initiation of the chemical stripper removal process in order for the Engineer to be present. The manufacturer's representative is required to be on site during the initial removal process.

D. Install tarpaulins or similar containment materials on the ground surface immediately under and adjacent to the area of the tank where the coating system is to be removed as described in Contractor's submittals and acceptable to the Engineer. Install the tarps in a watertight manner so as to completely contain all materials and liquids from chemical stripper application, removal, neutralization and rinsing of the tank surface. Consider all resulting waste hazardous and handle as such. Extend the watertight tarps a minimum of twenty feet beyond the outer perimeter of the tank.

E. Apply chemical strippers to the tank surface in accordance with the manufacturer’s recommendations for coverage, contact time, removal and surface cleaning.

F. For caustic based strippers, unless an inhibitor is recommended by the chemical stripper manufacturer and acceptable to the coatingmanufacturer, wash the surface after neutralization.

3.05 COATING APPLICATION

A. Apply coating to the standards represented in the SSPC Painting Manual, Volume 1, "Good Painting Practices" and manufacturer's recommendations for paint application procedures.

B. Use coating application equipment consistent with the coating manufacturer's recommendations. Supply air free from oil and moisture when tested in accordance with ASTM D 4285.

C. All mixing and thinning of coatings to be in accordance with manufacturer's recommendations.

D. Only compatible solvents recommended by the coating manufacturer will be used for thinning and clean up.

E. Strictly adhere to the re-coat intervals recommended and supplied by the coating manufacturer.

F. Do not coat any cleaned surface if "rust bloom" or recontamination has occurred. The Engineer to approve cleaned surfaces prior to application of coating.

G. The Engineer spot checks surfaces to ensure conformance. At Contractor's expense, re-prepare surfaces not found to meet specifications.

H. All painted surfaces to be free from all dust, dirt and contamination before succeeding coats are applied. The Engineer to approve each coat of paint before succeeding coats are applied.

I. All environmental (ambient) conditions to satisfy manufacturer's recommendations before coatings are applied.

J. All coats to be free of runs, drips, sags and holidays or other discontinuities. The finish is to be uniform.

K. Dry film thicknesses of all coats to conform to minimum and/or maximum thicknesses required by these specifications. Measure all dry film thicknesses in strict accordance with SSPC-PA2.

L. Interior – Prior to application of primer and prior to application of intermediate coat, brush stripe coat all welds, rivets, corners, edges, crevices and uniformly pitted surfaces. Brush stripe coat rough pits, depressions, and crevices to work in coatings. Do not thin stripe coats in excess of that recommended by the manufacturer.

1. For rehabilitation of an existing tank:

    a. Fill weld "deep pits" and grind flush at the direction of the Engineer. Payment to be at the unit price bid for "Extra 6-inch Diameter Floor Patches".

b. Moderately and badly pitted surfaces may exceed specified limits on the anchor profile. The primer coat dry film thickness must be sufficient to adequately cover the anchor profile.

M. Exterior - All welds, rivets, corners, edges and irregular surfaces are to be stripe coated as part of the first coat application. Brush stripe coat pits, depressions and crevices to work in coating. Apply coating by brush or roller, using manufacturers' recommended thinner (if applicable) for the application method selected. NO SPRAY PAINTING ON EXTERIOR SURFACES AT TANK SITES WILL BE PERMITTED WITHOUT THE USE OF CONTAINMENT SCREENS AND APPROVAL OF ENGINEER.

N. When more than one coat is to be applied, each coat should have a distinguishable color from the preceding and following coats. Note that stripe coating is considered to be part of the first coat application.

O. Exterior surface preparation and priming of all metal tank appurtenances to be in accordance with this specification. Intermediate and finish coatings to be the same as those of adjacent surfaces.

P. Pipe and Fittings

1. For elevated tanks, prepare the external surface of new and existing piping and fittings within the "dry" tank pedestal with the same surface preparation and coating system as the interior of the tank pedestal.

2. Prepare new above ground piping and fittings with the same surface preparation and coating system as specified for tank exterior.

3. Prepare existing above ground piping and fittings connected directly to the tank with the same surface preparation and coating system as specified for tank exterior. Limit this to exposed portions of piping at inlets/outlets and to the nozzle of the adjacent tank on interconnect lines. Additional limits of yard piping are indicated on the plans.

Q. Prepare and coat inaccessible interior surface of roof plate and rafters as follows:

1. For new tank construction, prepare inaccessible surfaces, such as interior surface of roof plate and rafters, with specified surface preparation. Prime coat prior to erection. Apply a minimum of two additional full coats prior to final placement. Surface preparation and prime coat application may be conducted off-site. Follow inspection of shop blasting and painting in accordance with this specification. Follow the recoat intervals recommended by the manufacturer.

2. For repair of existing tanks, prepare all inaccessible interior surfaces of roof plate and rafters to be installed with specified surface preparation and a minimum of two full coats prior to final placement.

R. Jack the roof plate/rafter interfaces, which are not accessible for surface preparation and coating work, off the rafters to facilitate blasting and coating the tops of rafters and the roof plate. Move wedges used to hold the roof plate off the rafters as required so that all areas between the rafters and roof plate are blasted and coated.

S. For wet surfaces, including immersion and condensation zones, maintain a constant positive flow of dehumidified air, with adequate circulation across the finish coat for a period of ten (10) days, minimum. Evacuate solvent from the bottom of the tank. Forced or induced airflow may be required. Any accelerated curing procedure must be recommended in writing by the manufacturer and approved by the Engineer.

T. Repair damaged areas in galvanized coating as follows:

1. Interior surfaces require a NSF approved cold galvanizing component.

2. Mechanical exterior damage to be prepared by hand tool (SP-2) or power tool (SP-3) spot cleaning and to be spot coated with an organic zinc coating approved by the Engineer.

3. Prepare damaged areas exhibiting red rust to bare metal (SP-11) and coat with an inorganic zinc coating approved by the Engineer.

U. Coatings work will be permitted during daylight hours only unless arrangements or permission has been granted in writing.

3.06 PROTECTION OF SURFACES

A. Unless otherwise specified, painting will not be required on the following items:

1. Exposed surfaces of Aluminum

2. Polished or finished Stainless Steel

3. Nickel, Monel, Copper, Bronze, Lead or Brass

4. Rubber and plastic including Fiberglass Reinforced Plastics

5. Chromium plated surfaces

B. If Contractor applies paint to or causes damage to surfaces to be protected or unspecified surfaces, removal of coating, repair or replacement of item is required.

C. Protect all surfaces, which are not to be painted, from overblasting, spraying, over spray, spatters, or spillage of paint.

3.07 PAINT SYSTEM IDENTIFICATION

A. Tank Label: Stencil (or use ready-to-apply decals) the information below to the side of the tank near the flush clean-out door for GST and the access door for EST about 3 feet from the ground after completion of the painting operation. Letters are to be 0.75 inches in height, the color is to be black and material is to be compatible with finish coat:

1. Date of coating application. Completion [month/year]

2. General Contractor, Painting Contractor

3. Interior coating system supplier and product number(s). Surface Preparation, Prime Coat, Intermediate Coat, Finish Coat, Caulking

4. Exterior coating system supplier and product number(s). Surface Preparation, Prime Coat, Intermediate Coat, Finish Coat

3.08 INSPECTION, TESTING, RECORD KEEPING

A. Schedule and coordinate work with the Engineer to allow for expeditious inspection by the City or designated representative, including the use of ladders, scaffolds, lighting and swingstages to provide regular access for inspections.

B. All surfaces ready to receive a coating must be approved by the Engineer before the application of the next succeeding specified coat. If the Contractor proceeds without such approval, he may, at the direction of the Engineer, be required to remove and/or recoat all such work at no additional cost to the City.

C. Measure wet film thickness at least once every thirty (30) minutes to make certain that proper film thickness is being achieved. More frequent checks may be required by the Engineer at the Engineer's direction.

D. Test all tank interior coated surfaces under the direction of the Engineer for nicks, scrapes and/or pinholes in the coating film using a low voltage, wet sponge holiday detector for thin film coating (<20 mils) and high voltage holiday detector for thick film coating (>20 mils). Perform holiday detection in accordance with NACE RP0188-90: "Discontinuity (Holiday) Testing of Protective Coatings." Correct any deficiencies to the satisfaction of the Engineer.

E. Record temperature, humidity, and dew point on a log including date and time reading obtained. Obtain a minimum of three such readings on days of coating application. The format for these records is presented in Table 3, "Daily Coating Summary Report" included in this Section. Enter the records into a Windows compatible file such as Quatro Pro or Excel and submit a hard copy with monthly pay requests for those months when coatings are applied. Furnish the Engineer with a 3-1/2" disk containing the complete coating summary report for the project at the end of the project, or in the interim, if requested.

F. Paint films showing sags, checks, blisters, teardrops, curtains, fish eyes, or fat edges will not be accepted. Entirely remove films exhibiting any of these defects and recoat the surface at no additional cost to the City.

G. Inspect blasted steel surfaces by the Engineer using SSPC-Vis 1-89, "Visual Standard for Abrasive Blast Cleaned Steel", or NACE TM-0175-75 for new steel.

H. Demonstrate surface profile conformance to the specifications by obtaining average results of a minimum of ten (10) equally spaced anchor profile determinations per 1000 square feet. Employ at the discretion of the Engineer, ASTM D 4417 "Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel" Method A, B or C. ASTM D 4417. Method C shall be employed to resolve any dispute. The average reading to be between 2.0 mils and 3.0 mils. Any individual profile point less than 1.5 mils or greater than 4.0 mils will be cause for rejection of the anchor profile. Rejected areas are to be reblasted to correct profile.

3.09 FINISH SCHEDULE

A. A list of the tanks to be coated is presented in Table 2, "Surface Preparation and Finish Schedule " at the end of this section. Table 2 contains the required pre-cleaning procedures, the degree of surface preparation and coating system schedule for the interior and exterior of the various tanks.

B. Utilize the following legend for TABLE 2 "Surface Preparation and Finish Schedule":

1. Prior to abrasive blasting, degrease oily residue using steam cleaner and/or water blaster. Check with black light and reclean if necessary. Check the pH of the surface for neutrality if an emulsifying type degreaser is used.

2. Prior to abrasive blasting, perform Solvent Cleaning (SSPC-SP-1-82) to remove oil, grease and other detrimental foreign contaminants for interior and/or exterior surfaces.

3. Power Tool Clean (SSPC-SP-3-82) any new welds, flame cut surfaces, buckshot and/or weld splatter associated with tank repairs, modifications and other new work.

4. Perform Near White Blast Cleaning (SSPC-SP10 - NACE No. 2) of all interior tank surfaces unless otherwise noted in the Finish Schedule. Achieve an AVERAGE of 2.0 mils to 3.0 mils with no individual reading greater than 4.0 mils or less than 1.5 mils for anchor profile on abrasive blasted surfaces.

5. Perform Near White Blast Cleaning (SSPC-SP10 - NACE No. 2) to the exterior surfaces. Achieve an AVERAGE of 2.0 mils to 3.0 mils with no individual reading greater than 4.0 mils or less than 1.5 mils for anchor profile on abrasive blasted surfaces.

6. Perform Commercial Blast (SSPC-SP6 - NACE No. 3) on all exterior surfaces. Achieve an AVERAGE of 2.0 mils to 3.0 mils with no individual reading greater than 4.0 mils or less than 1.5 mils for anchor profile on abrasive blasted surfaces.

7. Perform Brush-Off Blast (SSPC-SP7 - NACE No. 4) on all exterior surfaces to remove poorly adhering coatings, mildew, dirt, soil and other detrimental foreign contaminants. Use of TSP or equal will improve cleaning effectiveness.

8. Spot Repair by hand sanding and/or power tool cleaning any pinholed coatings, damaged coatings and/or rust spots. All repair areas are to be feathered into adjacent painted areas using the appropriate paint system specified for the applicable interior or exterior of the tank.

9. Three (3) Coat Interior Polyamide Epoxy Paint System having ANSI/NSF 61 approval for potable water service. Each coat in alternating colors.

    a. The total coating system to have a nominal dry film thickness of 10 mils to 16 mils.

    b. Each primer and intermediate coats to have a nominal 3 to 5 mils DFT. Finish coat to have a nominal 4 to 6 mils DFT.

    c. All DFT measurements are to be performed in accordance with SSPC-PA2 and represent the DFT, corrected for magnetic base readings.

10. Two (2) Coat Interior Polyamide Epoxy Paint System having ANSI/NSF 61 approval for potable water service. Each coat a different color.

    a. The total coating system to have a nominal dry film thickness of 7 mils to 11 mils.

    b. Primer coat to have a nominal dry film thickness of 3 to 5 mils, and for the finish coat, 4 to 6 mils.

    c. All DFT measurements are to be performed in accordance with SSPC-PA2 and represent the DFT corrected for magnetic base readings.

11. Interior Epoxy Caulk Material to be EPA and FDA approved for potable water service such as Raven Lining Systems A-7. Apply caulk material to surfaces which have received a Near White Metal Blast (SSPC SP-10 - NACE No. 2). Apply caulk in a smooth and continuous manner, overlapping material at least one inch on each side of seam to be caulked. Caulk to be at least 30 mils thick at centerline of seam. After material has cured but prior to application of any coating, lightly scarify the surface of the caulk material. Caulk material is not to be applied to continuous weld seams except as required to fill deep weld undercuts. The 1.0 inch overlap does not apply for deep pit repairs or undercuts.

12. Three (3) Coat Exterior Epoxy/Epoxy Urethane Paint System. Intermediate color to compliment topcoat color selected by the City.

    a. The total coating system to have a nominal dry film thickness of 9 to 12.5 mils.

    b. Primer coat to have a nominal dry film thickness (DFT) of 3 to 4.5 mils. Intermediate coat to have a nominal 4.5 to 6 mils DFT. Finish coat to have a nominal 1.5 to 2 mils DFT.

    c. All field coats to be brush or roller applied. SPRAY APPLICATION ON SITE REQUIRES APPROVAL OF CITY AND USE OF CONTAINMENT SCREENING.

    d. All DFT measurements are to be performed in accordance with SSPC-PA2 and represent the DFT adjusted for magnetic base readings of abrasive blast cleaned steel.

13. Two (2) Coat Exterior Epoxy /Urethane Paint System. Intermediate color to compliment topcoat color selected by the City.

    a. Total coating system to have a nominal dry film thickness of 6 to 8 mils.

    b. Primer coat to have a nominal 4.5 to 6 mils DFT. Finish coat to have a nominal 1.5 to 2 mils DFT.

    c. All field coats to be brush or roller applied. SPRAY APPLICATION ON SITE REQUIRES APPROVAL OF CITY AND USE OF CONTAINMENT SCREENING.

    d. All DFT measurements are to be performed in accordance with SSPC-PA2 and shall represent the DFT adjusted for magnetic base readings of abrasive blast cleaned steel.

14. Two (2) Coat Exterior Silicone Alkyd Paint System

    a. Prime all blasted and repaired areas with one coat of Alkyd Primer having a nominal DFT of 3 to 4.5 mils.

    b. Apply full Silicone Alkyd Finish Coat having a nominal DFT of 2.5 to 4 mils.

    c. Total coating system to have a nominal 5.5 to 8.5 mils DFT.

    d. All field coats to be brush or roller applied. SPRAY APPLICATION ON SITE REQUIRES APPROVAL OF CITY AND USE OF CONTAINMENT SCREENING.

e. All DFT measurements are to be performed in accordance with SSPC-PA2 and represent the DFT adjusted for magnetic base readings for abrasive blast cleaned steel.

15. Interior 100% Solids, Plural Component Paint System having ANSI/NSF 61 approval for potable water service.

a. Total coating system to have a minimum nominal dry film thickness of 20 to 25 mils.

b. Apply coating in one or two coats, as recommended by the manufacturer.

c. All DFT measurements are to be performed in accordance with SSPC-PA2 and shall represent the DFT corrected for magnetic base readings.

d. Application to be in strict accordance with the manufacturer's published requirements.

e. The use of dehumidification may be waived by the City when this system is utilized. Maintain surface cleanliness to ensure no coatings are applied over contaminated, rust blooms or otherwise discolored surfaces as specified elsewhere in these documents. Use ventilation equipment as required by the manufacturer to maintain a safe working environment.

16. Non-Skid Walk-way

a. GST – Provide three-foot wide safety/skid resistant roof walkway. Coating to be compatible with specified external prime coat coating system and applied to a properly cleaned surface. Spread crushed walnut shells or aluminum oxide on intermediate coat while still tacky to achieve a coarse textured finish. After this coat has cured, sweep all loose shells or grit from surface and apply finish coat. Finish coat paint color to be a contrasting shade to the roof color. For galvanized tanks, do not blast but clean according to SP-1. Apply one coat of wash primer, then apply skid resistant material.

b. EST – Provide safety/skid resistant walkway, as above, inside the handrail area on the tank roof.

17. Concrete Surfaces

a. Prior to application of specified system, pressure wash all surfaces to remove all dirt, laitance efflorescence and other non-cementitious material.

b. Prepare concrete, masonry units, brick and plaster surfaces by removing efflorescence, chalk, dust, dirt, grease and oils and by roughening the surfaces as required to remove glaze. High pressure water, 4,000 psi minimum at 2.5 gallons/minute minimum, with or without abrasive injection, will be used to remove poorly adherent or "powdery" existing paint.

c. Determine the alkalinity and moisture content of the surfaces. Where the alkalinity exceeds the paint manufacturer's recommendations for application of the paint, correct the condition in accordance with the paint manufacturer's recommendations. Do not apply paint to surfaces while the surface moisture content exceeds the paint manufacturer's moisture content limitations

18. Continuous tank ventilation system must be able to prevent the vapor concentration from reaching the TLV (threshold limit values) of exposure to the solvent(s) used in accordance with the TLV values published by the American Conference of Governmental Industrial Hygienists, 1991-1992 edition.

19. Inspect galvanized sheets for white rust deposits prior to erection. Clean any white rusted areas by the use of a water and scrub brush technique. Measure the coating thickness in accordance with ASTM E 376-69. Any thickness less than 3.0 mils may be cause for rejection of the plate.

20. On ground storage tanks with aluminum domes, apply 20 mils of Ameron 487 elastomeric polyurethane coating, or equivalent, to the top of the wind girder, exterior shell of the tank under the aluminum flashing at the wind girder, and lap 6" over the top edge of the shell inside the tank.

21. Apply 20 mils DFT nominal/16 mils minimum Corrocote II PW, 100% solids as manufactured by Madison Chemical Industries. Surface preparation to be in accordance with Manufacturer's published instructions.

3.10 SCHEDULING

A. Perform painting work according to the contract construction schedule as required in Section 01330 - Submittal Procedures.

B. Scheduling not to supersede temperature, humidity or other environmental requirements for coatings application included in these specifications.

C. Coordinate work of other trades and provide conditions for neat, clean, dust-free work.

3.11 SITE CLEAN-UP

A. The Contractor to maintain the construction site in a neat and orderly manner throughout the duration of the project.

TABLE NO. 1
COATING PRODUCTS

Coating System	**Coating Manufacturer**	**Primer Coat**	**Intermediate Coat**	**Finish Coat**
Tank Interior				
3 Coat Polyamide/	ACRO	4460	4460	4460
Polyamine Epoxy	CARBOLINE	891	891	891
	VALSPAR	32 SERIES	32 SERIES	32 SERIES
	TNEMEC	SERIES 20	SERIES 20	SERIES 20
	SHERWIN-WILLIAMS	TANK CLAD HS	TANK CLAD HS	TANK CLAD HS
2 Coat Polyamide Epoxy	ACRO	4460		4460
	CARBOLINE	891		891
	VALSPAR	32 SERIES		32 SERIES
	TNEMEC	SERIES 20		SERIES 20
	SHERWIN-WILLIAMS	TANK CLAD HS 60		TANK CLAD HS
2 Coat 100% Solids Plural Component	RAVEN			AQUATAPOXY A-
Tank Exterior				
3 Coat Epoxy/	ACRO	4422	4460	4429
Epoxy Polyurethane	CARBOLINE	893	890 or 893	134 HS or 134 HG
	VALSPAR	32 SERIES	32 SERIES	V40 SERIES
	TNEMEC	SERIES 20	SERIES 20	SERIES 74
	SHERWIN-WILLIAMS	Recoatable Epoxy Primer	Macropoxy 646	HI-SOLIDS Polyurethane
3 Coat Silicone Alkyd	ACRO	1144	2214V	2215V
	CARBOLINE	RUSTARMOR 29	SUBSIL 30 HS	SUBSIL 30 HS
	VALSPAR	U-13 F-28	20-W-9	21 SERIES
	TNEMEC	SERIES 37H	SERIES 2H	SERIES 82
	SHERWIN-WILLIAMS	KEM BOND HS	STEELMASTER 9500	STEELMASTER 9500
2 Coat Silicone Alkyd	ACRO	1104		2215V
	CARBOLINE	RUSTARMOR 29		SUBSIL 30 HS

Coating System	**Coating Manufacturer**	**Primer Coat**	**Intermediate Coat**	**Finish Coat**
	VALSPAR	13-R-89		V-20 SERIES
	TNEMEC	SERIES 37 H		SERIES 82
	SHERWIN-WILLIAMS	KEM BOND HS		STEELMASTER 9500
Skid Resistant Epoxy/ Polyurethane	ACRO	4422	4460	4429
	CARBOLINE	890	890	134 HS
	VALSPAR	32 SERIES	32-SERIES	V-40
	TNEMEC	SERIES 20	SERIES 20	SERIES 74
	SHERWIN-WILLIAMS	Recoatable Epoxy Primer	Macropoxy 646	HI-SOLIDS Polyurethane
Skid Resistant Silicone Alkyd	ACRO	1104	2214V	2215V
	CARBOLINE	RUSTARMOR 29	RUSTARMOR 29	SUBSIL 30 HS
	VALSPAR	V-13 F-28	20-W-9	21 SERIES
	TNEMEC	SERIES 37H	SERIES 2H	SERIES 82
	SHERWIN-WILLIAMS	KEM BOND HS	STEELMASTER 9500	STEELMASTER 9500
Special Service				
Pitted Surfaces Internal	RAVEN LINING	AQUATAPOXY A-6		AQUATAPOXY A-6
	SHERWIN-WILLIAMS	Steel Seam Trowel Grade		
Concrete Surfaces				
Internal	ACRO	4460	4460	4460
	CARBOLINE	891	891	891
	VALSPAR	32 SERIES	32-SERIES	V-40
	SHERWIN-WILLIAMS	TANK CLAD HS	TANK CLAD HS	TANK CLAD HS
Exterior Above Grade	ACRO	4453	4460	4429
	CARBOLINE	3359	3359	3359
	VALSPAR	CRETE/GARD II	CRETE/GARD II	CRETE/GARD II
	SHERWIN-WILLIAMS	METALATEX	METALATEX	METALATEX
Interior Flexible Caulking	RAVEN LINING	AQUATAPOXY A-7		

TABLE NO. 2
SURFACE PREPARATION AND FINISH SCHEDULE

Tank	INTERIOR			EXTERIOR			
	Surface Preparation	Paint System	Additional Work Items	Surface Preparation	Paint System	Additional Work Items	Comments

Notes:
1. See Table 1 "Coatings Products" for allowable coating manufacturers and products.
2. See Paragraph 3.09 B. "Finish Schedule" for description of items listed in this table.

END OF SECTION

SECTION 13111

CATHODIC PROTECTION FOR WATER TANK INTERIORS (SACRIFICIAL ANODE)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for sacrificial anode cathodic protection systems for the interior submerged surfaces of steel water storage tanks.

B. Specifications for anodes, wiring, test station and long life reference electrodes.

C. Requirement that all materials in contact with the water or exposed to the interior of the tank to be classified in accordance with ANSI/NSF 61 - Drinking Water System Components.

D. Reference to the National Electrical Code (latest edition) which is part of this specification.

1.02 RELATED SECTIONS

A. Section 01110 – Summary of Work

B. Section 01270 – Measurement and Payment

C. Section 01330 – Submittal Procedures

D. Section 01351 – Environmental Safety and Worker Protection

E. Section 13113 – Cathodic Protection for New Tank Bottoms

F. Section 13201 – Welded Steel Water Storage Tanks

1.03 MEASUREMENT AND PAYMENT

A. There is no separate measurement and payment for work performed under this Section. Include the cost for this work in the contract bid price for work of which this is a component part.

B. Payment will be full compensation for all labor, equipment, materials and supervision for the installation of the cathodic protection system, complete in place including anodes, reference cells, wiring, and all field welding, connections, adjustments, testing, cleanup, and other related work necessary for construction as shown on the Drawings and specified herein.

C. Refer to Sections 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ANSI/NSF 61 - Drinking Water System Components - Health Effects

B. ASTM D 1248 – Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

C. AWWA D 100 - Standard for Welded Steel Tanks for Water Storage

D. AWWA D 102 – Standard for Painting Steel Water-Storage Tanks

E. City of Houston Electrical Code.

F. NEC 70 - National Electrical Code (latest revision).

G. DOT 199 – Federal Substance Abuse and Testing Regulations

H. NACE International SP0196 – Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks

I. UL 83 - Thermoplastic-Insulated Wires and Cables.

J. UL 467 - Bonding and Grounding Equipment

K. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors

1.05 SUBMITTALS

A. General: Submittals to conform to the requirements of Section 01330 - Submittals.

B. Design Drawings and Computations: Prepare all computations and drawings by or under the direct supervision of a Corrosion Engineer who is a Professional Engineer, registered in the State of Texas with a minimum of ten years experience in cathodic protection design for water storage tanks. Design the system to provide effective corrosion control in accordance with the criterion for protection which is a tank-to-water potential, IR drop free, within a range of -0.850 volts to -1.050 volts relative to copper-copper sulfate reference electrode. Measure this potential free of the effect of voltage gradients (IR drops).

C. The Corrosion Engineer to base system capacity on:

1. Total surface area of the tank. Total surface area includes to the high water level (HWL) in bowl and wet risers in elevated tanks, which are 30-inch diameter or larger.

2. High quality interior coating.

3. Protection of bare steel surfaces due to coating deterioration of up to 10% of the total submerged surface area.

4. Chemical analysis of water including resistivity.

5. Minimum anode system life of twenty (20) years. Provide certificate, signed and sealed by Professional Engineer stating that computations and Drawings are in conformance with these design criteria.

D. Catalog Cuts: Submit manufacturer's catalog cuts for the system which demonstrates classification in accordance with ANSI/NSF 61 - Drinking Water System Components.

E. Operating and Maintenance Manual: Submit six (6) operating, monitoring and maintenance manuals for the cathodic protection system. Include operating instructions, maintenance data, product data and test procedures in the manuals.

F. Drawings: Maintain as-built Drawings of the corrosion system during installation and construction. Revise drawings to show exact locations of all wiring, connections and terminal boxes. Properly identify all items of equipment and material. Submit the original as-built Drawings to the City of Houston representative.

1.06 QUALITY ASSURANCE

A. Certification: Provide manufacturer's certification that all components of the cathodic protection system meet the requirements of the Drawings and specifications.

B. Drawings: The Drawings for the cathodic protection systems are diagrammatic. Do not scale the Drawings for exact locations unless scales are explicitly stated on the specific drawing. Determine exact locations by field conditions and non-interference with mechanical and structural features.

C. Inspection: All materials, fabrication and installations are subject to inspection and testing by the City of Houston or its designated representative.

1.07 QUALIFICATIONS

A. A minimum of five years experience installing and servicing the types of system described in this specification is required of the Cathodic Protection Contractor. Install the system by employees of the Cathodic Protection Contractor who have experience in the installation of water tank systems. All personnel subject to Federal Substance Abuse and Testing Regulations as required by DOT 199.

PART 2 PRODUCTS

All materials in contact with the water or exposed to the interior of the tank are to be classified in accordance with ANSI/NSF 61 “Drinking Water System Components”.

2.01 ANODES

A. General: Anode material to be high potential magnesium, having a diameter of 2.024 ±0.024 inches, extruded on a solid, 1/8-inch steel core with nominal length of 10-feet for each anode.

B. Composition: High potential magnesium alloy to conform to the following:

Element	% by Weight
Silicon	0.05 maximum
Copper	0.01 maximum
Nickel	0.001 maximum
Iron	0.002 maximum
Aluminum	2.5 – 3.5
Zinc	0.7 – 1.3
Manganese	0.2 minimum
Other	0.3 maximum
Magnesium	Remainder

C. Anode Lead Wire: Use No. 8 AWG stranded copper wire with medium density, high molecular weight polyethylene (HMWPE) insulation. Polyethylene to conform to ASTM D 1248, Type I, Class C, Grade 5.

D. Connection: Connect the anode-to-wire with a Thomas & Betts, C tap, crimp connector sized for No. 8 AWG stranded copper conductor. First crimp the wire to the 1/8-inch anode core and then silver solder to ensure electrical continuity and strength.

E. Anode Eye Ring: Drill and tap the end of the anode to a depth of 1-1/2 inches adjacent to the core wire. Screw a 3/8-inch diameter eye ring with a 3-inch shaft and a 1-inch inside diameter eye loop, 1-½ inches into the anode.

F. Encapsulation: Encapsulate the crimped connection and the shaft of the eye ring in epoxy. See Drawings.

2.02 MONITORING STATION

A. Enclosure: Use a NEMA 4X enclosure for the cathodic protection system monitoring station.

B. Meter: Cathodic protection potential/anode current DC voltmeter to have a push to read button connecting the permanent reference cell to the digital voltmeter with an internal resistance of not less than 1,000,000 ohms/volt and a minimum full scale of 1999 mV.

C. Shunt: Place a calibrated shunt in the anode circuit wired to the DC voltmeter for measuring DC current.

D. Resistor: Equip the monitoring station with a variable resistor (rheostat) sized not less than a 100 watt, 100 ohm, connected between the anode header cable and the tank lead wire.

E. Tank Negative Lead: Use No. 8 AWG stranded copper with THHW insulation for the system ground.

F. Test Lead: Install independent structure test lead not smaller than No. 18 AWG stranded copper TW or THHW insulation on the potential test circuit.

G. Tank Connections: Space the anode system structure and test structure connections six (6) or more inches apart on ladder stand off welded to tank shell. Connect with brass bolts as shown on Drawings.

H. Monitoring Station Mounting: Locate the monitoring station on the exterior of the tank for convenient operator serviceability approximately five (5) feet off the ground near the ladder.

2.03 REFERENCE ELECTRODES

A. General: Install two (2) copper-copper sulfate electrodes, manufactured with 99.99% pure copper coiled element. Cells are to remain stable (plus or minus 10 mV) in fresh water for a minimum of ten years.

B. Lead Wires: Use No. 14 AWG stranded copper wire with blue, medium density, high molecular weight polyethylene (HMWPE) insulation for the reference cell lead wire. Polyethylene to conform to ASTM D 1248, Type I, Class C, Grade 5. Terminate lead wire at monitoring station.

C. Encapsulation: Encapsulate the reference electrode to lead wire connection in epoxy to prevent water penetration.

2.04 ANODE SUSPENSION SYSTEM

A. Cord: Suspend the anode from a minimum 5/16 inch diameter polyester cord, tied to the anode eye ring and anchored to the roof of the tank as shown on the Drawings.

B. Lead Wires: Do not use the anode lead wire to support the weight of the anode.

2.05 ANODE HEADER CABLE

A. General: Use No. 8 AWG stranded copper, HMWPE insulated cable. Install header cable without cutting any strands of copper and run from each anode completing a full 3600 circle. Extend both ends of the anode header cable to the monitoring station where one end will terminate on a variable resistor. Connect the other end of the resistor to the tank with a No. 8 AWG copper wire. Terminate the other end of the header cable with a wire nut.

B. Interior Wiring: Insulate all wiring within the tank to prevent copper conductor contact with the potable water.

C. Exterior Wiring: Use stranded copper conductors, run in rigid, galvanized steel conduit for all wiring on the exterior of the tank.

2.06 ANODE CONNECTIONS

A. Connectors: Use a Thomas & Betts, C tap, crimp connector for a No. 8 AWG stranded to No. 8 AWG stranded copper wire connection for the anode lead wire to header cable splices.

B. Sealant: Seal splices between anode lead wires and collector cable with Scotchfill Insulation Putty, Scotch 130C Rubber Tape, and Scotch Super 88 Plastic Tape as manufactured by 3M. Coat the completed splice with Scotchkote.

PART 3 EXECUTION

3.01 PERFORMANCE

Perform all work in accordance with the following requirements:

A. General: Install components of the cathodic protection system in the manner and at the locations shown on the Drawings prepared by the Corrosion Engineer.

B. Inspection: Prior to installation, have the City of Houston or its designated representative, inspect materials and equipment. Replace any defective materials or components that do not satisfy the requirements of this specification.

C. Tank Attachments: All attachments to the interior, wetted surfaces of the tank should be constructed of non-metallic materials or mild steel that is provided with the same protective coating system as the tank shell. Where stainless steel accessories are used, such as ladders or safety rails, the stainless steel shall be electrically isolated from the tank.

D. Welding, Cutting and Coating: Follow AWWA Standards D 100 and D 102 for welding, cutting, and coating.

E. Electrical Continuity: Assure continuity by spot welding all sections of bolted or riveted tanks. Tank Construction Contractor to perform the welding.

F. Wiring: Handle and install lead wires to prevent damage from abrasion.

G. Connections: Seal electrical connections within the tank to prevent water penetration.

H. Monitoring Station: Mount the monitoring station at a convenient height (eye level) above grade for monitoring and service purposes.

I. Disinfection: The Tank Construction Contractor is responsible for disinfection.

J. Workmanship: Complete the work in a clean and safe manner.

K. Tank Closure: Security of all tank access locations (e.g. hatches) is the responsibility of the City of Houston.

3.02 ENERGIZING SYSTEM

A. General: After the system is installed and the tank is filled, provide startup service, which includes energizing, testing, and adjusting the system for optimum performance.

B. Prior to native state, polarized potential testing and commissioning of the system, give a minimum of 48 hours notice to the City of Houston, Engineering Project Manager to facilitate observation of the tests by a City Representative.

C. Method: Record all tank-to-water potential measurements with a calibrated, portable, copper-copper sulfate reference electrode and a portable, high impedance voltmeter. Measure native state, current "on" and "instant off" potentials at a minimum of five locations within the tank. Record potential and current measurements at the monitoring station.

D. Report: Review and evaluation of all test data is the responsibility of the Corrosion Engineer. In addition to the startup service, submit "as-built" drawings and an Operations and Maintenance Manual in accordance with Article1.05.

END OF SECTION

SECTION 13112

CATHODIC PROTECTION FOR WATER TANK INTERIORS (ICCP)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for impressed current cathodic protection (ICCP) systems for the interior submerged surfaces of steel water storage tanks where AC power is available.

B. Specifications for automatically controlled transformer - rectifiers, anode ring and long life reference electrodes.

C. Requirement that all materials in contact with the water or exposed to the interior of the tank to be classified in accordance with ANSI/NSF 61 - Drinking Water System Components.

D. The National Electrical Code (latest edition) is referenced and is part of this specification.

1.02 RELATED SECTIONS

A. Section 01110 – Summary of Work.

B. Section 01270 – Measurement and Payment

C. Section 01330 – Submittal Procedures.

D. Section 01351 – Environmental Safety and Worker Protection.

E. Section 13113 – Cathodic Protection for New Tank Bottoms.

F. Section 13201 – Welded Steel Water Storage Tanks.

1.03 MEASUREMENT AND PAYMENT

A. There is no separate measurement and payment for work performed under this Section. Include the cost for this work in the contract bid price for work of which this is a component part.

B. Payment will be full compensation for all labor, equipment, materials and supervision for the installation of the cathodic protection system, complete in place including rectifiers, automatic controllers, anodes, reference cells, power feeds, and all field welding, connections, adjustments, testing, cleanup, and other related work necessary for construction as shown on the Drawings and specified herein.

C. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ANSI/NSF 61 - Drinking Water System Components - Health Effects

B. ANSI/AWWA D104 - Automatically Controlled, Impressed - Current Cathodic Protection for the Interior Submerged Surfaces of Steel Water Storage Tanks

C. ASTM B 348 – Titanium and Titanium Alloy Bars and Billets

D. ASTM D 1248 – Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

E. ASTM D 3359 - Standard Test Methods for Rating Adhesion by Tape Test

F. AWWA D100 –Welded Carbon Steel Tanks for Water Storage

G. AWWA D102 –Coating Steel Water-Storage Tanks

H. NACE International SP0388 – Recommended Practice, Impressed Current Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks

I. NEC 70 - National Electrical Code (latest revision)

J. City of Houston Electrical Code

K. UL 83 - Thermoplastic-Insulated Wires and Cables

L. UL 467 - Bonding and Grounding Equipment

M. UL 486A - Wire Connectors

N. UL 506 – Specialty Transformers

1.05 SUBMITTALS

A. General: Submittals to conform to the requirements of Section 01330 - Submittals.

B. Design Drawings and Computations: Prepare all computations and drawings by or under the direct supervision of a Corrosion Engineer who is a Professional Engineer, registered in the State of Texas with a minimum of ten years experience in cathodic protection design for water storage tanks. Design the system to provide effective corrosion control in accordance with the criterion for protection which is tank-to-water potential, IR drop free, within a range of -0.850 volts to -1.050 volts relative to copper-copper sulfate reference electrode. Measure this potential free of the effect of voltage gradients (IR drops).

C. The Corrosion Engineer to base system capacity upon:

1. Total surface area of the tank. Total surface area includes to high water line in bowl and wet risers in elevated tanks, which are 30-inch diameter or larger.

2. High quality interior coating.

3. Protection of bare steel surfaces due to coating deterioration of up to 10% of total submerged surface area.

4. Chemical and electrical analysis of water including conductivity.

5. Minimum anode system life of twenty (20) years.

6. Provide certificate, signed and sealed by the Professional Engineer stating that computations and Drawings are in conformance with these design criteria.

D. Catalog Cuts: Submit manufacturer's catalog cuts for the system which demonstrates classification in accordance with ANSI/NSF 61 – Drinking Water System Components.

E. Rectifier Operation and Maintenance Manual: The rectifier manufacturer to include a complete operation and maintenance manual with each rectifier shipped to the job site. In addition to operating instructions, include in the manual a circuit diagram and spare parts list. Manufacturer to operate the rectifier under full load conditions at the factory, and thoroughly inspect and test prior to delivery to the job site. Report results of this testing on a manufacturer’s quality control form and include in the rectifier operation and maintenance manual. Each operating manual to be identified by rectifier model number and individual serial number.

F. Operating and Maintenance Manual: Submit six (6) operating, monitoring and maintenance manuals for the cathodic protection system. Include operating instructions, maintenance data, product data and test procedures in the manuals.

G. Drawings: Maintain as-built drawings of the corrosion control system during installation and construction. Revise drawings to show exact locations of all wiring, connections and terminal boxes. Properly identify all items of equipment and material. Submit the original as-built drawings to the City of Houston representative.

1.06 QUALITY ASSURANCE

A. Certification: Provide manufacturer's certification that all components of the cathodic protection system meet the requirements of the Drawings and specifications.

B. Drawings: The Drawings for the cathodic protection systems are diagrammatic and not scaled for exact locations unless scales are explicitly stated on the specific drawing. Determine exact locations by field conditions and non-interference with other mechanical and structural features.

C. Inspection: All materials, fabrication and installations are subject to inspection and testing by the City of Houston or its designated representative.

1.07 QUALIFICATIONS

A. A minimum of five years experience installing and servicing the types of system described in this specification is required for the Cathodic Protection Contractor. Install the system by employees of the Cathodic Protection Contractor who have experience in the installation of water tank systems. All personnel subject to Federal Substance Abuse and Testing Regulations that satisfy the requirements of DOT 199.

PART 2 PRODUCTS

All materials in contact with the water or exposed to the interior of the tank are to be classified in accordance with ANSI/NSF 61 “Drinking Water System Components”.

2.01 TRANSFORMER-RECTIFIER

A. Use air-cooled cathodic protection transformer-rectifiers with automatic potential control.

B. DC Output Ratings: Rate rectifiers as shown on the Drawings. Provide for continuous, full rated output at an ambient temperature of 45° C, in full sunlight with an expected life in excess of 10 years.

C. AC Input Ratings: Obtain full rated DC output with an AC input voltage at 5% below the nominal value. Continuous AC input voltage at 10% above the nominal value shall not damage the transformer, the diode bridge assembly, or exceed any component ratings. (Note: This applies provided that the rectifier has not been previously adjusted to exceed the maximum DC voltage or amperage rating of the unit.)

D. Cooling: Cool units by natural air convection. Vent cabinets for natural air convection and screen against insects.

E. Rectifying Elements: For rectifying elements, use silicon diodes sized as follows:

1. The Peak Inverse Voltage (PIV) of the diode to be 300% of the maximum impressed voltage on the diode or 400 volts, whichever is greater.

2. Configure diodes into a full-wave bridge assembly. Size diodes to carry an average current of no more than 55% of the manufacturer’s recommended maximum current rating.

3. Size heat sinks to keep diode case temperatures less than 100° C at rated rectifier output and at maximum rated ambient temperature.

4. Protect diodes against overload by means of semiconductor fuses, located in the transformer secondary leg to the diode bridge assembly.

5. Equip diodes with supplemental Metal Oxide Varistor (M.O.V.) surge arrestors at the diode bridge assembly sized to provide protection against secondary over- voltage surges.

F. AC Circuit Breakers: Provide input overload and short circuit protection by magnetic trip circuit breakers. Size the circuit breaker to hold 100 percent of rated load. It may trip between 101 percent and 125 percent of rated load and must trip at 125 percent and above. This applies to all rectifiers with rated AC input currents greater than 4 amperes. For units rated below 4 amperes, use a 5 ampere rated circuit breaker.

G. Surge Protection: Provide separate AC and DC surge protection by means of high energy Metal Oxide Varistors rated at 500 joules on DC output and 1000 joules on the AC input.

H. Electrical Panels: Electrical panel minimum thickness is 0.187" NEMA Grade "XX" laminated phenolic, rated for Class "B" operation (105° C maximum). Equip rectifiers rated at 100 amperes DC or higher with panels constructed from a minimum sheet thickness of 1/4" "UTR" fiberglass reinforced laminate rated for Class "F" operation (155° C). Either permanently silk-screen onto the panel or use 1/16” lamicoid (plastic laminate) adhesive labels permanently engraved with white lettering on a black background, the rectifier instrument panel identifications. Mechanically affix the adhesive labels to the panel via stainless steel rivets or screws.

I. Connection Hardware: For all electrical hardware, use copper or high conductivity brass, suitably sized, and finished with electrolyses nickel plating for superior corrosion resistance. Tightly secure all connections with lock washers and nuts torqued to manufacturer's recommended specifications. For all electrical connections, use the “double nut” method to ensure that any compression of the panel material will not affect the electrical conductivity of the connection.

J. Enclosures:

1. Construct enclosures from a minimum 12 gauge, wiped coat mill galvanized steel, finished in 3 – 5 mils of polyester fusion bonded powder coating.

2. Use stainless steel hinges and cabinet assembly bolts.

3. Equip enclosures with a pad-lockable draw latch. Latch shall be manufactured from 12 gauge steel, finished in zinc-dichromate plating. Draw latch shall accommodate a 3/8 inch shackle padlock.

4. Equip enclosures with a grounding lug sized to accommodate up to a No. 6 AWG conductor.

5. Provide separate conduit knockouts for AC and DC; conveniently located and adequately sized for input and output conduit connectors.

6. Furnish cabinet with suitable channel brackets for wall or pole mounting.

7. Equip rectifier with slide-out chassis and hinged door, for access to the front and at least one side of the cabinet.

K. Automatic Controller: Use IR Drop Free automatic controller:

1. Automatic controller to adjust current output to compensate for changes in water level, temperature of water, water chemistry, and cathodic polarization.

2. Control from copper/copper sulfate reference electrodes with a minimum of two electrodes positioned in the tank. One cell is the operating cell and the other is for a back up and testing.

3. Reference electrodes to constantly monitor the tank-to-water potential, free of IR drop.

4. Automatic controller to automatically adjust the current output to maintain the tank-to-water potential, free of IR drop, to a preset value.

5. Operate within 25 mV of preset value.

6. Automatically limit current to a preset value.

7. Use a digital potential meter to display tank-to-water potential, free of IR drop.

L. Wet Riser: Provide, if shown on the Drawings, a separate automatic potential controller for the wet riser. For the automatic controller for the wet riser, use the same type and install in the same cabinet as the automatic potential controller for the bowl anode system. The bowl and riser controllers to operate independently of each other from copper/copper sulfate reference electrodes positioned to monitor the bowl area and wet riser areas separately.

M. Transformers: Transformers to conform to UL 506, Specialty Transformers and the following:

1. Isolation transformer designed with separate isolated primary and secondary windings with a minimum efficiency of 95%.

2. Equip transformer secondary with a minimum of 25 steps of secondary voltage adjustment (5-COARSE, 5-FINE). Use tap bars for tap adjustment.

3. Rate transformer materials and construction for Class "H" operation (180° C). Further enhance insulation materials by dipping in thermosetting varnish and baking.

4. Rate the transformer for a minimum dielectric strength of 2250 volt applied for one minute between the windings, and between the windings and the core.

N. Miscellaneous:

1. All rectifiers to operate with either a 115 or 230-volt, single phase, 60 hertz AC input.

2. Cathodic Protection Rectifier to be 100% quality control tested as outlined in this specification.

3. During manufacture, subject the rectifier to frequent visual and performance testing to ensure a high degree of quality.

4. Subject rectifiers to 100% testing of the following rectifier electrical parameters:

   a. AC input voltage, current, apparent power and true power.

   b. DC output current, voltage and power.

   c. AC power factor.

   d. AC to DC conversion efficiency.

   e. Output ripple.

2.02 EXTERNAL DISCONNECT SWITCH

A. General: Locate an AC disconnect switch, external to the rectifier unit immediately adjacent to the rectifier.

B. Disconnect Switch: Use a fusible, circuit breaker with rainproof enclosure and lockable cover for incoming 120/240 volt, single phase AC power for external disconnect. Use Square D, model Q02100NRBCP or approved equal.

C. Label: Clearly label the disconnect switch “Cathodic Protection Power Supply.”

2.03 REFERENCE ELECTRODES

A. General: Reference electrodes to consist of copper-copper sulfate electrodes, manufactured utilizing a 99.99% pure copper coiled element. The cells are to be manufactured to remain stable (plus or minus 10 mV) in fresh water for a minimum of ten years.

B. Lead Wires: Reference cell lead wire to be No. 14 AWG stranded copper wire with blue, medium density, high molecular weight polyethylene (HMWPE) insulation. The polyethylene to conform to ASTM D 1248, Type I, Class C, Grade 5. Lead wire to be terminated at rectifier.

C. Encapsulation: Encapsulate the reference electrode to lead wire connection to prevent water migration.

2.04 ANODE SUSPENSION SYSTEM

A. General: There are two anode suspension systems to be used based upon the source water for the tank which determines the access requirements for cleaning. Use a horizontal system for surface water tanks and a vertical system for ground water tanks.

B. Horizontal System: Comply with ANSI/AWWA Standard D104, Section 4.2.4.2.1 Type A, Horizontal System for anode suspension. Secure a minimum 5/16 inch diameter polyester cord to steel anchors welded to the side wall of the tank bowl, or to the exterior of the dry access column of spheroidal type tanks. Tie and tape all cord to cord connections. For larger capacity tanks, flotation buoys may be used to obtain more effective patterns of protective current distribution.

C. Vertical System: Comply with ANSI/AWWA Standard D104, Section 4.2.4.2.2. Type C, Vertical System for anode suspension. Attach the anode lead wire to coated or stainless steal clevises which are welded or bolted to the roof or roof supports.

2.05 ANODE MATERIAL

A. For the anode, use a copper cored, mixed metal oxide coated titanium wire as manufactured by Eltech Systems Corporation or approved equal.

B. Anode Substrate: Draw the anode wire to a diameter of 0.062 inches from Grade 1 or Grade 2 Titanium per ASTM B 348. Clean the substrate and roughen the surface. Remove all organic materials such as cutting oils, which could interfere with coating adhesion by cleaning. Achieve surface roughness by chemically etching the substrate as a minimum. Blasting the substrate may be used in addition to chemical etching, but not as a substitute. Apply an anti-passivation layer to the substrate prior to application of the mixed metal oxide coating.

C. Mixed Metal Oxide Coating: Apply an electrocatalytic coating to the prepared titanium substrate. Coating composition to be iridium oxide and tantalum oxide. Coordinate the total coating loading requirements with the manufacturer's proprietary information to achieve the required performance. The average gain rate for catalyst application not to exceed 0.16 g/ft2 (1.7 g/m2) and the maximum gain rate for any single coat not to exceed 0.25 g/ft2 (2.7 g/m2). Measure coating loading using an X-ray gauge which is calibrated at least once per shift for the specific coating type. This test directly measures precious metal loading. Simple weight gain is not an acceptable measure. Test the adhesion of the catalytic coating according to ASTM D 3359. The manufacturer to certify conformance with these requirements.

D. Connections: Seal all anode to header cable connections to prevent water penetration.

2.06 WIRING

A. Insulate all wiring within the tank as provided with the ANSI/NSF 61 classified system to prevent copper conductor contact with the potable water. For all wiring on the exterior of the tank, use stranded copper conductors with TW or THW insulation, run in rigid, galvanized steel conduit.

PART 3 EXECUTION

3.01 PERFORMANCE

A. Perform all work in accordance with the following requirements.

B. General: Install components of the cathodic protection system in the manner and at the locations as shown on the Drawings prepared by the Corrosion Engineer.

C. Inspection: Have the materials and equipment inspected by the City or its designated representative prior to installation. Replace any used or defective materials, or components that do not satisfy the requirements of this specification.

D. Rectifier Mounting: Perform welding of steel rectifier mounting bolts by the Tank Construction Contractor prior to coating the tank. Furnish drawings and materials to the Tank Construction Contractor prior to coating.

E. Tank Attachment: All attachments to the interior, wetted surfaces of the tank should be constructed of non-metallic materials or mild steel that is provided with the same protective coating system as the tank shell. Where stainless steel accessories are used, such as ladders or safety rails, the stainless steel shall be electrically isolated from the tank.

F. Welding, Cutting, Coating: Weld, cut and coat in accordance with AWWA Standards D 100 and D 102.

G. Electrical Continuity: Assure electrical continuity of all sections of bolted or riveted tanks by spot welding. Welding to be performed by the Tank Construction Contractor.

H. Conduit and Wiring: Perform electrical work in accordance with the National Electrical Code.

I. Lead Wires: Handle and install lead wires to prevent damage from abrasion.

J. Electrical Connections: Seal electrical connections within the tank to prevent water penetration.

K. Transformer-Rectifier Mounting: Mount the transformer-rectifier with the indicating meters approximately five feet above grade for monitoring and service purposes.

L. Electrical Service: Provide AC electrical service for the transformer-rectifier unit. Furnish and install the necessary wiring, conduits, wires, external disconnect switch and equipment to the service connection.

M. Disinfection: Disinfection is the responsibility of the Tank Construction Contractor.

N. Workmanship: Complete work in a clean and safe manner.

O. Tank Closure: Securing of all tank access locations (e.g. hatches) is the responsibility of the City.

3.02 ENERGIZING SYSTEM

A. General: After the system is installed and the tank is filled, provide startup service which includes energizing, testing, and adjusting the system for optimum performance.

B. Notice: Prior to native state, polarized potential testing and commissioning of the system, give a minimum of 48 hours notice to the City of Houston, Engineering Project Manager to facilitate observation of the tests by a City representative.

C. Locks: In order to maintain the set parameters for the transformer-rectifier, install a hardened steel lock for the transformer-rectifier enclosure provided by the City of Houston, Cathodic Protection Program Administrator. The external disconnect will be locked by City of Houston Water Production Personnel.

D. Methods: Field test the system by conducting IR drop-free measurements. Measure “instant off” tank-to-electrolyte potentials to determine system performance and to adjust the system. Record all tank-to-water potential measurements with the permanent and with a calibrated, portable, copper-copper sulfate reference electrode and a portable high impedance voltmeter. Measure a minimum of five locations within the tank.

E. Reports: Review and evaluation of all test data is to be performed by the Corrosion Engineer. In addition to the startup service, submit “as-built” drawings and an Operations and Maintenance Manual to the City of Houston in accordance with Article 1.05.

END OF SECTION

SECTION 13113

CATHODIC PROTECTION FOR NEW TANK BOTTOMS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for impressed current cathodic protection systems for the bottom (soil side) of steel water storage tanks that are constructed at grade level.

B. Specifications for manually controlled transformer-rectifiers, distributed anodes and permanent reference electrodes.

C. The National Electrical Code (latest edition) is referenced and is part of this specification.

1.02 RELATED SECTIONS

A. Section 01110 – Summary of Work

B. Section 01270 – Measurement and Payment

C. Section 01330 – Submittal Procedures

D. Section 01351 – Environmental Safety and Worker Protection

E. Section 13111 – Cathodic Protection for Water Tank Interiors (Sacrificial Anode)

F. Section 13112 – Cathodic Protection for Water Tank Interiors (ICCP)

G. Section 13201 – Welded Steel Water Storage Tanks

1.03 MEASUREMENT AND PAYMENT

A. No separate measurement and payment for work performed under this Section. Include the cost for this work in the contract bid price for work of which this is a component part.

B. Payment will be full compensation for all labor, equipment, materials and supervision for the installation of the cathodic protection system, complete in place including rectifier systems with distributed anode ground bed under the tank. Included are junction boxes, reference cells, wiring and all excavation, backfill, field welding, connections, adjustments, testing, cleanup, and other related work necessary for construction as shown on the drawings and specified herein.

C. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ASTM C 94 - Ready Mixed Concrete

B. ASTM D 1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

C. ASTM B 348 – Titanium and Titanium Alloy Bars and Billets

D. ASTM D 3359 – Standard Test Methods for Rating Adhesion by Tape Test

E. NEC 70 - National Electrical Code

F. City of Houston Electrical Code

G. NACE International SP0193 –External Cathodic Protection of On- Grade Carbon Steel Storage Tank Bottoms

H. NACE International SP0169 - Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems

I. NEMA TC6 - Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations

J. NEMA TC9 - Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation

K. NEMA 4 - Type 3R Enclosures

L. UL 83 - Thermoplastic-Insulated Wires and Cables

M. UL 467 - Bonding and Grounding Equipment

N. UL 486A-486B - Wire Connectors

O. UL 506 – Specialty Transformers

1.05 SUBMITTALS

A. General: Submittals to conform to the requirements of Section 01330 - Submittals.

B. Design Drawings and Computations: Prepare all computations and drawings by or under the direct supervision of a Corrosion Engineer who is a Professional Engineer, registered in the State of Texas with a minimum of ten years experience in cathodic protection design. A 50- year design life is required for the anode system.

C. Catalog Cuts: Submit manufacturer's catalog cuts for each item. Include the manufacturer’s name and provide sufficient information to show that the materials meet the requirements of the drawings and specifications. Where more than one item or catalog number appears on a catalog cut, clearly identify the item proposed.

D. Notice: Give the City of Houston Representative a minimum of 48 hours notice prior to placing the anodes.

E. Rectifier Operation and Maintenance Manual: Include a complete operation and maintenance manual with each rectifier shipped to the job site. In addition to operating instructions, include a circuit diagram and spare parts list. Operate the rectifier under full load conditions at the factory and thoroughly inspect and test rectifier by the manufacturer prior to delivery to the job site. Report results of this testing on a manufacturer's quality control form and include in the operation manual. Reference each operating manual by rectifier model number and individual serial number.

F. Operating and Maintenance Manual: Submit six (6) operating, monitoring and maintenance manuals for the cathodic protection systems. Include in the manuals, initial test data, operating instructions, maintenance data, product data and test procedures.

G. Drawings: Maintain as-built drawings of the corrosion control system during installation and construction. Revise drawings to show exact locations of all anodes, wiring, connections, terminal boxes and power supplies. Properly identify all items of equipment and material. Submit the original as-built drawings to the City of Houston or its designated representative.

1.06 QUALITY ASSURANCE

A. Provide manufacturer's certifications that all components of the cathodic protection systems meet the requirements of the drawings and specifications. Reference the applicable section of the specifications and the applicable standard details on the certification.

B. The drawings for the cathodic protection systems are diagrammatic and do not scale for exact locations unless scales are explicitly stated on the specific drawing. To determine exact locations, use field conditions, non-interference with other utilities or mechanical and structural features. Note other existing utilities in the area and during excavation. Do not damage these utilities. Repair any damaged utilities to the satisfaction of the City of Houston at the Contractor's expense.

C. All materials, fabrication and installations are subject to inspection and testing by the City of Houston or its designated representative.

PART 2 PRODUCTS

2.01 IMPRESSED CURRENT ANODES

A. Description: Use mixed metal oxide coated, titanium tubes, as manufactured by Elgard or approved equal.

1. Anode Substrate: Form the tubular anode substrate from Grade 1 or Grade 2 Titanium per ASTM B 348.

2. Mixed Metal Oxide Coating: Deposit an electrocatalytic coating of iridium oxide on the titanium surface. Specifically design the coating for oxygen evolution. Do not include ruthenium oxide as a component element of the coating. Physical properties of the mixed metal oxide to conform to the following:

Density	0.163 pounds/cubic inch
Melting Point	1260°F
Resistivity	1.0 X 10-5 ohm-cm
Coverage	20-30 m2/gm

3. Size: Tubular anode dimensions to be 1.25” diameter x 48” long.

B. Anode Lead Wire Connection:

1. Use No. 8 AWG, seven strand, copper conductor with HMW/PE insulation for the anode lead wire.

2. Attach the anode lead wire internally at the longitudinal center of the tubular anode by use of a brass wedge connector which grips firmly to the internal circumference of the anode. Protect this connection from moisture intrusion by filling the entire anode tube with a waterproofing sealant.

3. The resistance of the finished connection not to exceed 0.001 ohms.

4. The pull-out strength of the connection not to be less than the breaking strength of the No.8 AWG wire or 520 pounds.

C. Anode Canister:

1. Package each anode in a 24 gauge, galvanized steel, spiral crimped canister, 6 inches in diameter by 60-inches long filled with calcined petroleum coke.

2. Place the petroleum coke around the anode and vibrate to achieve maximum compaction.

3. Cap the cylinder at each end with a ¾ inch plywood cap affixed with sheet metal screws. The top cap shall have a ½ inch diameter hole drilled in the center for the anode lead wire.

D. Anode Backfill: Use SWK calcined petroleum coke, as manufactured by Loresco to fill the canister containing the impressed current anodes. Anode backfill to conform to the following:

1. Typical Chemical Analysis.

Component	Percent Composition
Carbon (fixed)	99.35 minimum
Ash	0.6 maximum
Volatiles	0 (950 □ C)
Moisture	0.05

2. Physical Properties.

   a. Bulk Density, pounds/cubic foot 70 pounds/cubic foot

3. Particle Analysis.

   a. Range from 0.004 to 0.50 inches.

2.02 RECTIFIERS

A. Cathodic protection rectifiers to be air-cooled, tap adjust Super Custom model as manufactured by Corrpower, Universal Rectifiers or approved equal conforming to NEMA MR-20-1958 and listed in the CSA File No. 45382.

B. DC Output Ratings: Rate rectifiers as shown on the drawings. Supply units that are capable of operating at continuous, full rated output at an ambient temperature of 45° C, in full sunlight with an expected life in excess of 10 years.

C. AC Input Ratings: Obtain full rated DC output, with an input voltage +10 percent of the nominal rated input.

D. Cooling: Cool by natural air convection. Vent cabinets for natural air convection and screen against insects.

E. Voltage Adjustments: Provide adjustment of the output voltage by means of not less than 25 approximately equal steps of secondary taps from 5 percent of rated voltage to full-rated voltage.

F. Rectifying Elements: Rectifying elements require silicon diodes sized as follows:

1. Rate diode voltage at 400 volts minimum for rectifier outputs up to 100 VDC, and 800 volts minimum for rectifiers with outputs from 100 to 200 VDC.

2. Configure diodes into a full-wave bridge assembly. Size diodes to carry a minimum average current of one half of rated rectifier output.

3. Size heat sinks to keep diode junction temperatures less than 100° C at rated output and maximum ambient temperature.

4. Protect diodes against overload by means of semiconductor fuses, located in the transformer secondary leg to the diode bridge assembly.

5. Equip diodes with supplemental Metal Oxide Varistor (M.O.V.) surge arrestors at the diode bridge assembly, sized to provide protection against secondary over- voltage surges.

G. AC Circuit Breakers: Provide input overload and short circuit protection by magnetic circuit breakers. Size the circuit breaker to hold 100 percent of rated load. It may trip between 101 percent and 125 percent of rated load and must trip at 125 percent and above.

H. Surge Protection: Provide separate AC and DC surge protection by means of high energy Metal Oxide Varistors rated at 500 joules on the DC output and 750 joules on the AC output.

I. Electrical Panels: Construct electrical panels from a minimum thickness of 1/4" NEMA "XX" laminated phenolic, rated for Class "B" operation (105° C maximum). Equip rectifiers rated at 100 amperes DC or higher with panels constructed from a minimum sheet thickness of 1/4" "UTR" fiberglass reinforced laminate rated for Class "F" operation (155° C). Permanently silk-screen rectifier front panel identifications onto the panel.

J. Connection Hardware: Use only copper or high conductivity brass, suitably sized, and finished in electroless nickel plating for superior corrosion resistance. Tightly secure all connections with lock washers and nuts torqued to manufacturer’s recommended specifications.

K. Enclosures:

1. Construct enclosures from a minimum 12 gauge, wiped coat mill galvanized steel, finished in 3 - 5 mils of polyester fusion bonded powder coating.

2. Use stainless steel hinges and cabinet assembly bolts.

3. Equip enclosures with a pad-lockable draw latch. Latch shall be manufactured from 12 gauge steel, finished in zinc-dichromate plating. Draw latch shall accommodate a 3/8 inch shackle padlock.

4. Equip enclosures with a grounding lug sized to accommodate up to a No. 6 AWG conductor.

5. Provide separate conduit knockouts for AC and DC; conveniently located and adequately sized for input and output conduit connectors.

6. Furnish cabinet with suitable channel brackets for wall or pole mounting.

7. Equip rectifier with slide-out chassis and hinged door, for access to the front and at least one side of the cabinet.

L. Rectifier Instrumentation:

1. Equip rectifier with separate analog ammeter and voltmeter.

2. Meters to be a minimum of 3-1/2" size, with a minimum scale length of 2-7/8"

3. Meters to be 0 - 50 millivolts full scale deflection, taut-band movement with four- to-one swamping (i.e. internal meter resistance comprised of 25% winding resistance and 75% fully temperature compensated dropping resistor for wide temperature range performance).

4. Provide meter with accuracy of + 2% full scale deflection at 25° C., temperature compensated to 0.085% per degree C.

5. Scale rectifier meters to have rated output no less than 70%, or greater than 85% of full scale deflection.

6. Meter shunts shall be panel-mounted Holloway type "SW" style, with an accuracy of +0.25%.

M. Transformers: Construct transformers to meet UL 506, Specialty Transformers and the following:

1. Transformer designed as full isolation, with separate isolated primary and secondary windings and a minimum efficiency of 95%.

2. Equip transformer secondary with a minimum of 25 steps of secondary voltage adjustment (5-COARSE, 5-FINE). Provide tap adjustment by means of tap bars.

3. Rate transformer materials and construction for Class "H" operation (180° C). Further enhance insulation materials by dipping in thermosetting varnish and baking.

4. Rate transformer for a minimum dielectric strength of 2250 volts applied for one minute between the windings, and the core.

N. Current Interrupters: Include a built-in current interrupter rated in accordance with the capacity of the rectifier unit in the rectifier. Equip the interrupter with a solid-state timer with independently adjustable "On" and "Off" times. Equip the interrupter with a switch to enable the operator to operate the rectifier in an interrupt or continuous mode of output.

O. Miscellaneous:

1. Supply rectifiers capable of operating on either 115 or 230 volt, single phase, 60 hertz AC input.

2. All cathodic protection rectifiers to be 100% quality control tested as outlined in this specification.

3. During manufacture, subject the rectifier to frequent visual and performance testing to assure a high degree of quality.

4. Subject rectifiers to 100% testing of the following rectifier electrical parameters:

   a. AC input voltage, current, apparent power and true power.

   b. DC output current, voltage and power.

   c. AC power factor.

   d. AC to DC conversion efficiency.

   e. Output ripple.

   f. Correct operation of optional features such as interrupters, filters, etc.

5. Give each rectifier a final overall visual inspection prior to packaging.

2.03 EXTERNAL DISCONNECT SWITCH

A. General: Locate an AC disconnect switch, external to the rectifier unit immediately adjacent to the rectifier.

B. Disconnect Switch: Provide a fusible, circuit breaker with rainproof enclosure and lockable cover for incoming 120/240 volt, single phase AC power. Use Square D, model Q02100NRBCP or approved equal.

C. Label: Clearly label the disconnect switch “Cathodic Protection Power Supply.”

2.04 DC CABLES

A. Cables: Use seven strand, copper conductors with high molecular weight polyethylene (HMW/PE) insulation, for rectifier positive and negative cables.

2.05 PERMANENT REFERENCE ELECTRODES

A. Type: Provide two copper/copper sulfate, double membrane, ceramic cells in a geomembrane package, such as a Permacell Plus or approved equal.

B. Wire: Equip the electrodes with No. 14 AWG stranded copper wire with blue HMW/PE insulation of suitable length to extend from the center of the tank to the terminal board of the test station without splicing.

2.06 JUNCTION BOX

A. General: Terminate all wiring from within the ring wall in a junction box equipped with a phenolic panel and hinged cover.

B. Reference Cell: Include insulated, numbered terminal blocks for the reference cell leads.

C. Test Lead: Include a ground lug for termination of a negative test lead from the tank.

2.07 THERMITE WELD EQUIPMENT

A. Charges and Molds: Use weld charges and mold size as specified by the manufacturer for the specific surface configuration. Weld charges and molds to be the product of a manufacturer regularly engaged in the production of such materials.

B. Weld Coating: Coat all bare metal and weld with Stopaq CZ tape.

PART 3 EXECUTION

3.01 ANODES

A. General: Install the cathodic protection system after the Tank Construction Contractor has constructed the ring wall with the conduit penetration shown on the drawings.

B. Field Location: Contractor is responsible for verifying actual field conditions, location of underground structures, and assuring adequate physical separation from other structures and utilities. Determine and verify the exact placement in the field with a representative of the City of Houston.

C. Anode Placement: Place the anode canisters inside the ring wall in contact with native soil or fill prior to tank pad construction. Install the anodes a minimum of 24-inches and maximum of 48-inches below the elevation of the tank bottom. Use the number of anodes and arrange as shown on the drawings.

D. Anode Handling: Do not handle the anodes by the lead wires nor drop during transport or placement.

3.02 PERMANENT REFERENCE CELL

A. General: Install the two permanent reference cells at the locations shown on the drawings.

B. Installation: Install the permanent reference cells as follows:

1. Dig a hole in the soil for placement of the reference cell.

2. Install within one foot of tank bottom.

3. Backfill the cell with select granular material.

4. Compact soil around cell by hand.

5. Saturate the backfilled reference electrode with 5 gallons of water.

6. Route the No. 14 AWG lead wire to the conduit penetration of the ring wall.

3.03 JUNCTION BOX

A. General: Route all anode lead wires and reference cell leads through the conduit penetrating the ring wall and terminate in the junction box. Attach the ground leads to the exterior of the tank.

B. Installation: Install the junction box as follows:

1. Mount the junction box at the ring wall.

2. Terminate the reference cell lead wires on the numbered, insulated terminal block. Record the identification number for each cell on the as-built drawing.

3. Terminate the anode leads on the shunts connected to the copper bar.

4. Connect one ground conductor between a tank ground connection and the ground lug in the junction box.

3.04 BACKFILL

A. Backfilling operation within the ring wall to be performed by the Tank Construction Contractor. The Tank Construction Contractor to compact the sand while being careful to avoid damage to the anodes, reference cells and wiring, and shall be prepared to suspend operations for repair if damage is indicated by inspection during pad construction.

3.05 WIRE AND CABLE

A. Depth: Install all underground wires and cables a minimum of 24 inches below final grade with a minimum separation of 12 inches from other underground structures

B. Conduit: Place all positive and negative cables in rigid, galvanized steel conduit when above-grade.

1. Use insulating bushings at each end of all conduit runs.

2. Extend galvanized steel, rigid conduit 12 inches below grade.

3.06 NEGATIVE CABLE ATTACHMENT

A. Attach the rectifier negative cable by thermite welding.

B. Clean and dry the tank surface to which the wires are to be attached.

C. Use a grinding wheel to remove all coating, mill scale, oxide, grease and dirt from an area approximately 3 inches square. Clean the surface to bright metal.

D. Remove approximately 1 inch of insulation from the end of the wire to be thermite welded to the tank, exposing clean, oxide-free copper for welding.

E. Using the properly sized, vertical thermite weld mold as recommended by the manufacturer, place the wire between the graphite mold and the prepared metal surface.

F. Place the metal disk in the bottom of the mold.

G. Place the thermite weld charge in the mold. Squeeze the bottom of the weld charge container to spread ignition powder over the charge.

H. Close the mold cover and ignite the starting powder with a flint gun.

I. After the exothermic reaction, remove the thermite weld mold and gently strike the weld with a hammer to remove the weld slag. Pull on the wire to assure a secure connection. If the weld is not secure or the wire breaks, repeat the procedure.

J. If the weld is secure, coat all bare metal and weld metal with Stopaq CZ tape. Cover with a plastic weld cap.

3.07 CATHODIC PROTECTION RECTIFIER

A. Codes: Comply with the latest edition of the National Electrical Code (NEC) and with all City of Houston and local codes and standards.

B. Mounting: Pole-mount all cathodic protection rectifiers. The pole may be omitted, and the rectifier mounted on the side of the tank, if approved by the City of Houston or its designated representative. Install rectifiers at a height of 4 feet above final grade.

C. Identification: Equip all rectifiers with permanent engraved nameplates which identify the units with “Cathodic Protection Rectifier, Property of City of Houston.”

D. Conduit: Place all wiring to the rectifier in rigid galvanized steel conduit when run above grade.

1. Use insulating bushings at each end of all conduit runs.

2. Extend galvanized steel, rigid conduit 12 inches below grade.

E. Electrical Service: Provide AC electrical service for each rectifier unit. Furnish and install the necessary wiring, conduits, wires, external disconnect switch and equipment to the service connection as required by the local power company.

F. Completion: The installation is not considered complete until the AC and DC wiring is installed, and the rectifier is capable of operating at full rated load.

3.08 SYSTEM TESTING

A. General: After the cathodic protection equipment has been installed, inspect, test and adjust the system as necessary to achieve compliance with cathodic protection criteria set forth by NACE International in SP0193.

B. Energization: Initial energizing of the cathodic protection system to be performed by a Corrosion Engineer.

C. Notice: Prior to native state, polarized potential testing, and commissioning of the system, give a minimum of 48 hours notice to the City of Houston, Engineering Project Manager to facilitate observation of the tests by a City Representative.

D. Method: The Corrosion Engineer to:

1. Observe native state and polarized (Instant Off) tank-to-soil potentials to ensure that cathodic protection is being provided to the tank bottom in accordance with the AMPP criterion.

2. Record tank-to-soil potential measurements on the permanent reference electrodes and around the perimeter of the tank.

3. Determine if interference exists on nearby structures and, if so, take steps to mitigate the interference.

E. Verification and Responsibilities:

1. Correct any deficiencies in materials or installation procedures discovered during the post-installation inspection at the Contractor’s expense.

2. Corrosion Engineer to provide written documentation of any deficiencies discovered during the post installation inspection.

F. Equipment: Use only cathodic protection testing instruments that are in proper working order and calibrated according to factory specifications.

G. Locks: In order to maintain the set parameters for the transformer-rectifier, install a hardened steel lock for the transformer-rectifier enclosure provided by the City of Houston,Cathodic Protection Program Administrator. The external disconnect will be locked by City of Houston, Water Production Personnel.

H. Report: Submit a written report in accordance with Article 1.05, Submittals.

END OF SECTION

SECTION 13201

WELDED STEEL WATER STORAGE TANKS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Design, fabrication, erection, and testing of steel ground water storage tanks, with steel roof or aluminum geodesic domed roof including concrete ringwall and compacted sand foundation.

1.02 RELATED SECTIONS

A. Section 01330 – Submittal Procedures

B. Section 02340 – Compacted Sand Fill Under Tank Floor Plate

1.03 MEASUREMENT AND PAYMENT

A. No separate measurement and payment for work performed under this Section. The Contractor shall include the cost for this work in the contract bid price for work of which this is a component part.

1.04 REFERENCES

A. AWWA D 100 - Welded Carbon Steel Tanks for Water Storage

B. AWWA B 300 – Hypochlorites

C. AWWA C 207 – Steel Pipe Flanges for Waterworks Service - Sizes 4 in. through 144 in. (100 mm through 3,600mm)

D. AWS B 3.0-77 – Standard for Welding Procedures and Performance Qualification

E. API 650 – Welded Steel Tanks for Oil Storage

F. ASTM A 6 – Standard for General Requirements for Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling

G. ASTM A 20 – Standard for Steel Plates for Pressure Vessels

H. ASTM A 307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength

I. ASTM C 509 – Standard Specifications for Elastomeric Cellular Preformed Gasket and Sealing Material

J. ASTM 4940 – Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Cleaning Abrasives

K. AISC 316 – AISC Manual of Steel Construction

1.05 SUBMITTALS

A. Design Drawings and Calculations:

B. Contractor shall prepare design drawings on 11-inch x 17-inch or 22-inch x 34-inch blueline. Submit in accordance with Section 01330. All drawings shall be dimensioned, easily readable, and adequately referenced. Drawings shall contain the following minimum information for each tank:

1. Plan view, elevation view, and section views as necessary, drawn to a scale as required for clarity.

2. Location, size, and type of all wall and roof penetrations.

3. Location and size of all piping, connections, and appurtenances.

4. Fabrication details and details of all connections.

5. Aluminum Dome drawings and calculations, prepared and sealed by a Professional Engineer licensed in the state of Texas.

6. Material specifications (ASTM designation) and code or standards references.

7. Describe AWS welding procedure proposed for all welds. Indicate welding process, degrees of bevel and root dimension.

C. Design calculations are to be submitted on 8-1/2" x 11" paper, easily readable and suitable for easy reproduction.

D. All design drawings and calculations are to be prepared by, or under the direct supervision of, and officially sealed by a Professional Engineer licensed in the State of Texas attesting to the conformance with design criteria.

E. Test Reports:

1. Furnish mill test reports.

2. Submit weld test reports prior to initiation of field painting.

F. Aluminum Dome

1. Drawings describing the completed structure and all its components shall be submitted, complete with materials of construction and typical details, and accompanied by a Certificate of Design.

2. Records certifying the satisfactory inspection of all welds of aluminum structural components shall be submitted prior to delivery of the fabricated materials.

1.06 DESIGN REQUIREMENTS

A. Design, fabricate, erect, and test in accordance with "AWWA Standard for Welded Steel Tanks for Water Storage" (AWWA D100), except as modified herein and as may be shown on plans.

B. Design in accordance with Section 14 of AWWA D100 will NOT be acceptable.

C. Comply with applicable OSHA Rules and Regulations.

D. Tank Design Loads:

1. Dead load plus 15 pounds per square foot live load for roof.

2. Wind load velocity of 110 mph from any direction.

3. No earthquake load required.

4. Design for at least the following load combinations:

a. Dead + water + live or

b. Dead + water + wind or

c. Dead + wind

5. Allowable stresses for load combinations that include wind may be increased by 1/3 as long as specified allowable for dead load + water + live are not exceeded.

E. Steel Roof Design:

1. Tank roof to be so supported and erected that no ponding will occur.

2. The roof will have a minimum slope of 3/4 inch per foot.

3. Do not use splices in rafters or beam spans.

4. Design rafters and beams so that

a. Bending stresses do not exceed 15,000 psi

b. Ratio of span to deflection is greater than 180

c. Depth of member is not less than .025 times the span

5. Design columns as main members.

6. Roof plates shall be welded on the top side with a full fillet weld on all seams.

7. Roof plates shall be attached to the top angle of the tank with a continuous fillet weld on the top side only.

8. Tank shells shall have top angles of not less than the following sizes: 35 feet and smaller diameter - 2 x 2 x 3/16 inches, 35 feet to 60 feet diameter - 2 x 2 x 1/4 inches, larger than 60 feet diameter - 3 x 3 x 3/8 inches.

9. Roof plates of supported cone roofs shall not be attached to the supporting members.

F. Aluminum Dome Design:

1. The dome supports are to be attached directly to the top of the tank. Attachment points utilizing slide bearing, low friction pads are not acceptable.

2. The dome structure shall be designed to sustain the loads specified herein, with allowable stresses as defined in AWWA D100.

3. The load cases to be considered shall be those described below unless more severe loads are specified by the purchaser.

   a. Dead Load - the dead load shall be defined as the weight of the structure and all material permanently attached to and supported by the structure.

   b. Live Load - The uniform live load shall be 15 psf.

   c. Unbalanced Live Load - An unbalanced load of one half of the uniform load applied to one half of the roof with no live load on the other half.

   d. Wind Load - Wind pressure shall be designed for a wind load velocity of 110 mph from any direction. Horizontal pressures shall be considered to act concurrently with vertical pressures.

   e. Load Combinations - The loads described above shall be applied to the dome cover in the following combinations.

      (1) Dead Load

      (2) Dead Load and Uniform Live Load

      (3) Dead Load and Unbalanced Live Load

      (4) Dead Load and Wind Load

(5) Dead Load, Uniform Live Load and Wind Load

(6) Dead Load, Unbalanced Live Load and Wind Load

f. Temperature- The load combinations listed above shall be considered for a temperature change of 100 degrees F below the installation temperature and 100 degrees F above the installation temperature, and for a material temperature range of 40 degrees F below to 160 degrees F above zero.

g. Panel Design Load - In addition to the above mentioned loads and load combinations, the aluminum panels shall be designed for a 250 pound load distributed over one square foot at any location and a plus or minus 60 psf load distributed over the entire area of any given panel. These loads are to be taken as acting separately, from one another and not simultaneously with other design loads.

h. The tank designer shall be responsible for coordinating the design requirements for supporting the fixed domed roof on the tank shell, including wind girder. Consideration shall be given to vertical, radial and lateral forces from the fixed domed roof. Load eccentricities shall be considered. The type of connection between the roof and tank shell shall be fixed.

i. Provide a positive seal at the roof/shell junction to close the gap at the top of the shell.

j. The exterior wind girder shall be designed to not trap water or create any difficulties to clean and/or coat. All welds shall be seal welded.

k. No earthquake load required.

G. Aluminum Dome Description:

1. The dome roof shall be clear-span from the periphery structure. The frame shall consist of aluminum structural members with the joints arrayed on the surface of a sphere. The arrangement of members shall result in a pattern of triangular spaces. These spaces shall be closed with light gauge aluminum panels. The members shall be joined by means of bolting their flanges to aluminum gusset plates.

2. All metal components of the aluminum dome structure shall be aluminum or 300 series stainless steel. No galvanized, painted, or plated steel shall be used anywhere in the dome above the mounting bracket base plates. Dissimilar materials in the supporting structure shall be isolated from the aluminum dome by means of a compatible elastomeric gasket.

3. The entire structure shall be designed as a watertight system under all design load conditions. The design shall prevent water pooling at the joints through the use of a flanged hub cover.

4. The aluminum closure panels shall be attached continuously along their edges to the structural members by means of clamping bars which engage the panels in an interlocking joint. This clamping bar shall also secure an elastomeric weather seal gasket which shall form a continuous watertight seal along the panel edges. The use of panel attachment fasteners which penetrate both the panel and the flange of the structural member will not be accepted.

5. The exterior finish of aluminum geodesic domes, including plates, batten bars, hub covers, roof vents, handrails, and roof hatches, shall be "Aluminum Association Nondirectional Textured, M42, Fine Matte Finish".

6. Acceptable aluminum dome manufacturers are:

   a. Conservatek - Conroe, Texas

   b. Temcor - Torrance, California

   c. Ultraflote - Houston, Texas

1.07 QUALITY ASSURANCE

A. Conduct performance tests to qualify welders and welding operators in accordance with AWS B3.0-77

B. Quality control for all welding shall be in accordance with AWWA D100:

1. Field inspection by means of radiographs will be performed by the Owner at the Owner’s direction and the Owner’s cost.

2. Contractor shall vacuum test all bottom plate welds. Test corner welds by oil penetrate. Include costs for these tests in the cost of the tank.

3. Radiographs will be performed as recommended by AWWA D100, Section 11.

4. All areas found to be defective shall be repaired by the Contractor at the Contractor’s expense.

5. Any retesting to check repaired areas will be paid for by the Contractor.

C. The initial supply of water required for leak test shall be supplied by the Owner. Additional water required for subsequent leak tests shall be at the Contractor's expense.

PART 2 PRODUCTS

2.01 MATERIALS

A. Structural and Other Metals:

1. As per AWWA D100 and the Aluminum Association "Specifications for Aluminum Structures".

B. Accessories as shown on Plans include:

1. Exterior tank ladder, cage, roof hatch, vents, handrails, internal tank ladder, cathodic protection, drain penetrations, overflow and drain piping.

2. Inlet, outlet, drain piping, and overflow pipe with funnels to be as shown on plans.

3. Roof Vents:

a. Configuration and materials of construction as shown on plans. Vents are to be located between rafters.

b. Screens (16 mesh) are to be installed on all vents. Screens for all vents to be AISC 316 Stainless Steel with 50% opening area and stainless steel bands.

4. Safety Handrails:

a. Provide in accordance with plans.

5. Overflow Assembly:

a. Size and configuration per plans and welded per AWWA D100.

6. Shell Clean-Out Fittings:

a. Provide flush type shell clean out fittings as shown on plans. Design and installation to be per AWWA D100 and API 650.

7. Roof Hatches:

a. Install roof hatches as shown on plans. Roof hatches are to be located between rafters or aluminum dome grid support beams. Hatches are to be constructed from 0.09" aluminum.

b. All roof hatches shall be provided with a hinged cover and hasp for locking. The hatch opening shall have a curb at least 4-inches high, and the cover shall have a downward overlap of at least 2 inches.

8. Piping Connections, Sumps and Drains:

a. Provide piping connections, sumps, and drains as shown on plans.

b. For shell or roof penetrations less than three (3) inches diameter, use 3000# half or full forged steel couplings for piping connections unless shown otherwise on Plans.

c. For shell or roof penetrations three (3) inches in diameter or larger, use flanged nozzles. Reinforce shell or roof plate as required by AWWA D100 and API 650. All flanges to be flat face in compliance with AWWA C207, Class D.

d. Flush type drains and openings, where shown on plans, shall be designed and installed in accordance with API 650.

9. Personal Safety Equipment

a. For each tank constructed, provide two DBI/SALA model 2000 full-body, buckle- type harnesses (size XL), two DBI/SALA model L3300DP shock-absorbing lanyards, three foot length, and two safety climb connectors.

C. Materials for Aluminum Dome:

The following is a summary of approved materials and/or materials specifications. All aluminum alloys shall be as defined by the Aluminum Association and published in the ALUMINUM STANDARDS AND DATA.

1. Bolts and Fasteners - All bolts and fasteners shall be 6061-T6 or 7075-T73 aluminum, or Series 300 stainless steel.

2. Plates and Sheets - Plate and sheet material shall be aluminum alloy 3003-H16, 3105- H154, 6061.T6 or 5052-H32; Aluminum Association M42, Fine Matte finish as fabricated. Structural gussets shall be 0.375" nominal minimum thickness. Aluminum sheet material shall be 0.050" thickness.

3. Structural Shapes - Aluminum structural shapes shall be alloy 6061-T6. The aluminum structural members shall be a minimum of 6" deep.

4. Miscellaneous Shapes - Miscellaneous aluminum shapes shall be allow 6061-T6 or 6063-T5.

5. Gaskets - All gaskets shall be Neoprene conforming to ASTM C509 or silicone, resistant to ozone and shielded from exposure to ultraviolet light.

6. Sealant - All sealants shall be resistant to ozone and ultraviolet light, and conform with Federal Specification TT-S-00230C.

7. Supports - The hinge pin assembly shall be constructed of 300 series stainless steel. No coatings are required on these pieces. The top mount gusset plate assembly shall be fabricated from normal carbon steel. All points of connection between these plates and between the pieces and the tank shell shall be seal welded. Coat all carbon steel with interior tank work. This interface detail shall be coordinated between the dome manufacturer and the tank manufacturer.

8. Safety Equipment for each dome (or approved equal):

   a. Two DBI/SALA model 2000 full-body, buckle-type harnesses (size XL).

   b. Two DBI/SALA model L3300DP shock-absorbing lanyards, three foot length.

   c. Four DBI/SALA model LS1441 rope grabs for 5/8" dia. nylon rope.

   d. Four lengths of 5/8" dia nylon safety rope. Two ropes to be used to repel from center roof bollard to wind girder and two ropes 25' in length.

   e. Four DBI/SALA model L338 wire rope grabs for 3/8" dia. SST cable.

   f. Three 3/8" dia. SST cables; one from platform to center bollard, two from center bollard to roof vents (secure cable at both ends).

9. Dome Patch Kit:

   a. 10- 6" x 6" patches (to be constructed from excess panel material)

   b. Caulk (as required for the above patches)

   c. Rivets (as required for above patches)

PART 3 EXECUTION

3.01 JOINT FABRICATION

A. Tank Shell: Butt Welds.

B. Steel Roof and Bottom: Lap Weld.

C. Roof Framing: As specified by aluminum dome manufacturer for aluminum roof and tank designer for steel tanks.

3.02 FIELD ERECTION

A. Tank Foundation:

1. Tank foundations shall consist of:

    a. Sand cushion within a concrete ringwall.

    b. Sand cushion shall meet the requirements of Section 02340 - Compacted Sand Fill Under Tank Floor Plate.

    c. Sand shall not be saturated with oil.

    d. Installation shall be as shown on Plans.

    e. Install asphalt pad expansion joint material between tank bottom and foundation for tanks with external cathodic protection. For tanks without external cathodic protection, install pad over entire tank foundation, including ringwall and sand cushion. Asphalt pad material shall meet the requirements of Section 13204 - Asphaltic Fiber Expansion Joint Filler.

    f. Pad joints to be sealed as shown on plans.

2. Sitework:

    a. The site should be graded such that positive surface drainage away from the work areas is established and maintained at all times.

    b. Water should not be allowed to pond on the surface during construction.

    c. The surface soils are moisture sensitive. If wet, such soils will become unstable and unable to support construction efforts.

    d. Failure to keep sandy and silty surface soils drained may necessitate chemical stabilization at Contractor's expense.

3. Sand material under the tank floor:

    a. Free of water soluble ionic contamination (salt). Salt content of the sand shall be determined and limited in accordance with ASTM 4940-89. Additional requirements per Section 02340 - Compacted Sand Fill Under Tank Floor Plate.

    b. Compacted to density specified and of the gradation described in Section 02340 - Compacted Sand Fill Under Tank Floor Plate.

    c. In a written report to the Engineer, Contractor to provide elevation data to verify crown at center of tank and slope of sand cushion. Provide report prior to installation of floor plate.

4. Cement stabilized sand:

a. Placed as indicated on the Plans.

b. Placed and compacted within 2 hours or initial set, whichever occurs first.

5. Concrete ringwall:

a. Installed with one (1) continuous concrete pour.

b. Formed on both sides.

c. Ringwalls and slabs after grouting or before placing the joint filler shall be level within ∀ 1/8-inch in any 30-feet circumference under the shell. The levelness on the circumference shall not vary by more than ∀ 1/4-inch from an established plane. The tolerance on poured concrete before grouting shall be ∀ 1-inch Contractor to record and furnish written report to Engineer prior to installation of floor plate.

B. Steel Reservoirs:

1. All steel reservoirs and appurtenances to be constructed per AWWA D100 and applicable portions of API 650, Section 5.5, except Contractor may elect to suspend the requirement for rolling of shell plate provided all erection tolerance requirements of this specification are met.

2. Square and bevel all shell plates prior to delivery to the job site.

3. Assemble and weld plates to maintain proper curvature.

4. No de-coiled steel shall be used in the tank shell construction.

5. Roll top angle to the curvature of the tank for steel roof tanks prior to shipment to the job site.

6. The tank will be measured for conformance to the criteria stated below at various times throughout construction. Construction of the tank may be halted by the Engineer and corrections required prior to re-commencement of construction should deficiencies be noted in one or more of the criteria.

7. Plumbness: The maximum out-of plumbness of the top of the shell relative to the bottom of the shell shall not exceed 1/200 of the total tank height. The out-of plumbness in one shell plate shall not exceed the permissible variations for flatness and waviness as specified in ASTM A6 or ASTM A20, whichever is applicable.

8. Roundness: Radii measured at 1 foot above the bottom corner weld shall not exceed the following tolerances:

Tank Diameter (feet)	Radius Tolerance
0-40 feet	± 1/2 inch
40-150 feet	± 3/4 inch
150-250 feet	± 1 inch
250 feet and over	± 1-1/4 inch

9. Peaking and Banding: Local deviations from the theoretical shape (for example, weld discontinuities and flat spots) shall be limited as follows:

    a. Peaking at vertical weld joints shall not exceed 1/2 inch. Peaking at vertical weld joints shall be determined using a horizontal sweep board 36 inches long.

    b. Banding at horizontal weld joints shall not exceed 1/2 inch. Banding at horizontal weld joints shall be determined using a vertical sweep board 36 inches long.

    c. Flat spots measured in the vertical plane shall not exceed the appropriate plate flatness and waviness requirements given in ASTM A6 and A20, whichever is applicable.

10. Measurements: Measurements listed in items above shall be taken as each tank ring is completed. Contractor shall repair defects, correct alignments and take other corrective actions as required to ensure each tank ring is constructed in strict compliance with these specifications prior to proceeding with additional tank rings.

C. Aluminum Dome

1. No equipment shall be supplied or installed by any manufacturer not regularly engaged in the manufacturing and production of domes in the size and character herein specified. The manufacturer must have installed and had in satisfactory use for a period not less than ten (10) years at least five (5) domes of the same type as units specified herein.

2. All work shall be executed by skilled mechanics, with supervision experienced in the erection of domes. The dome shall be erected plumb and level and in proper alignment. The dome erector shall provide satisfactory evidence of the successful installation of at least five (5) domes of the same type as specified herein.

3. The aluminum dome roof shall be leak tested utilizing a low pressure soap bubble test procedure as follows:

    a. Test Setup and Equipment

(1) Blind or otherwise cover any vents, hatches, piping inlets/outlets, etc. in the dome or tank.

(2) Connect a compressor to the hose bib in the tank shell.

(3) Locate a manometer near the hose bib or other convenient location, to verify the internal pressure achieved during the test.

(4) Pressurize the interior of the tank and maintain between 1/2-inch and 1-inch water column positive pressure throughout the test.

(5) Carry out the soap bubble test, described below.

b. Test Procedure

(1) Apply a soap solution to the strut caps, hub covers, and splices between aluminum sheeting, as well as at hatch frames and other joints that may be subject to allowing rainwater infiltration into the tank interior.

(2) Observe the treated joints for bubble formation.

(3) If soap bubbles form at a given point, that joint will be cleaned, prepped, repaired, and retested by applying additional soap solution.

(4) The interface of the dome flashing with the tank windgirder will not be tested, as rainwater will not tend to infiltrate the tank at this location.

c. Acceptance Criteria

(1) Joints along the exterior surface of the dome which do not evidence any soap bubble formation shall be deemed water-tight.

D. Cleanliness:

1. Provide proper sanitary waste facilities.

2. Only healthy personnel may enter tank.

3. If necessary, Owner's physician will judge physical fitness of all persons entering tank.

4. Keep interior of tank and accessories clean and free from foreign matter.

3.03 MONITORING TANK SETTLEMENT

A. Tank settlement for new tanks is to be monitored by the Contractor during initial filling of the tank. The tank monitoring program shall conform to the following minimum requirements:

1. All survey data must be sealed and certified by a Registered Professional Surveyor or Licensed Engineer in the State of Texas.

2. Establish eight (8) reference points at the top of the concrete ringwall foundation, equally spaced around the periphery. One point shall be located at or near the suction sump(s).

3. Record the initial elevation at these eight points when tank erection is complete and before filling with water.

4. Record the elevations at the eight (8) points when tank is full to overflow.

5. Record elevations again approximately 24 hours after tank is filled.

6. Submit each set of tank readings to the City for review.

7. If the tank settles more than two inches in any location, Contractor shall at Contractor's expense adjust piping connections at couplings so as not to exceed the piping alignment tolerances of the couplings.

8. Submit each set of tank readings to the City for review.

9. Elevations are to be related to benchmarks shown on the Plans.

END OF SECTION

SECTION 13202

REHABILITATION OF WELDED STEEL WATER STORAGE TANKS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Fabricate materials and make repairs to steel water storage tanks.

1.02 RELATED SECTIONS

A. Section 01576 – Waste Material Disposal

B. Section 02136 – Waste Material Handling, Testing and Disposal

C. Section 02662 – Piping, Valves, Fittings, and Accessories for Water Storage Tanks

1.03 MEASUREMENT AND PAYMENT

A. No separate measurement and payment for work performed under this Section except as indicated in paragraphs 1.03.B and 1.03.C. The Contractor shall include the cost for this work in the contract bid price for work of which this is a component part.

B. Measure "extra shell plates, all sizes, all thickness, including removal and disposal of old plates" by pounds, complete in place. Pay for "extra shell plates, all sizes, all thickness, including removal and disposal of old plates" by unit price bid per pound.

C. Measure "extra floor plates, all sizes, all thickness, including sand fill, including removal and disposal of old plates and underlying fill" by pounds, complete in place. Pay for "extra floor plates, all sizes, all thickness, including sand fill, including removal and disposal of old plates and underlying fill" by unit bid per pound.

D. Measure "extra roof plates, all sizes, all thickness, including removal and disposal of old plates" by pounds, complete in place. Pay for "extra roof plates, all sizes, all thickness, including removal and disposal of old plates" by unit price bid per pound.

E. Measure "extra roof rafters, and clips including removal and disposal of old members" by pounds. Pay for "extra structural members, roof rafters, and all supporting structures, all shapes, all sizes including removal and disposal of old members" by unit price bid per pound.

F. Measure "extra 6-in. diameter floor patches including welding in place and grinding smooth" by each patch. Pay for "extra 6-in. diameter floor patches including welding in place and grinding smooth" by unit price bid per pound.

1.04 REFERENCES

A. AWWA D 100 - Welded Carbon Steel Tanks for Water Storage

B. AWWA B 300 – Hypochlorites

C. AWWA C 207 – Steel Pipe Flanges for Waterworks Service - Sizes 4 in. through 144 in. (100 mm through 3,600mm)

D. AWS B 3.0-77 – Standard for Welding Procedures and Performance Qualification

E. API 650 –Welded Steel Tanks for Oil Storage

F. API 653 –Tank Inspection, Repair, Alteration and Reconstruction

G. ASTM A 307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength

H. ASTM C 509 – Standard Specifications for Elastomeric Cellular Preformed Gasket and Sealing Material

1.05 SUBMITTALS

A. Submittal Drawings and Calculations:

1. Dimensioned, easily readable, and adequately referenced.

2. Plan view, elevation view, and sectional views as necessary.

3. Location, size, and type of all wall and roof penetrations.

4. Location and size of all piping, connections, and appurtenances.

5. Fabrication details and details of all connections.

6. Aluminum dome drawings and calculations, prepared and sealed by a Professional Engineer licensed in the State of Texas.

7. Material specifications (ASTM designation) and code or standards references.

8. Describe AWS welding procedure proposed for full penetration welds. Indicate welding process, degrees of bevel and root dimension.

B. Test Reports: Furnish mill test reports.

C. Aluminum Dome

1. Drawings describing the completed structure and all its components shall be submitted, complete with materials of construction and typical details, and accompanied by a Certificate of Design.

2. Records certifying the satisfactory inspection of all welds of aluminum structural components shall be submitted prior to delivery of the fabricated materials.

1.06 DESIGN REQUIREMENTS

A. Design, fabricate, erect, and test in accordance with "AWWA Standard for Welded Steel Tanks for Water Storage" (AWWA D100), except as modified herein. Minimum plate thickness and size of structural members are shown on the drawings.

B. Design in accordance with Section 14 of AWWA D100 will not be acceptable.

C. Comply with applicable OSHA Rules and Regulations.

D. Modifications and repairs shall conform to American Petroleum Institute=s (API) Standard 653 - Tank Inspection, Repair, Alteration, and Reconstruction, where possible.

E. Aluminum Dome Retrofit Design:

1. The dome supports are to be attached directly to the top of the tank. Attachment points utilizing slide bearing, low friction pads are not acceptable.

2. The entire dome structure shall be designed to sustain the loads specified herein, with allowable stresses as defined in AWWA D100.

3. The load cases to be considered shall be those described below unless more severe loads are specified by the purchaser.

a. Dead Load - the dead load shall be defined as the weight of the structure and all material permanently attached to and supported by the structure.

b. Live Load - The uniform live load shall be 15 psf.

c. Unbalanced Live Load - An unbalanced load of one half of the uniform load applied to one half of the roof with no live load on the other half.

d. Wind Load - Wind pressure shall be designed for a wind load velocity of 110 mph from any direction. Horizontal pressures shall be considered to act concurrently with vertical pressures.

e. Load Combinations - The loads described above shall be applied to the dome cover in the following combinations.

(1) Dead Load

(2) Dead Load and Uniform Live Load

(3) Dead Load and Unbalanced Live Load

(4) Dead Load and Wind Load

(5) Dead Load, Uniform Live Load and Wind Load

(6) Dead Load, Unbalanced Live Load and Wind Load

f. Temperature- The load combinations listed above shall be considered for a temperature change of 100 degrees F below the installation temperature and 100 degrees F above the installation temperature, and for a material temperature range of 40 degrees F below to 160 degrees F above zero.

g. Panel Design Load - In addition to the above mentioned loads and load combinations, the aluminum panels shall be designed for a 250 pound load distributed over one square foot an any location and a plus or minus 60 psf load distributed over the entire area of any given panel. These loads are to be taken as acting separately, from one another and not simultaneously with other design loads.

h. The dome designer shall be responsible for coordinating the design requirements for supporting the fixed domed roof on the existing tank shell, including the wind girder to be added. Consideration shall be given to vertical, radial and lateral forces from the fixed domed roof. Load eccentricities shall be considered. The type of connection between the roof and tank shell shall be fixed.

i. Provide a positive seal at the roof/shell junction to close the gap at the top of the shell.

j. The exterior wind girder shall be designed to not trap water or create any difficulties to clean and/or coat. All welds shall be seal welded.

k. No earthquake load required.

F. Aluminum Dome Description (for tanks to receive retrofit):

1. The dome roof shall be clear-span from the periphery structure. The frame shall consist of aluminum structural members with the joints arrayed on the surface of a sphere. The arrangement of members shall result in a pattern of triangular spaces. These spaces shall be closed with light gauge aluminum panels. The members shall be joined by means of bolting their flanges to aluminum gusset plates.

2. All metal components of the aluminum dome structure shall be aluminum or 300 series stainless steel. No galvanized, painted, or plated steel shall be used anywhere in the dome above the mounting bracket base plates. Dissimilar materials in the supporting structure shall be isolated from the aluminum dome by means of a compatible elastomeric gasket.

3. The entire structure shall be designed as a watertight system under all design load conditions. The design shall prevent water pooling at the joints through the use of a flanged hub cover.

4. The aluminum closure panels shall be attached continuously along their edges to the structural members by means of clamping bars which engage the panels in an interlocking joint. This clamping bar shall also secure an elastomeric weather seal gasket which shall form a continuous watertight seal along the panel edges. The use of panel attachment fasteners which penetrate both the panel and the flange of the structural member will not be accepted.

5. The exterior finish of aluminum geodesic domes shall be "Aluminum Association Nondirectional Textured, M42, Fine Matte Finish".

6. Acceptable aluminum dome manufacturers are:

   a. Conservatek - Conroe, Texas

   b. Temcor - Torrance, California

   c. Ultraflote - Houston, Texas

1.07 QUALITY ASSURANCE

A. Conduct performance tests to qualify welders and welding operators in accordance with AWS B3.0-77.

B. Quality control for all welding shall be in accordance with AWWA D100:

1. Field inspection by means of radiographs will be performed by the Owner at Owner’s direction and Owner’s cost.

2. Radiographs will be performed as recommended by AWWA D100, Section 11.

3. All areas found to be defective shall be repaired by the Contractor at the Contractor’s expense.

4. Any retesting to check repaired areas will be paid for by the Contractor.

C. Water required for additional leak test shall be at Contractor's expense.

PART 2 PRODUCTS

2.01 MATERIALS

A. Structural and Other Metals: As per AWWA D100 and Aluminum Association "Specifications for Aluminum Structures".

B. Accessories as shown on Plans include:

1. Exterior tank ladder, cage, roof hatch, vents, cathodic protection, interior ladder, handrails, drain penetrations, overflow and drain piping.

2. Inlet, outlet, drain piping, and overflow pipe with funnels to be as shown on plans.

3. Roof Vents:

a. Configuration and materials of construction as shown on plans. Vents are to be located between rafters.

b. Screens (16 mesh) are to be installed on all vents. Screens for all vents to be AISI 316 Stainless Steel with 50% opening area and stainless steel bands.

4. Safety Handrails: Provide in accordance with plans.

5. Overflow Assembly: Size and configuration per plans and welded per AWWA D100.

6. Shell Clean Out Fittings: Provide flush type shell clean out fittings as shown on plans. Design and installation to be per AWWA D100 and API 650.

7. Roof Hatches:

a. Install roof hatches as shown on plans. Roof hatches are to be located between rafters or aluminum dome grid support beams. Hatches are to be constructed from .09" aluminum.

b. All roof hatches shall be provided with a hinged cover and hasp for locking. The hatch opening shall have a curb at least 4-inches high, and the cover shall have a downward overlap of at least 2 inches.

8. Piping Connections, Sumps and Drains:

a. Provide piping connections, sumps, and drains as shown on plans.

b. For shell or roof penetrations less than 3 inches diameter, use 3000# half or full forged steel couplings for piping connections unless shown otherwise on Plans.

c. For shell or roof penetrations 3 inches in diameter or larger, use flanged nozzles. Reinforce shell or roof plate as required by AWWA D100 and API 650. All flanges to be flat face in compliance with AWWA C207, Class D.

d. Flush type drains and openings, where shown on plans, shall be designed and installed in accordance with API 650.

9. Foundation Sealant: Pad joints to be sealed with Gulf State No. 210 Mastic Sealant or equal.

10. Personal Safety Equipment

a. For each tank constructed, provide two DBI/SALA model 2000 full-body, buckle- type harnesses (size XL), two DBI/SALA model L3300DP shock-absorbing lanyards, three foot length, and two safety climb connectors.

C. MATERIALS FOR ALUMINUM DOME:

The following is a summary of approved materials and/or materials specifications. All aluminum alloys shall be as defined by the Aluminum Association and published in the ALUMINUM STANDARDS AND DATA.

1. Bolts and Fasteners - All bolts and fasteners shall be 6061-T6 or 7075-T73 aluminum, or Series 300 stainless steel.

2. Plates and Sheets - Plate and sheet material shall be aluminum alloy 3003-H16, 3105- H154, 6061.T6 or 5052-H32; Aluminum Association M42, Fine Matte finish as fabricated. Structural gussets shall be 0.375" nominal minimum thickness. Aluminum sheet material shall be 0.050" thickness.

3. Structural Shapes - Aluminum structural shapes shall be alloy 6061-T6. The aluminum structural members shall be a minimum of 6" deep.

4. Miscellaneous Shapes - Miscellaneous aluminum shapes shall be allowed 6061-T6 or 6063- T5.

5. Gaskets - All gaskets shall be Neoprene conforming to ASTM C509 or silicone, resistant to ozone and shielded from exposure to ultraviolet light.

6. Sealant - All sealants shall be resistant to ozone and ultraviolet light and conform with Federal Specification TT-S-00230C.

7. Supports - The hinge pin assembly shall be constructed of 300 series stainless steel. No coatings are required on these pieces. The top mount gusset plate assembly shall be normal carbon steel. All points of connection between these plates and between the pieces and the tank shell shall be seal welded. This interface detail shall be coordinated between the dome manufacturer and the tank manufacturer.

8. Safety Equipment for each dome (or approved equal):

   a. Two DBI/SALA model 2000 full-body, buckle-type harnesses (size XL).

   b. Two DBI/SALA model L3300DP shock-absorbing lanyards, three-foot length.

   c. Four DBI/SALA model LS1441 rope grabs for 5/8" dia. nylon rope.

   d. Four lengths of 5/8" dia nylon safety rope. Two ropes to be used to repel from center roof bollard to wind girder and two ropes 25' in length.

   e. Four DBI/SALA model L338 wire rope grabs for 3/8" dia. SST cable.

   f. Three 3/8" dia. SST cables; one from platform to center bollard, two from center bollard to roof vents (secure cable at both ends).

9. Dome Patch Kit:

   a. 10- 6" x 6" patches (to be constructed from excess panel material)

   b. Caulk (as required for the above patches)

   c. Rivets (as required for above patches)

D. Temporary Closures:

1. All material required for the closure and protection of tank inlet and outlet piping that is not to be removed shall be furnished and properly installed by the Contractor.

2. Blind flanges for temporary closures to be per AWWA C207, Class B. Bolting to be per ASTM A307, Grade B. Gaskets to be 1/8-inch red rubber, full face and factory cut.

3. Disinfectant to be calcium hypochlorite meeting the requirements of the AWWA "Standard for Hypochlorites" (AWWA B300).

4. Water for flushing or disinfection of plant piping systems to meet the Texas Department of Health Standard for potable water.

5. Chlorine neutralizing chemical (e.g. sulfur dioxide, sodium bisulfite, sodium sulfite, etc.), if required for residual reduction for heavily chlorinated water, are to be of grade and analysis approved by the City.

PART 3 EXECUTION

3.01 JOINT FABRICATION

A. Tank Shell: Butt Welds.

B. Roof and Bottom: Lap Weld.

C. Roof Framing: As specified by aluminum dome manufacturer for aluminum roof and tank designer for steel tanks.

3.02 FIELD ERECTION

A. Tank Rehabilitation Items:

1. Contractor shall fabricate and install ladders, cages, roof hatches, vents, cathodic systems, level sensing equipment and other appurtenances that may be shown on the plans.

2. Roll plates, top angle, and wind girder to curvature of tank, and handle and deliver materials so that they maintain shape and are not crimped or have "broken back."

3. Assemble and weld plates to maintain proper curvature.

4. Where partial replacement of roof plates is called for on the plans the Contractor shall sweep blast the entire area. When sweep blasting is complete the Engineer will inspect the roof and identify the areas of the roof that are to be replaced.

5. Where partial replacement of the rafters is called for on the plans the Contractor shall sweep blast all the rafters. When the sweep blasting is complete the Engineer will inspect the rafters and identify which rafters are to be replaced.

6. Where patching of floors is required, the Engineer will inspect the floor for pitting and metal loss after the substrate has been blasted. The Engineer will identify all pitted areas to be patched with a minimum 6" diameter steel plate patch. The patch is to be welded all around and ground smooth prior to application of the specified coating. If the Contractor identifies pitted or corroded areas during the Contractor’s blasting operation, the Contractor shall notify the Engineer immediately.

B. Aluminum Dome

1. No equipment shall be supplied or installed by any manufacturer not regularly engaged in the manufacturing and production of domes in the size and character herein specified. The manufacturer must have installed and had in satisfactory use for a period not less than ten (10) years at least five (5) domes of the same type as units specified herein.

2. All work shall be executed by skilled mechanics, with supervision experienced in the erection of domes. The dome shall be erected plumb and level and in proper alignment. The dome erector shall provide satisfactory evidence of the successful installation of at least five (5) domes of the same type as specified herein.

3. The aluminum dome roof shall be leak tested utilizing a low-pressure soap bubble test procedure as follows:

    a. Test Setup and Equipment

        (1) Blind or otherwise cover any vents, hatches, piping inlets/outlets, etc. in the dome or tank.

        (2) Connect a compressor to the hose bib in the tank shell.

        (3) Locate a manometer near the hose bib or other convenient location, to verify the internal pressure achieved during the test.

        (4) Pressurize the interior of the tank and maintain between 1/2-inch and 1-inch water column positive pressure throughout the test.

        (5) Carry out the soap bubble test, described below.

    b. Test Procedure

        (1) Apply a soap solution to the strut caps, hub covers, and splices between aluminum sheeting, as well as at hatch frames and other joints that may be subject to allowing rainwater infiltration into the tank interior.

        (2) Observe the treated joints for bubble formation.

        (3) If soap bubbles form at a given point, that joint will be cleaned, prepped, repaired, and retested by applying additional soap solution.

        (4) The interface of the dome flashing with the tank windgirder will not be tested, as rainwater will not tend to infiltrate the tank at this location.

c. Acceptance Criteria

(1) Joints along the exterior surface of the dome which do not evidence any soap bubble formation shall be deemed water-tight.

C. Cleanliness:

1. Provide proper sanitary waste facilities.

2. Only healthy personnel may enter tank.

3. If necessary, Owner's physician will judge physical fitness of all persons entering tank.

4. Keep interior of tank and accessories clean and free from foreign matter.

3.03 EXTERIOR PIPING AND VALVES

A. General handling and preparation of exterior piping and valves will be done in accordance with Section 02662 - Piping, Valves, Fittings and Accessories for Water Storage Tanks.

3.04 DISPOSAL OF WASTE MATERIAL

A. The City will remove from service and drain or cause to be drained the water from the existing tank prior to release to the Contractor for rehabilitation. Water and deposits left in the tank subsequent to draining are to be removed and disposed of by the Contractor. All waste disposal to be in accordance with Section 01576 - Waste Material Disposal and 02136 - Waste Material Handling, Testing and Disposal.

END OF SECTION

SECTION 13203

TANK CLEAN-UP AND DISINFECTION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Clean-up and disinfection of the rehabilitated storage tanks and/or new storage tanks complete with all required disinfecting and neutralizing chemicals, and all equipment, labor and superintendence.

1.02 MEASUREMENT AND PAYMENT

A. No separate measurement and payment for work performed under this Item.

B. The Contractor shall include the cost for this work in the contract bid price for work of which this is a component part.

1.03 REFERENCES

A. AWWA B 300 – Standard for Hypochlorites

B. AWWA C 651 – Standard for Disinfecting Water Mains

C. AWWA C 652 – Standard for Disinfection of Water Storage Facilities

1.04 SUBMITTALS

A. Prior to starting disinfection work, furnish to Engineer a detailed outline of proposed sequence of work, manners of filling and flushing units, source and quality of water to be used, and disposal of wastewater.

B. Submit material data sheets on all disinfectants and neutralization chemicals to be used.

1.05 QUALITY ASSURANCE

A. Bacteriological Sampling and Testing:

1. Bacteriological sampling and water quality testing of disinfected tank to be conducted by Water Quality Control Branch, Public Utility Division of the City of Houston, Houston Public Works.

2. Results to be acceptable to City of Houston.

3. Tank to be verified free of coliform bacteria contamination. Work to be in accordance with AWWA C652, Disinfection of Water Storage Facilities, as applicable.

4. Methods of bacteriological analysis are as specified in the Standard Methods for Examination of Water and Wastewater by the American Public Health Association, latest edition.

PART 2 PRODUCTS

2.01 DISINFECTANT

A. Disinfectant to be calcium hypochlorite meeting the requirements of the AWWA B300 "Standard for Hypochlorites".

2.02 WATER

A. Water for the first tank washdown, disinfection, fill and testing of piping to meet the TCEQ Standards for potable water will be provided by the City.

B. The Contractor may be required to pay for water required for refill or retesting due to failures in workmanship caused by the Contractor discovered during initial testing.

2.03 CHLORINE NEUTRALIZING CHEMICALS

A. Chlorine neutralizing chemicals (e.g. sulfur dioxide, sodium bisulfite, sodium sulfite, etc.), if required for residual reduction of heavily chlorinated water, are to be of grade and analysis approved by the City. Provide the City with standard operating procedures for neutralizing any chlorine prior to discharge. Contractor shall determine if a TPDES permit is required for discharge. If discharging to existing sewer, Contractor shall ensure that existing capacity is sufficient to prevent backup from occurring. Provide the Owner with standard operating procedures neutralizing any chlorine prior to discharge.

PART 3 EXECUTION

3.01 CLEAN-UP

A. Remove all construction equipment, scaffolding, planks, tools, rags, paint containers, erection lugs, brackets weld burrs, weld spatter, or other materials not part of the tank structure.

B. Clean tank of dirt, blast products, and debris by sweeping, scrubbing, vacuuming or equally effective measures.

C. Hose down tank interior (walls, roof and floor) with potable water to remove remaining foreign materials.

D. Collect and properly dispose of all accumulated rinse water and associated solids.

3.02 DISINFECTION

A. General:

1. All inside surfaces of the tank including roof, rafters and other structural members above the high water level but excluding the tank overflow piping are to be disinfected. Thoroughly rinse chlorinated water from roof and rafters prior to the filling of the tank.

B. Initial Disinfection Procedure:

1. Spray and/or brush interior of tank with chlorine solution of one pound of 65 percent calcium hypochlorite to 100 gallons of water.

2. Thoroughly coat all surfaces including inlet and outlet piping up to and including first block valve.

3. Surfaces to be disinfected to remain in contact with disinfectant solution for a minimum of 30 minutes.

4. After minimum contact time has elapsed, disinfected surfaces to be flushed by hosing down with potable water.

C. Secondary Disinfection Procedure:

1. Fill tank with water, furnished by Owner, to approximately eight feet above the tank floor.

2. Add 65% calcium hypochlorite in solution to obtain a 5 ppm residual in the eight feet of water in the tank as follows:

3. Use the following formula to calculate weight of 65% Calcium Hypochlorite to use to obtain 5ppm:

$$\frac{\text{(Total weight of water) X (5 ppm)}}{\text{(1,000,000) X (.65)}}$$

4. Fill the tank with water to top of overflow.

5. Let stand for a minimum of 24 hours or until the chlorine residual is less than or equal to 4 ppm.

6. Tests for leakage shall be made at this time.

7. In the event leaks occur, water shall be lowered to two feet below the point the leaks occur.

8. After repairs, the process shall be repeated.

D. Water Sampling:

1. Water samples are to be taken from the tank by the Owner for bacteriological and quality analyses.

2. The Contractor shall notify the Engineer when the tank is ready to be sampled.

3. All sampling to be done during normal business working hours.

E. Additional Testing Requirements:

1. Repeat disinfection procedure, if necessary, at Contractor's expense until acceptable water samples are obtained.

2. Contractor responsible for disposing of chlorinated water.

3. Responsibility to include the obtaining of any necessary permits and all required neutralizing chemicals.

4. After the bacteriological criteria have been satisfied, the water in the tank must have a chlorine residual of less than 2.0 ppm before the tank is placed in service.

5. A Partial Certificate of Substantial Completion will be issued for each tank. The Contractor shall complete all requirements for bacteriological testing, fill the tank for use by the City, restore tank site, and complete all other ancillary construction to obtain the Certificate of Substantial Completion. The Contractor shall complete all incorrect or incomplete items cited with each Partial Certificate of Substantial Completion within 30 days.

3.03 DISINFECTION OF PLANT PIPING

A. General:

1. Furnish pump, pipe connections and necessary apparatus, gauges and meters.

2. Furnish necessary labor, assistance and chlorination agent for disinfection.

B. Contamination Control:

1. Prevent admission of contaminated water to previously disinfected units.

2. If contaminated water is admitted to previously disinfected units, disinfect these units at no additional cost to Owner.

C. Disinfect:

1. In accordance with applicable sections of AWWA C651, Disinfecting Water Mains and as follows:

a. Chlorine dose, 50 mg/l minimum.

b. Retain chlorine water in system until completion of hydrostatic tests. Minimum retention period to be 24 hours.

c. Following chlorination, flush treated water from piping until replacement water has chlorine content not more than 0.1 mg/l in excess of residual in water from supply line, and in any event not more than 0.2 mg/l total.

d. If initial treatment results in an unsatisfactory bacterial test, repeat disinfection procedures at no additional cost to Owner until satisfactory results are obtained.

END OF SECTION

SECTION 13501

SPEED CUSHIONS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Speed cushions are traffic calming devices that are installed with gaps between cushions to allow some vehicles with wide axles (primarily emergency vehicles and transit vehicles) and bicycles to pass by the speed cushion without any vertical deflection.

B. The rubber speed cushions are prefabricated in one piece or in sections that, when assembled, can meet the size and shape dimensions of a standard speed cushion (78”x80”).

C. Asphalt speed cushions are formed in place with the Type D asphalt mix to the size and shape dimensions of a standard speed cushion (78”x144”).

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02741 – Asphaltic Concrete Pavement

D. Section 02743 - Tack Coat

E. Section 02767 - Thermoplastic Pavement Markings

F. Section 02951 - Pavement Repair and Restoration

1.03 MEASUREMENT AND PAYMENT

A. Measurement.

1. Speed cushions installed or replaced will be measured by each cushion, complete-in-place.

2. Relocation of rubber speed cushions will be measured by each cushion removed and re-installed.

3. Repair of rubber speed cushions will be measured by each side ramp or entrance ramp module replaced.

4. Removal of asphalt speed cushion will be measured by each cushion removed and pavement within its footprint restored in accordance with Section 02951 - Pavement Repair and Restoration.

5. Removal of rubber speed cushion will be measured by each cushion (including installation hardware) removed. If directed by the Project Manager, salvaged materials will be delivered to the Traffic Operations Division - Maintenance Building at 2200 Patterson St.

B. Unit Prices.

1. Speed cushions will be paid for at the unit price bid for "Speed Cushions" of type specified. The price shall be full compensation for labor, materials, tools, equipment and incidentals necessary to complete the work. Payment for asphalt speed cushions includes milling of existing pavement, tack coat, and placement and compaction of asphalt. Separate payment is made for thermoplastic markings applied to asphalt speed cushions.

2. Payment for relocation of rubber speed cushions will be by each cushion removed and reinstalled.

3. Payment for side ramp and entrance ramp modules of a rubber speed cushion will be by each module furnished and installed.

4. Removal of each asphalt speed cushion will be paid for at the unit price bid. The price shall be full compensation for labor, materials, tools, equipment and incidentals necessary to remove and dispose the cushion as well as to restore the pavement surface in accordance with Section 02951 - Pavement Repair and Restoration.

5. Payment for removal of rubber speed cushions will be by each cushion removed and disposed or salvaged.

6. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 SUBMITTALS

A. For rubber speed cushions, submit manufacturer's product data and installation instruction to the Traffic Operations Division for approval.

B. If applicable, submit completed manufacturer's warranty documents to the Traffic Operations Division prior to project completion and acceptance.

C. Submit product data in accordance with Section 01330 – Submittal Procedures.

1.05 WARRANTY

A. The contractor shall provide a one year warranty on labor and material for speed cushions. The asphalt cushion height shall remain at least 3" tall after 12 months.

PART 2 PRODUCTS

2.01 MATERIALS

A. Rubber speed cushions shall meet the following material specifications.

1. Recycled rubber composite
2. Tensile strength = 500 psi (minimum)
3. Shore hardness = 65A (minimum)
4. Skid resistance = 89 (dry)
5. Conformable to pavement variances without curling

B. Rubber speed cushions, complete-in-place, shall meet the following properties.

1. Height = 3”; Width = 78”; Length = 80” (along direction of travel); side ramp module = 15”x40”, entrance ramp module = 16”x40”
2. Side slope = 1:4
3. Ramp slope = 1:10
4. Cushion color = black; marking color = white

C. Asphalt speed cushions shall be constructed with type D asphalt mix per Section 02741 – Asphaltic Concrete Pavement.

D. Striping for asphalt speed cushions shall meet the requirements of Section 02767 – Thermoplastic Pavement Markings.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. Construction shall meet the following requirements.

1. Speed cushions must be placed at locations shown on the plans or approved by the Traffic Operations Division.
2. Speed cushions shall not be placed over manholes, valves, meters, survey monuments, or other irregularities in the roadway.

B. Rubber speed cushions shall be installed per manufacturer’s specifications.

C. Construction of asphalt speed cushions.

1. A tack coat (per Section 02743 - Tack Coat) shall be applied prior to application of asphalt material.

2. Cushions shall be compacted per City of Houston Specifications and shape according to dimensions in Standard Detail 13501-01. Compaction shall require utilization of all necessary sizes and types of rollers to accomplish proper compaction and shape.

3. Striping shall meet the requirements of Section 02767 - Thermoplastic Pavement Markings and dimensions shown in Standard Detail 13501-01.

D. Removal of asphalt speed cushions.

1. Sawcut and mill pavement to depth of at least 2 inches around entire perimeter of the cushion.

2. Resurface the pavement in accordance with Section 02951 - Pavement Repair and Restoration.

END OF SECTION

SECTION 15640

JOINT BONDING AND ELECTRICAL ISOLATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Joint bonding requirements for electrical continuity along steel, ductile iron and concrete cylinder pipe.

B. Electrical isolation devices for installation at connections to existing piping, at selected below grade to above ground piping transitions, at cased crossings and at tunnels.

1.02 RELATED SECTIONS

A. Section 01330 – Submittal Procedures

B. Section 15641 - Corrosion Control Test Stations

C. Section 16640 - Cathodic Protection for Pipelines

1.03 UNIT PRICES

A. No payment will be made for joint bonding and electrical isolation under this section. Include cost in unit price for water mains or sewers.

1.04 REFERENCES

A. ASTM D 1248 - Standard Specification for Polyethylene Plastics Extrusion Material for Wire and Cable

B. AWWA C207 - Steel Pipe Flanges for Waterworks Service -Sizes 4 in. through 144 in.

C. AWWA M9 Manual - Concrete Pressure Pipe

D. ANSI B16.1 - Cast Iron Pipe Flanges and Flanged Fittings

E. ANSI B16.5 - Pipe Flange and Flanged Fittings

1.05 SUBMITTALS

A. General: Submit in accordance with the requirements of Section 01330 - Submittals.

B. Design Drawings and Computations: Prepare all computations and drawings by or under the direct supervision of a Professional Engineer, registered in the State of Texas with a minimum of ten years of corrosion control experience.

C. Catalog Cuts: Submit manufacturer's catalog cuts for each item. Include the manufacturer's name in the catalog cuts and provide sufficient information to show that the materials meet the requirements of the drawings and specifications. Where more than one item or catalog number appears on a catalog cut, clearly identify the item proposed.

D. Test Results: Submit electrical continuity and flange isolation test results to the City of Houston or its designated representative.

1.06 QUALITY CONTROL

A. Provide manufacturer's certification that all electrical continuity bonding meets the requirements of the drawings and specifications. Reference certification to applicable section of specifications and applicable standard detail.

B. Provide manufacturer's certification that all isolation devices meet the published material specifications.

C. All materials, fabrication, and installations are subject to inspection and testing by the City of Houston or its designated representative.

PART 2 PRODUCTS

2.01 DESCRIPTION OF MATERIALS

A. Joint bonding and electrical isolation materials to be incorporated into the project include, but are not limited to, the following:

1. Electrical continuity bonds
2. Flange isolation assemblies
3. Casing spacers
4. End seals

2.02 ELECTRICAL CONTINUITY BONDS

A. Applications: Applications for electrical continuity bonding include the following:

1. Bonding across bolted joint assemblies
2. Bonding across gasketed joint assemblies

B. Preparation of Prestressed Concrete Pipe for Bonding:

1. General:

a. Fabrication: Use prestressed concrete pipe for this project that has been fabricated in such a manner as to establish electrical continuity between metallic components of pipe and joints.

2. Acceptable Methods: Establish electrical continuity as indicated in drawings and specifications. Criteria for Electric Continuity:

a. Tensile Wire: Pipe manufacturer to obtain a resistance no greater than 0.03 ohms between any wire and steel joint ring at end of pipe farthest from that wire. Manufacturer to report values obtained and method of measurement.

b. Internal Pipe Joint Components: Pipe manufacturer to obtain resistance of less than 0.03 ohms between any component and steel pipe cylinder.

3. Tensile Wire Continuity:

a. Establish continuity between tensile wire coils and steel cylinder on embedded cylinder type prestressed pipe by tightly wrapping tensile wire over longitudinal mild steel straps during pipe manufacture.

(1) Use and install two continuous straps 180˚ apart longitudinally along the pipe. These straps must maintain electrical continuity between metallic components.

(2) Use steel straps made of mild steel and free of grease, mill scale, or other high resistance deposits.

(3) Make longitudinal straps electrically continuous with pipe cylinder by steel fasteners of suitable dimensions placed between steel cylinder and longitudinal straps. Connect fasteners so as to remain intact during pipe fabrication process.

4. Steel Cylinder Continuity:

a. Establish continuity of all joint components and steel cylinder. These components include the following:

(1) Anchor socket brackets.

(2) Anchor socket.

(3) Spigot ring.

(4) Bell ring.

b. If mechanical contact does not provide a resistance of less than 0.03 ohms between components, tack weld component to provide electrical continuity.

C. Preparation of Steel Pipe for Bonding: Bonding wires are not required for welded steel pipe

D. Preparation of Ductile Iron Pipe for Bonding: Install insulated bond wires as shown on contract drawings.

E. Electrical Bond Wires: Electrical bond wires are to be a minimum No. 2 AWG, seven strand, copper cable with THHN insulation. Remove one inch of THHN insulation from each end of the bond wire. Provide the minimum number of bond wires as shown on drawings for steel or ductile iron pipe.

F. Electrical Bond Clip: Weld three (3) ASTM 366 steel bonding clips, each approximately 0.13 inches thick, 2.5 inches long, and 1.25 inches wide, with 1/8- inch fillet welds to the bell and spigot of adjacent prestressed concrete cylinder pipe or steel pipe with rubber gasketed joints. Manufacture clips to maintain continuity regardless of small deflections of finished joints.

2.03 FLANGE ISOLATION

A. Applications: Required applications of dielectric flange isolation assemblies include but are not limited to the following:

1. At selected locations where new piping is mechanically connected to existing piping.

2. At selected below-grade to aboveground piping transitions.

3. At locations shown on the drawings.

B. Isolation: Provide electrical isolation through the installation of the following materials:

1. Welded flange connections to steel pipe

2. Flange connections to bell and spigot adapters for concrete cylinder and ductile iron pipe.

3. Flange Isolation Gasket

4. Sleeves and Washers

C. Flange Isolation Gasket: Provide type “E” gaskets with an EPDM sealing element.

1. Thickness: Gasket to be 1/8 inch thick.

2. Dimensions: Gasket to be 1/8 inch less in I.D. than the I.D. of the flange in which it is to be installed and extend to the O.D. of the flange.

3. Flange Face: Provide sealing element positioned to accommodate either flat or raised face flanges.

4. Temperature Range: Temperature range of the product shall be -65°F to +250°F.

5. Product Performance Testing: Gasket shall meet or exceed the following test criteria:

ASTM D149	Dielectric Strength (short term)	550 Volts/mil
ASTM D695	Compressive Strength	50,000 psi minimum
ASTM D229	Water Absorption	0.15% maximum
ASTM D 790	Flexural Strength	50,000 psi minimum
ASTM D785	Hardness	110 minimum
ASTM D256	IZOID Impact Strength	12.5 ft-lbs/in minimum
ASTM D638	Tensile Strength	45,000 psi minimum
ASTM D32	Shear Strength	20,000 minimum
ASTM F-36	Compressibility	2.1% maximum
ASTM F-36	Recovery	88.9% minimum
ASTM F-38(B)	Creep Relation	5.1% maximum
DIN-3535	Gas Permeability	0.43cm3/min. maximum

D. Alternate Isolation Gasket: As an alternate to the above, provide a plain-faced phenolic gasket. Place the phenolic gasket between two full-faced gaskets. Provide cloth-inserted rubber gasket material, 1/8 inch thick in accordance with AWWA C207. Use factory cut gaskets of proper dimensions.

E. Sleeves and Washers:

1. Sleeve: Provide full length 1/32 inch thick, mylar sleeves for each bolt. The length of the sleeve shall extend half way into the outside steel backup washers.

2. Isolation Washers: Supply two, 1/8 inch thick, Pyrox G-10 isolation washers per bolt. Isolation washers to have a compressive strength of 50,000 psi, a dielectric strength of 550 volts/mil and maximum water absorption of 0.10%.

3. Backup Washers: Provide two, 1/8 inch thick, zinc plated, hot rolled steel backup washers for each bolt. For pipe greater than 30 inch diameter, provide two additional steel washers to be placed inside the isolation washers for additional support.

4. Size: The isolation washers and the backup washers shall be of the same O.D. and I.D., with a sufficiently large I.D. to fit over the isolation sleeve.

F. Coatings: Coat buried isolation flanges with petroleum based tape or synthetic, a-polar polymer wrap.

2.04 CASING SPACERS

A. For water or wastewater piping installed in tunnels or cased crossings, install casing spacers between the piping and the casing or tunnel liner to provide electrical isolation.

B. Inside diameter of casing or tunnel liner must be 4 inches greater in diameter than the outside diameter of the piping. In the case of mechanically coupled piping, the casing must be a minimum of 4 inches greater in diameter than the outside diameter of the coupling at its largest point.

C. For welded steel pipe 12-inch diameter and smaller, use injection molded polyethylene insulators, Model PE as manufactured by Pipeline Seal and Insulator, Inc. or approved equal.

D. For all other pipe materials 12-inch diameter and smaller, use 8-inch wide steel insulators with 2 inch wide glass reinforced runners, Model C8G-2 as manufactured by Pipeline Seal and Insulator, Inc. or approved equal.

E. For all piping greater than 12-inch diameter, use 12-inch wide steel insulators with 2 inch wide glass reinforced runners, Model C12G-2 as manufactured by Pipeline Seal and Insulator, Inc. or approved equal.

2.05 CASING END SEALS

A. For all piping less than 24-inch diameter, use hard rubber seals, Model PL Link Seal as manufactured by the Thunderline Corporation or approved equal.

B. For all piping 24-inch diameter and greater, use pull-on, 1/8-inch thick, synthetic rubber end seals, Model C, as manufactured by Pipeline Seal and Insulator, Inc. or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION OF ELECTRICAL CONTINUITY BOND WIRES

A. Inspection: Use continuous bond wires with no cuts or tears in the insulation covering the conductor.

B. General: Attach bond wires at required locations by thermite welding.

C. Thermite Welding: Perform thermite welding of bond wires to piping in the following manner:

1. Clean and dry pipe to which wires are to be attached.

2. Use grinding wheel to remove all coating, mill scale, oxide, grease, and dirt from an area approximately 3 inches square. Grind surface to bright metal.

3. Remove approximately 1 inch of insulation from each end of wire to be thermite welded to pipe, exposing clean, oxide-free copper for welding.

4. Select proper size thermite weld mold as recommended by manufacturer. Place wire between graphite mold and the prepared metal surface. Use a copper sleeve crimped over wire for all 12 AWG wires.

5. Place metal disk in bottom of mold.

6. Pour thermite weld charge into the mold. Squeeze bottom of cartridge to spread ignition powder over change.

7. Close mold cover and ignite starting powder with flint gun.

8. After exothermic reaction, remove thermite weld mold and gently strike weld with a hammer to remove weld slag. Pull on wire to assure a secure connection. If weld is not secure or the wire breaks, repeat procedure with new wire.

9. If weld is secure, coat all bare metal and weld metal with Kop-Coat. Cover coated weld with a plastic weld cap.

D. Post-Installation Inspection: Make post-installation inspection of all electrical continuity bonds through a visual examination of each thermite weld connection for strength and suitable coating prior to backfilling. In addition, perform one or more of the following tests:

1. Circulate current through pipe using DC power supply. Calculate resistance through known length of pipe. Resistance must not exceed 150% of theoretical resistance for pipe and bonds.

2. Measure resistance through select bonded joints with a digital low resistance ohmmeter (DLRO). Resistance of 0.001 ohms or less is acceptable.

3. Position a CSE at a stationary location adjacent to bonded pipeline. Impress a temporary current on pipe. Record static, current-applied, and instant “off” pipe-to-soil potential readings along the pipe relative to the stationary CSE.

   a. Static potential measurements referenced to stationary CSE must be nearly identical along the pipe to indicate electrical continuity.

   b. Instant “off” potentials referenced to stationary CSE must be nearly identical along pipe to indicate electrical continuity.

   c. The difference between the instant “off” and the static potential referenced to stationary CSE must be equal at each point of contact to pipe to indicate electrical continuity.

4. If any of the above procedures indicates a poor quality bond connection, rebond the joint.

5. Record results and submit to City of Houston or its designated representative for approval prior to backfilling.

E. Backfilling of Bonded Joints:

1. Backfill bonded piping in manner that prevents damage to the bond wires and all connections to the metallic structures.

2. If construction activity damages a bonded connection, install new bond wire.

3.02 INSTALLATION OF FLANGE ISOLATION DEVICES

A. Placement: Install above-grade dielectric insulators at a minimum 12 inches and maximum of 48 inches above final grade.

B. Assembly: Place gasket, sleeves, and washers as shown on the drawings. Follow manufacturer's recommendations for even tightening to proper torque. See drawings.

C. Testing: Immediately after an insulating fitting has been installed, test electrical isolation with a Gas Electronics model, 601 meter. Fully document test results and submit to the City of Houston or its designated representative.

D. Painting: Do not use metal base paints on insulating fittings.

E. Encapsulation: Encapsulate below-grade insulating flanges with the Carboline Densyl tape system, or approved equal, after the insulating flange has been tested for effectiveness.

3.03 INSTALLATION OF CASING SPACERS

A. Assemble and securely fasten casing spacers to the pipeline to be installed in casings or tunnels.

B. Avoid inadvertent metallic contact between casing and carrier pipe. Place spacers close enough to ensure that the pipe is adequately supported throughout its length, particularly at the ends, to offset settling and possible electrical shorting. The end spacer must be within 6 inches of the end of the casing pipe, regardless of size of casing and pipe or type of spacer used. Install spacers on PVC pipe at the insertion line to prevent over-insertion of the spigot into the bell.

C. Grade the bottom of the trench adjacent to each end of the casing to provide a firm, uniform and continuous support for the pipe. If the trench requires some backfill to establish the final trench bottom grade, place the backfill material in 6-inch lifts and compact each layer.

D. After the casing or tunnel liner has been placed, pump dry and maintain dry until the casing spacers and end seals are installed.

E. Install casing spacers in accordance with the manufacturer's instructions. Correctly assemble, evenly tighten, and prevent damage during tightening of the insulators and pipe insertion.

F. Insulator Spacing:

1. Maximum distance between spacers to be 10 feet for pipe sizes 6 inches and smaller, and 6 feet for pipe sizes greater than 6 inches.

2. For ductile-iron pipe, flanged pipe, or bell and spigot pipe, install spacers within one foot on each side of the bell or flange, and one in the center of the joint where 18 foot or 20 foot long joints are used.

3. If the casing or pipe is angled or bent, reduce the spacing.

3.04 INSTALLATION OF END SEALS

A. Assemble hard rubber Link-Seals around the pipe and slide into the annular space between the pipe and casing. Evenly tighten the bolts to provide a positive seal.

B. Place pull-on synthetic rubber end seals on the pipe and pull over the end of the casing. Securely fasten stainless steel bands.

3.05 ELECTRICAL CONTINUITY TESTS

A. Immediately after the pipe has been installed in the casing, but prior to connecting the line, perform an electrical continuity test to determine whether the casing is in fact insulated from the pipe. Have the continuity check fully documented and approved by the City of Houston or its designated representative prior to backfilling.

B. If the electrical isolation between pipe and casing is not effective, immediately investigate the cause and remedy the situation. Under no circumstances, backfill a shorted casing.

END OF SECTION

SECTION 15641

CORROSION CONTROL TEST STATIONS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Test station materials and installation requirements.

B. Locations requiring test stations are adjacent to manholes, major pipeline crossings, cased crossings and tunnels, below-grade insulated flanges and select sacrificial anode installations.

1.02 RELATED SECTIONS

A. Section 01330 – Submittal Procedures

B. Section 15640 - Joint Bonding and Electrical Isolation

C. Section 16640 - Cathodic Protection for Pipelines

1.03 UNIT PRICES

A. No payment will be made for corrosion control test stations under this section. Include cost in unit price for water mains or sewers.

1.04 REFERENCES

A. ASTM D 1248 - Polyethylene Plastic Molding and Extrusion Material

B. NACE International SP0169 - Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems

C. AWWA M9 Manual - Concrete Pressure Pipe

D. UL 83 - Thermoplastic Insulated Wires

E. UL 486A - Wire Connectors for Use with Copper Conductors

1.05 SUBMITTALS

A. General: Submittals to conform to the requirements of Section 01330 - Submittal Procedures.

B. Design Drawings and Computations: Prepare all computations and drawings by or under the direct supervision of a Professional Engineer, registered in the State of Texas with a minimum of ten years experience in corrosion control.

C. Catalog Cuts: Submit manufacturer's catalog cuts for each item. Include the manufacturer' name on the catalog cuts and provide sufficient information to show that the materials meet the requirements of the drawings and specifications. Where more than one item or catalog number appears on a catalog cut, clearly identify the item proposed.

D. Drawings: During installation and construction, maintain as-built drawings of the corrosion control test stations. Revise drawings to show exact locations of all wiring, connections, and terminal boxes. Properly identify all items of equipment and material. Submit the original as-built drawings to the City of Houston or its designated representative.

1.06 QUALITY CONTROL

A. Provide manufacturer's certifications that all components of the corrosion control test stations meet the requirements of the drawings and specifications. Reference the applicable section of the specifications and the applicable standard details on the certification.

B. The drawings for the corrosion control test stations are diagrammatic and do not scale for exact locations, unless scales are explicitly stated on the specific drawing. Field conditions, non-interference with other utilities or mechanical and structural features determine exact locations. Note other existing utilities in the area and during excavation, do not damage these utilities. Repair any damaged utilities to the satisfaction of the City of Houston at the Contractor's expense.

C. All materials, fabrication, and installations are subject to inspection and testing by the City of Houston or its designated representative.

PART 2 PRODUCTS

2.01 FLUSH MOUNT TEST STATIONS

A. Test stations consist of test wires, a terminal box and a traffic box as shown on the drawings.

B. For the terminal box, use a five terminal Big Fink as manufactured by Cott Manufacturing Company or approved equal

C. For the concrete traffic box; use an 10.25-inch diameter 3-RT with a cast iron cover marked "CP Test" as manufactured by Brooks Products, Inc or approved equal.

2.02 ABOVE-GRADE TEST STATIONS

A. At test station locations where flush mounted structures are not practical, use an above- grade test station, and place such that possible damage from vandalism, traffic, etc. is minimized.

B. For the test station, use a five terminal Big Fink as manufactured by Cott Manufacturing or approved equal.

C. Have a lockable, corrosion-proof plastic cover for the terminal boxes. Mount on a 5-foot length of 3-inch diameter UV-resistant plastic conduit.

D. Install the test station adjacent to a permanent structure, if possible, for physical protection.

2.03 PERMANENT REFERENCE ELECTRODES

A. Type: Provide a copper/copper sulfate, double membrane, ceramic cell in a geomembrane package such as a Permacell Plus or approved equal.

B. Wire: Equip the electrode with No. 14 AWG stranded copper wire with blue HMWPE insulation of suitable length to attach to the terminal board of the test station without splicing.

2.04 TEST STATION LEAD WIRES

A. Test station lead wires of all sizes shall have TW, THW or THHN insulation.

B. Color code insulation based upon connection to underground structures:

1. Water piping: white

2. Foreign structures: red

3. Steel casings: yellow

C. Wire all terminal boards as shown on the drawings.

2.05 THERMITE WELD EQUIPMENT

A. Charges and Molds: Select weld charges and mold size for the specific surface configuration in accordance with manufacturer recommendations. Use Erico, Cadweld, or Continental Industries, Thermoweld weld charges and molds.

B. Weld Coating: Coat weld with Stopaq CZ tape or approved equal.

PART 3 EXECUTION

3.01 APPLICATIONS

A. Required applications of corrosion control test stations include locations where future testing is anticipated for the following reasons:

1. Testing to determine the effectiveness of the installed cathodic protection systems and to allow for startup adjustments.

2. Testing to determine interference effects from and on adjacent or crossing foreign underground structures.

3. Testing to determine sources and magnitude of stray d-c currents and required mitigative measures.

4. Periodic monitoring to determine status of existing cathodic protection systems, stray current, and foreign line influence.

B. Install test stations at each of the following locations:

1. On continuous pipelines adjacent to all manhole locations unless otherwise shown or noted on the drawings.

2. At all major underground pipeline crossings.

3. At all cased crossings and tunnels (both ends).

4. At all underground isolation flanges.

5. At galvanic anode locations, where indicated.

6. At all other locations shown on the drawings.

3.02 GENERAL

A. Locate test stations adjacent to manholes where possible. If a flush mounted test station is not feasible in a particular location, then an above-grade test station may be used, subject to approval by the City of Houston or its designated representative.

B. Use continuous test station lead wires without cuts or tears in the insulation.

C. Locate test stations as close to directly over the pipe as possible. If the pipe is installed under a road, place the test station at the curb for easy access.

D. Attach test lead wires to the pipe by thermite welding.

E. Use color coded test wires as indicated on the drawings.

F. Wire test station terminal board configurations as shown on the drawings.

G. At foreign pipeline crossing test stations, the owners of the pipeline must be notified and must give permission before the test leads are connected to their pipeline. The owner should have a representative present. If owner refuses test leads connected to their pipeline, then document owner's refusal and install potential test station on water main. Document owner contact name, phone number, email address, and date of contact. Submit documentation to City of Houston.

H. Enclose all wires in grey electrical PVC conduit.

3.03 FLUSH-MOUNT TEST STATIONS

A. Install flush-mount test stations as shown on the drawings.

B. Coil sufficient slack beneath the test station to allow for soil settlement and to prevent damage to the leads during backfilling. Leave additional slack to allow for withdrawal of the terminal board a minimum of 18 inches above the top of the concrete traffic box for test purposes.

C. Install flush-mount test stations with permanent copper/copper sulfate reference electrodes where indicated on the drawings.

1. Install reference electrode approximately 12-inches from the pipe.

2. Compact native soil by hand around the electrode. Use select granular backfill material for the balance of the backfill.

3. Saturate the backfilled reference electrode with 5 gallons of water.

D. Set test stations outside areas of permanent paving in a Portland cement concrete pad, minimum of 24 inches square and no less than 4 inches thick.

3.04 ABOVE-GRADE TEST STATIONS

A. Install above-grade test stations where a flush mounted test station cannot be located. Use and location of above-grade test stations must be approved by the City of Houston or its designated representative.

B. Locate test station adjacent to a permanent structure (e.g. a power pole), if possible, for physical protection.

C. Coil sufficient slack beneath the test station to allow for soil settlement. Do not damage the leads during backfilling.

D. Set test stations in a Portland cement concrete anchor, a minimum of 12 inches in diameter and no less than 2 feet thick.

3.05 TEST LEAD WIRE ATTACHMENT

A. Attach test leads to the pipe by thermite welding.

B. Clean and dry the pipe to which the wires are to be attached.

C. Use grinding wheel to remove all coating, mill scale, oxide, grease, and dirt from an area approximately 3 inches square. Grind the surface to bright metal.

D. Remove approximately 1 inch of insulation from each end of the wires to be thermite welded to the pipe, exposing clean, oxide-free copper for welding.

E. Using the proper size thermite weld mold as recommended by the manufacturer, place the wire between the graphite mold and the prepared metal surface. Use a copper sleeve crimped over the wire for all No. 12 AWG wires.

F. Place the metal disk in the bottom of the mold.

G. Pour the thermite weld charge into the mold. Squeeze the bottom of the cartridge to spread ignition powder over the charge.

H. Close the mold cover and ignite the starting powder with a flint gun.

I. After the exothermic reaction, remove the thermite weld mold and gently strike the weld with a hammer to remove the weld slag. Pull on the wire to assure a secure connection. If the weld is not secure or the wire breaks, repeat the procedure.

J. If the weld is secure, coat all bare metal and weld metal with Stopaq CZ tape.

3.06 POST INSTALLATION BACKFILLING OF TEST STATION - LEAD WIRES.

A. Protect test station wires to prevent damage to the wire insulation and conductor integrity during backfilling.

B. After completion of the backfilling of the test wires to the pipe, verify the connection by recording a pipe-to-soil potential.

C. Replace any test wire found to have a high resistance connection.

END OF SECTION

SECTION 16010

BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Basic requirements specifically applicable to the work of Division 16 - Electrical Requirements.

B. The Contractor shall furnish equipment, materials, and labor for assembly and installation plus check-out and start-up of the complete electrical system as shown on the Drawings and stipulated in the Specifications.

1.02 REFERENCES

A. As a minimum requirement, the electrical system shall be constructed in accordance with:

1. American National Standards Institute/National Fire Protection Association (ANSI/NFPA), No. 70 - National Electrical Code (NEC). The contractor shall provide all electrical work / installations based on the latest addition of the NEC.

2. City of Houston Building Code.

3. Other applicable Codes and Standards as referenced in other Master Specifications.

B. Comply with local, county, state and federal regulations and codes in effect as of date of purchase.

C. Equipment of foreign manufacture must meet U.S. codes and standards.

D. Equipment and materials shall conform to requirements of specification and to the criteria provided in data sheets for the project.

1.03 QUALITY ASSURANCE

A. Product Conformance Certificate and Quality Assurance Release. Submit an overall conformance certificate for electrical components signed by the person responsible for product quality. Specifically identify the purchased material or equipment by project name and location, purchase order number, supplements, and item number where applicable, including materials and services provided by others. Indicate that all requirements have been met and identify any approved deviations.

B. Field Inspection

1. Electrical work shall be inspected and approved by the local code inspectors, the wastewater inspectors, and the Project Manager prior to starting the 7-day test or scheduling training.

2. Contractor shall give a minimum of two days' notice to the Inspectors that the installation is ready for inspection and two days' notice to the Project Manager.

3. Concealed work shall be inspected and approved by code inspectors and wastewater inspectors before it is covered:

   a. Conduit with stub-ups, underground in duct banks before concrete is poured. Conduit in slabs, walls and ceilings, complete with boxes.

4. Electrical equipment and materials shall be inspected upon arrival by the Project Manager for compliance with specifications.

1.04 SITE CONDITIONS

A. Take the following site conditions into consideration when fabricating, erecting, installing and wiring electrical equipment under this contract:

1. Plant Location _____

   Houston, Texas

2. Plant Type and Size _____

3. Plant Site Elevation _____

4. Seismic Zone Zone 0

5. Wind Velocity 90 mph

6. Temperature, Min./Max.:

   a. Coldest Winter Month High 60 degrees F Low 41 degrees F

   b. Warmest Summer Month High 94 degrees F Low 73 degrees F

   c. Lowest Expected 11 degrees F

   d. Highest Expected 107 degrees F

7. Rainfall:

   a. Annual 45 inches

   b. Design 3.4 inches/hour, 8.4 inches/24 hours

8. Design Relative Humidity: 98%

9. Station Barometric Pressure:

   a. Average Annual 29.5 inches Hg Absolute.

10. Utility Water Systems:

	Design Pressure	Design Temp.
River Water	PSI	degrees F
Well Water	PSI	degrees F
City Water	PSI	degrees F

11. Electric Power Supply Characteristics (Available to Contractor):

	Voltage	Phase	Hz	Wire	Delta or Wye
1					
2					
3					

PART 2 PRODUCTS

2.01 COMPONENT DESIGN

A. Components utilized in the construction of the material or equipment shall be of the latest proven design, new and in current production. Do not use obsolete components or components to be phased out of production.

2.02 FACTORY INSPECTION

A. Provide free access with prior notice for the Project Manager at all times to the shop where the material or equipment is being fabricated or tested. Provide reasonable facilities for inspection, witnessing tests, and examining records. Give 7-days notice prior to starting tests which are scheduled for factory inspection.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify dimensions and ratings of equipment and materials to ensure proper fit and performance.

3.02 INSTALLATION

A. Install equipment and materials in accordance with the Drawings and manufacturer's written instructions. If field conditions necessitate changes in electrical installation, obtain approval from the City Engineer.

B. Conductor voltage drop shall not exceed 2 percent for feeders and 3 percent for branch circuits.

3.03 DEMONSTRATION

A. Test the electrical system to specification requirements and to demonstrate correct installation and operation of equipment. O & M Manual shall be furnished prior to testing for reference during testing and corrections for final O & M.

B. Before 7-days test, demonstrate the system to the wastewater inspectors and the Project Manager. Show the system to be fully operational. All alarms, safeties, and communication points to central and locally must operate in both full-automatic and back-up modes. Use fresh water in the test medium.

C. Operate the system continuously for a period of 7 days in full automatic, without failure, to qualify as acceptable. "Failure" is considered any problem that requires correction by process control instructions, maintenance personnel, such as: high or low water level, any motor alarm, power failure, phase failure, communication failure, PLC failure, process control software failure, requiring rewriting or transducer failure. This would exclude conditions not under the control of Contractor, such as: evident lightning strikes, 25-year rains, local power utility power failure longer than the specified duration of service. Failures due to uncontrollable situations would allow the 7-day test to continue, as soon as test conditions are restored and the City Engineer is notified.

D. The existing station shall remain in service during this test.

END OF SECTION

SECTION 16124

CONDUCTIVE TRACE WIRE FOR NON-METALLIC WATER LINE PIPES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for the installation of the trace wire and components for the purposes of locating non-metallic water line pipes, laterals, and appurtenances.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 02506 – Polyvinyl Chloride Pipe

D. Section 02511 - Water Lines

E. Section 02531- Gravity Sanitary Sewers

F. Section 02532 - Sanitary Sewer Force Mains.

G. Section 02631 - Storm Sewers

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made to provide and install trace wire and associated components under this Section. Include payment in related unit price work.

2. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.04 DEFINITIONS

A. Access Points: Access points are designed to provide easy access and allow proper direct connection to the trace wire equipment. Access points also allow external connection and disconnection to trace wire.

B. AWG – American Wire Gauge is the US standard measure for the diameter of electrical conductors.

C. THHN – Thermoplastic high heat-resistant nylon coated wire.

D. Trace Wire – Also known as tracer wire, locating wire, is used to assist in locating non-metallic pipes after they have been buried in the ground.

1.05 REFERENCES

A. APWA Uniform Color Code.

B. ASTM B1010/B1010M – Standard Specification for Copper-Clad Steel Electrical Conductor for Tracer Wire Applications

C. ASTM B170 – Standard Specification for Oxygen-Free Electrolytic Copper-Refinery Shapes.

D. ASTM B227 - Standard Specification for Hard Drawn Copper-Clad Steel Wire.

E. ASTM B910/B910M - Standard Specification for Annealed Copper-Clad Steel Wire.

F. ASTM D1248 – Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

1.06 SUBMITTALS

A. Submittals to confirm to requirements of Section 01330 – Submittal Procedures.

B. Submit for review manufacturer's product data sheets for the following:

1. Trace wire and insulation

2. Connectors

3. Ground rod

4. Termination and access points

C. Provide layout of trace wire, connectors, ground rods, termination and access points for review.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide trace wire for non-metallic water lines.

B. Provide system components including trace wires, connectors, ground rods and access points which are compatible to ensure end to end conductivity for detecting underground utility assets.

C. Provide high density, high molecular weight polyethylene insulation. Color code as per APWA Uniform Color Code for specific utilities being marked.

D. Provide trace wire that is domestically manufactured in the USA.

E. Manufacture must provide 5-year warranty or provide third-party documentation of a 5-year corrosion test.

F. Trace wire manufacturer or manufacturer's representative to provide installation training for Contractors who have not previously received the training. Project Manager to be notified of scheduled training prior to installation.

2.02 TRACE WIRE

A. Open Trench Installations: Provide High Strength Copper-Clad Steel (HS-CCS), fully annealed high carbon 1055 grade steel trace wire which conforms to one of the following:

1. 12-AWG with minimum 450lb tensile break load, and minimum 30 mil HDPE insulation thickness, or

2. 10-AWG with minimum 680lb tensile break load, and minimum 30 mil HDPE insulation thickness.

B. Trenchless Installations: Provide Extra-High Strength Copper-Clad Steel (EHS-CCS), hard drawn, high carbon 1055 grade steel trace wire which conforms to one of the following:

1. 12-AWG Extra with a minimum break load of 1,150 lb., and a minimum HDPE insulation thickness of 45 mil, or

2. 10-AWG Extra with a minimum break load of 2,030 lb., and a minimum HDPE insulation thickness of 45 mil, or

3. 8-AWG Extra with a minimum break load of 2,700 lb., and a minimum HDPE insulation thickness of 45 mil.

C. THHN wire is not permitted for any trace wire installation.

D. Nylon jackets or coatings are not permitted for any trace wire installation.

2.03 CONNECTORS

A. Provide waterproof and corrosion-proof trace wire connectors. Install without cutting or splicing the trace wire. Protect vulnerable wire splices and keep the locator signal flowing across connections.

B. Interconnect mainline trace wires at intersections, at mainline tees and mainline crosses. At tees, connect the three wires using a 3-way lockable connector. At crosses, join the four wires using a 4-way lockable connector. The use of two 3- way lockable connectors with a short jumper wire between them is acceptable.

C. Provide dielectric silicone filled connectors, to seal out any moisture and corrosion. Install in a manner to prevent any uninsulated wire exposure.

D. Non-locking, friction fit, or taped connectors are prohibited.

2.04 GROUNDING

A. Properly ground trace wire at dead-ends/stub and entry points.

B. Ground trace wire using a 15-lb, drive-in magnesium ground rod with minimum 20-feet red #12 AWG Copper-Clad Steel (CCS) wire with 30 mil HDPE insulated jacket connected to the anode specifically manufactured for grounding purpose and buried at the same elevation as the utility.

C. Brass, steel, or copper ground rods are not accepted.

2.05 TERMINATION/ACCESS

A. At Grade level Access Point:

1. Provide with suitable cover cap identified as “Water” and color coded as per APWA Uniform Color Code standard.

2. Set cover cap at grade level. If cover cap is within pavement, provide material suitable for vehicular loading.

3. Allow locator to switch ground off and on from top of lid without the need to remove lid.

4. Provide anti-corrosion wax/gel to protect wires.

5. Include encapsulated magnet molded into the top portion of the tube.

B. Above grade Level Access Point:

1. Provide at Fire Hydrants. Install with two internal wire connections to protect wire from corrosion and color code as per APWA Uniform Color Code standard.

C. Termination: Terminate service laterals and dead ends using two terminal external switchable lid access point with a grounding.

PART 3 EXECUTION

3.01 GENERAL

A. Place trace wire in same orientation as installed pipe. Using a tape or plastic tie, secure the trace wire to the pipe every 5 feet in the three o'clock position. No looping or coiling allowed.

B. Ground at dead ends, the beginning and end of the pipe, and at service connections.

C. Do not connect trace wire to existing conductive pipe, casing or appurtenances. Do not connect trace wire to existing trace wire systems. Treat these locations a dead ends.

D. Provide 1 ft excess/slack wire at access points after meeting final elevation.

E. Provide complete replacement of damaged wires, access points, or connectors with approved products at no additional cost to the City.

F. Connecting trace wire by twisting wires and taping or brass fittings with connection lugs is not permitted.

G. Provide waterproof/corrosion proof connectors, with need to remove jacket during installation. All connections should have half knot tied prior to connections to prevent wire pull out.

H. For long pipelines more than 2,500-ft without services, provide a single connection access point and do not ground in the middle, only the end and beginning.

I. Lay mainline trace wire continuously, by passing around the outside of valves and fittings, on the north or east side, so that there is no metallic contact.

J. Terminate trace wire on water service laterals at an access point, color coded blue for water lines, and located directly above the service lateral or curb stop at the edge of road right-of-way.

K. Install above-ground trace wire access points at fire hydrants. Provide two connection points. One for ground wire connection (lowest connection point) and second for trace wire. Affix to fire hydrant flange with HDPE bracket secured to fire hydrant flange bolt. Operator must be able to connect at this access point without removing the cover. Wire must not be exposed at any point to the environment.

3.02 CONDUCTIVITY TESTING

A. Provide a conductivity test for new trace wire installations using typical low frequency (512 Hz) line tracing equipment, witnessed by the Contractor, and Project Manager or Project Manager's representative, prior to Substantial Completion.

END OF SECTION

SECTION 16130

ADVANCED TRANSPORTATION CONTROLLER (ATC) CABINET ASSEMBLY

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This specification defines the minimum detailed requirements applicable to traffic signal controller cabinets. The intent of specification is to set forth the minimum acceptable physical, electrical and mechanical design and requirements within which all equipment operates satisfactorily and reliably, and the means by which the equipment shall be tested to determine whether it shall so operate.

B. These specifications describe the materials necessary to provide the 120 VAC High Voltage (HV) Advanced Transportation Controller (ATC) traffic signal cabinets for use with Type 2070 Advanced Transportation Controller (ATC). The Type 2070 Controller Unit to be furnished with the ATC Cabinet Assembly shall meet the requirements of Specification Section 16731.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 16731 – Model 2070 Controller Unit

1.03 MEASUREMENT AND PAYMENT

A. Unit Price

1. Each ATC Cabinet Assembly shall include a Model 2070 Controller Unit (Section 16731) and other components as specified in Table 1 of this specification. This Item will be measured as each controller cabinet assembly by type furnished.

2. The materials furnished in accordance with this Item and measured as provided under “Measurement” as each specified type of assembly furnished.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ATC 5201 v06.25 – Advanced Transportation Controller

B. ATC 5301 v02.02 - Advanced Transportation Controller

C. ASTM B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

D. ASTM A 666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

E. ASTM B 633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel

F. EIA-310-B – Cabinets, Racks, Panels, and Associated Equipment

G. Federal Specification QQ-P-416C – Cadmium Plating

H. ITS Cabinet Standard v01.02.17b – Intelligent Transportation System (ITS) Standard Specification for Roadside Cabinets

I. NFPA 70 – National Electric Code

1.05 WARRANTY

A. All materials furnished will be warranted by the supplier for a period of two (2) years from date of delivery. Units or components that are identified as being defective before the warranty has expired shall be replaced within thirty (30) calendar days. The vendor shall be responsible for all costs, including shipping, incurred by City for all units that are installed at an intersection and fail as a result of warranty covered failure within the warranty period.

1.06 SUBMITTALS

A. Manuals. Two copies of manual documentation must be supplied for each item purchased. The manual must be bound in durable covers made of either 65-pound stock paper or clear plastic. The manual must be printed on paper measuring 8-1/2 in. by 11 in., with the exception that schematics, layouts, parts lists and plan details may be on sheets measuring 11 in. by 17 in., with each sheet neatly folded to a size of 8-1/2 in. by 11 in. A minimum of Times New Roman or Arial 10 point font must be used for all manual text, excluding drawings and schematics. Drawing text may use a smaller font size.

1. Cabinet Wiring Diagrams. Two copies of cabinet wiring diagrams must be included in each cabinet. Cabinet wiring diagrams must be on non-fading, minimum 22 in. x 34 in., sheets.

a. Manual Contents. Each manual must utilize the following outline, to the extent possible:

(1) Table of Contents

(2) Glossary

(3) Manufacturer Contact Information

(a) Address

(b) Telephone Number

(c) Fax Number

(d) General Email Address

(4) General Description

(5) General Characteristics

(6) Installation

(7) Adjustments

(8) Theory of Operation

(a) Systems Description (include block diagram).

(b) Detailed Description of Circuit Operation.

(9) Maintenance

(a) Preventive Maintenance.

(b) Trouble Analysis.

(c) Trouble Shooting Sequence Chart.

(d) Wave Forms.

(e) Voltage Measurements.

(f) Alignment Procedures.

(10) Parts List (include circuit and board designation, part type and class, power rating, component manufacturer, mechanical part manufacturer, data specification sheets for special design components and original manufacturer's part number).

(11) Electrical Interconnection Details & Drawings.

(12) Schematic and Logic Diagram

(13) Assembly Drawings and a pictorial diagram showing physical locations and identification of each component or part.

(14) The date, serial numbers, model numbers and revision numbers of equipment covered by the manuals must be printed on the front cover of the manuals.

b. Manual Pouches. Manuals for the cabinet must be furnished in a weatherproof plastic pouch placed in the cabinet.

c. Draft Manual. A preliminary draft of the manual must be submitted, when required, to the City of Houston for approval prior to final printing.

1.07 DELIVERY, STORAGE AND HANDLING

A. Packaging. Each item delivered must be individually packed in its own shipping container. When loose Styrofoam is used for packing the item, the item must be sealed in a plastic bag to prevent direct contact with the Styrofoam.

B. Delivery. Each item delivered for testing must be complete, including manuals, and ready for testing. The cabinet shall be delivered mounted with bolts on a ply board shipping pallet. The cabinet shall be enclosed in a slipcover cardboard packing shell. The housing doors shall be blocked to prevent movement during transportation.

1.08 QUALITY ASSURANCE

A. ATC Cabinets shall be certified by the manufacturer as conforming to the latest national standards, currently the ATC 5301 v02.02, Advanced Transportation Controller (ATC) Cabinet Standard Version 02, (dated March 18, 2019) for ATC components, and the ITS Cabinet Standard v01.02.17b, Intelligent Transportation System (ITS) Standard Specifications for Roadside Cabinets, (dated November 16, 2006) for ITS components and cabinet shell housing. The ATC Cabinets shall conform to any exceptions and additions stated herein unless otherwise specified.

PART 2 PRODUCTS

2.01 MATERIALS

A. All sharp edges and corners must be rounded and free of any burrs.

1. Aluminum. Aluminum sheets must be Type 3003-H14 or Type 5052-H32 ASTM Designation B209 aluminum alloy. Rod, Bar and Extruded must be Type 6061-T6, or equal.

2. Stainless Steel. Stainless Steel sheets must be annealed or one-quarter-hard complying with the ASTM Designation: A666 for Type 304, Grades A or B, stainless steel sheet.

3. Cold Rolled Steel. Cold Rolled Steel sheet, rod, bar and extruded must be Type 1018/1020.

a. Plating. All cold roll steel must be plated. All plating must be either cadmium plating meeting the requirements of Federal Specification QQ-P-416G, Type 2 Class l or zinc plating meeting the requirements of ASTM B633-85 Type II SC4.

B. Mechanical Hardware. All bolts, nuts, washers, screws, hinges and hinge pins must be stainless steel unless otherwise specified.

C. Electrical Isolation. Within the circuit of any device, module, or Printed Circuit Board (PCB), electrical isolation must be provided between DC logic ground, equipment ground and the AC- conductor. They must be electrically isolated from each other by 500 Megohms, minimum, when tested at the input terminals with 500 VDC.

D. Daughter Boards. Keyboards and LCD/LED Displays are considered daughter boards. Daughter boards must be mechanically secured with a minimum of four spacers/metal screws. Connectors must be either Flat Cable or PCB Headers. Components are allowed to be mounted under the daughter board.

2.02 COMPONENTS

A. General. All components must be second sourced and be of such design, fabrication, nomenclature or other identification as to be purchased from a wholesale distributor or from the component manufacturer, except as follows:

1. When component is of such special design that it precludes the purchase of identical components from any wholesale distributor or component manufacturer, one spare duplicate component must be furnished with each 20, or fraction, thereof, components used.

2. The electronic circuit design must be such that all components of the same generic type, regardless of manufacturer, function equally in accordance with the specifications.

B. ATC Cabinet Components

1. Model 2202-HV Universal High-Density Switch Pack / Flasher Units (HDSP-FU)

a. The HDSP-FU shall comply with the ATC 5301 Standard Sec. 6.2 – HDSP-FU.

b. When located in the Output Assembly, the Model 2202-HV HDSP-FU shall be:

(1) Two channels per card

(a) 6 outputs rated at 5 mA to 1 Amp (1-135 watts)

(b) Over-current protected

(c) Load current monitored for each output

(2) Modular PCB-based plug-in device containing six solid-state switches

(3) 1.2” x 4.5” card format with DIN style connector

(4) LED compatible to <2 watts

(5) CMUip controlled output over-ride for fail-safe operation

(6) “ID” Led for each channel driven by CMUip based troubleshooting

(7) Serial Bus #3 compatible

c. When located in the Service Assembly, the Model 2202-HV HDSP-FU shall be:

(1) Two channels per card

(a) Four outputs rated at 5 mA to 2 Amps each

(b) Over-current protected

(c) Load current monitored for each output

(2) Modular PCB-based plug-in device containing four solid-state switches

(3) 1.2” x 4.5” card format with DIN style connector

(4) Supports CMUip Flasher Alarm function

2. Model 2212-HV Cabinet Monitor Unit (CMUip)

a. The CMUip-2212-HV Cabinet Monitor Unit (CMUip) shall comply with the ATC 5301 Standard Sec. 6.3 – CMU. It shall be a compact, pluggable and modular.

(1) 32-channel fully monitor output capability

(2) Direct SB#3 communication to each HDSP-FU for field voltage and load current status

(3) Ethernet port for diagnostics

(4) CMUip is programmed with interchangeable DataKey

(5) Built-in Diagnostic Wizard: The CMUip analyzes the ATC Controller output commands and HDSP-FU field input status

(a) Isolates whether the cabinet fault was caused by an ATC malfunction or a failure in the load bay or field wiring

(b) Identifies the faulty channel(s) and output directly

(c) Provides guidance on how the technician should isolate the cause of the malfunction

3. DataKey Programming Tool

a. The Programming Tool provides the capability to Read and Write data from the CMUip DataKey device. The DataKey software shall be compatible with the CMUip-2212-HV

4. Model 2220 Auxiliary Display Unit (ADU)

a. The ADU-2220 shall be a rack mounted display module.

(1) 32 channels of RYG status plus a Blue LED for fault status provides a full view of the intersection signal states.

(2) The LCD menu driven display provides detailed status information from the CMUip along with an interface to the patented EDI SmartMonitor® technology.

(a) The built-in Diagnostic Wizard provides a concise view of the signal states involved in the fault, pinpoints faulty signal inputs, and provides guidance on how the technician should isolate the cause of the malfunction.

(3) View status, configuration settings, voltages, currents, and event logs.

5. Model 2218 Serial Interface Unit (SIU2)

a. The SIU2218 shall comply with the ATC 5301 Standard Sec. 6.1 – SIU.

b. The Model 2218 Serial Interface Unit (SIU2) shall be modular PCB-based plug-in device.

(1) SIU2 is housed in each Input and Output Assembly.

(a) The SIU2 converts serial data from the ATC Controller into parallel outputs to the assembly.

(b) The SIU2 converts parallel inputs from the assembly into serial data to the ATC Controller.

I. 54 programmable inputs / outputs

II. 4 opto-isolated inputs

(2) Diagnostic monitoring software uses the front panel EIA-232 port

(3) 1.5 inch width faceplate

6. Model 2216 Cabinet Power Supply (CPS)

a. The PS-2216 Cabinet Power Supply (CPS) shall comply with the ATC 5301 Standard Sec. 6.4 and 6.4.11. It shall be a rack mounted and high efficiency design and shall be either of the following:

(1) PS2216EP-24-HV Cabinet Power Supply (48v, 24v)

(2) PS2216-2412-HV Cabinet Power Supply (48v, 24v, 12v)

b. Outputs

(1) 1 Amp at 48 Vdc

(2) 5 Amps at 24 Vdc (maximum)

(3) 5 Amps at 12 Vdc (maximum) for PS-2216-2412 only

c. Power Factor corrected input

d. 1U height with Phoenix connector or equal

e. Fuse and LED indicator for each output

7. Model 2205 High-Density Flash Transfer Relay (HDFTR)

a. The Model 2205 High-Density Flash Transfer Relay (HDFTR) shall be:

(1) Hermetically Sealed Cover - Moisture proof, prevents contact contamination, insect proof (fire ant, etc.)

(2) Dry Nitrogen Filled - Protects contacts from corrosion, prevents condensation

(3) Metal Can - Robust design, shock/impact resistant

(4) Solid Pins - Robust, bend proof

(5) Ratings: 5 Amps @ 120 Vac switching, 10 Amps surge

(6) 48 Vdc coil voltage

(7) LED indicator to display contact transfer position

8. Main Contactor

a. The Main Contactor shall be mercury free and shall be rated:

(1) Input: 48 Vdc coil voltage

(2) Output: 60 Amps @ 120Vac

(3) Contacts: SPST-NO

(4) Equipped with input indicator

(5) Operation at rated current:1,000,000

(6) Power: less than 3 Watts

(7) Located in the Output Assembly

(8) External testing terminal block for power of normal or flash state

9. Cabinet Suppressor-Filter

a. The Cabinet Suppressor-Filter unit shall incorporate the use of warning and failure indicators and shall have a dry relay contact remote sensing circuit. The unit shall be modular and pluggable with a 12-position Beau 5412 connector. The unit shall be rated at continuous service current of 15 Amp and maximum clamp voltage of 390 Vac. The unit shall filter noise and spike from 10 KHz to 25 MHz and shall have a peak surge current of 48 KA.

2.03 CABINET OVERVIEW

A. The ATC and ATC Cabinet is part of the ATC suite of standards published by ITE, ASHTO, and NEMA to describe advanced traffic control products. The ATC Cabinet includes advanced monitoring features focused on the low current signal displays, high-density load switches, efficient power supplies, and backward compatibility for devices such as input cards. The ATC Cabinet is designed to work with the Advanced Transportation Controller (ATC Standard 5201) using a serial interface between the controller and the cabinet assemblies.

B. The cabinet utilizes concepts from both the NEMA and Model 170 traffic signal equipment. From the Model 170 it takes the concept of rack-mounted subassemblies. From NEMA, it borrows the basic serial connections between the controller and subassemblies.

C. The cabinet provides the communications paths between the various subsystems, as well as a system to monitor their operation. The cabinet provides power supplies suitable for the various electronic subassemblies mounted throughout the cabinet.

D. Each of the subassemblies is connected to the controller using a serial bus, similar to that used in the NEMA TS2-2003 Type 1 cabinet specification. Using a serial interconnection between subassemblies allows for easy system expansion. The ATC Cabinet is essentially a platform within which modular components may be added to serve a variety of ITS applications

E. Key ATC Cabinet elements include the following: Universal High Density Switch Pack / Flasher (HDSP-FU), Cabinet Monitor Unit (CMU), Auxiliary Display Unit (ADU), Serial Interface Unit (SIU), Cabinet Power Supply (PS), and High-Density Flash Transfer Relay Unit (HDFTR).

F. The cabinet is constructed in a modular manner with power distribution and serial connectors conveniently located throughout the cabinet to facilitate a wide variety of configurations and future expansion. Each of these subassemblies is discussed below. A separate standard describes the controller.

2.04 GENERAL REQUIREMENTS

A. All furnished equipment must be new and unused. Vacuum or gaseous tubes and electro- mechanical devices (unless specifically called out) will not be used.

B. All equipment such as components and assemblies, as defined in this specification, in the cabinet shall be clearly and permanently labeled.

C. All marker strips shall be made of material that can be easily and legibly written on using a pencil or ballpoint pen and be located immediately below the item they are to identify and must be clearly visible with the items installed.

D. All fuses, circuit breakers, switches (except police panel switches) and indicators shall be readily visible and accessible when the cabinet front door(s) is open.

E. All circuit breakers located on the rack shall have covers to prevent accidental tripping.

F. Any components over 50V with exposed terminals shall be protected from incidental contact per NEC requirements.

G. Wire raceway shall be integrated as part of the cabinet allowing for neat internal and field wiring.

H. All assemblies shall be modular with pluggable cabling.

I. Door switches shall be powered by 48 VDC.

J. The Cabinet shall include, but is not limited to, the following assemblies: Service Assembly (SA), Input Assembly (IA), Output Assembly (OA), SB1/SB2 and DC/Clean Power Bus, Field Input Termination Assembly (FITA), and Field Output Termination Assembly (FOTA).

K. The assemblies in the cabinet shall be readily accessible and removable with simple hand tools such as screwdriver, and without removing any other equipment.

L. The cabinet shall be capable of remaining in flashing operation with any of the following assemblies removed: input assembly (IA), output assembly (OA), cabinet power supply (PS), and controller.

M. Replacing the ATC Cabinet fan shall not require any tool.

N. All assemblies shall be mounted in the 19" rack and bolted securely on the right and/or left side of the rack per cabinet version detail.

O. Nylon Guides. Guides (top and bottom) shall be provided for assembly plug-in units. The guides shall begin 0.50 inch from the assembly front panel face.

P. All modules and assemblies shall adhere to the following ATC 5201 v6.25, sec. 9.1.5.1 requirement that "No component shall be applied contrary to its manufacturer's recommendations or data sheets."

Q. All conductors, terminals, and parts which could be hazardous to maintenance personnel shall be protected with suitable insulating material.

R. All bolts, nuts, washers, screws (size 8 or larger, hinges, and hinge pins shall be stainless steel unless otherwise specified.

2.05 ELECTRICAL, ENVIRONMENTAL, AND TESTING REQUIREMENTS

A. General. The requirements called out in this specification dealing with equipment evaluation are a minimum guide. Compliance is not limited to the testing and inspection described. The ATC Cabinet Inspection and Testing Requirements shall comply with the Electrical, Environmental and Testing Requirements of the ITS Cabinet Standard v01.02.17b.

B. Certification. Manufacturers will follow these test procedures and certify that they have conducted inspection and testing in accordance with this specification.

C. Inspection. Perform a visual and physical inspection including mechanical, dimensional and assembly conformance of all parts of this specification.

D. Electrical, Environmental, and Testing Requirements. Meet all Electrical, Environmental, and Testing Requirements in the latest national standard (ATC 5301, ATC Cabinet Standard Version 02; currently v02.02 dated March 18, 2019) specifically Section 11 – Environmental and Testing Requirements.

E. Quality Control / Final Test. A complete QC/Final Test report shall be supplied with the ATC Cabinet. Ensure the test report indicated the name of the tester and is signed by a responsible manager.

F. Quality Control Procedure & Test Report. Supply the quality control procedure and test report format to the Engineer for approval within 15 days following the award of the contract. Include the following items:

1. Acceptance testing of all supplied components,

2. Physical and functional testing of all modules and items, and

3. A minimum 100-hr burn-in of all equipment.

G. Cabinet Print. Furnish wiring diagram sheets for the cabinet in a weatherproof plastic pouch placed in the drawer. Ensure cabinet wiring diagrams are on non-fading media.

2.06 CABINET HOUSING

A. General. The ATC Cabinet Housing shall conform to the ITS Cabinet Standard v01.02.17b, dated November 16, 2006, Sec. 6.2 Housings, except as specified below.

B. `Standard Cabinet Housings. There are two (2) different cabinet assembly configurations for the City of Houston, which consist of a specific collection of ATC Cabinet assemblies described in detail in article 2.07. Each of these assemblies is installed in a cabinet that is designed for a particular group of applications and is sized to hold the equipment required. The cabinets have doors both on the front and the back. The equipment is mounted on a standard EIA 19 in. rack that is fitted inside each cabinet. Each cabinet housing includes at least the following common features:

1. Enclosure

2. Gasketing

3. Doors

4. Police Panel

5. Latches/Locks

6. Ventilation and Air Filtration

7. Hinges and Door Catches

8. Assembly Supports and Mounting each cabinet.

C. Housing Construction: The housing shall be rainproof. It shall have front and rear doors, each equipped with a lock and handle. The enclosure top shall be crowned to prevent standing water.

1. Cabinet Housing Configurations:

a. ATC Cabinet Housing 1. (Referred to as ATC Cabinet 356 version or ATC 356)

(1) This Housing configuration shall be based on the ITS Housing #2 type enclosure. This version very similar to the Type 336S series of cabinet used for the Model 170 Controller system and is meant for applications that require less space for inputs and outputs. This cabinet might be found at small two through eight-phase traffic signals, ramp meters, data stations and similar less space demanding applications. Dimensions are width 24.25 in., depth 20.25 in., and height 46.25 in.

b. ATC Cabinet Housing 2. (Referred to as ATC Cabinet 350 version or ATC 350)

(1) This Housing configuration shall be based on the ITS Housing #3 type enclosure. This is a large two rack, four door cabinet with bottom details and a bolt pattern similar in size to the NEMA P cabinet. It is meant for installations requiring a lot of equipment. An example application may be a traffic signal controller with a communications hub or a ramp meter, or perhaps additional input/output assemblies. Dimensions are width 44.50 in., depth 26.00 in., and height 66.38 in

(a) Facing the front, the left rack cage shall be the ATC cabinet side with modular interchangeable ATC assemblies (excluding the service assembly) interconnected through an advanced serial data bus.

(b) The right rack cage shall include shelving for the UPS system components, ITS devices and a power strip for powering additional devices and equipment.

2. Material Thickness: The enclosure, doors, lifting eyes, gasket channels, police panel door, spacer supports and all supports welded to the enclosure and doors shall be fabricated of 0.125 inch minimum thickness aluminum sheet. The filter shell, filter through, fan support and police panel enclosure shall be fabricated of 0.080 inch minimum thickness aluminum sheet. The spacer supports shall have the option to use 0.059 inch minimum stainless steel sheet.

3. Welds: All exterior seams for enclosure and doors shall be continuously welded and shall be smooth. All edges shall be filled to a radius of 0.03125 inch minimum. Exterior cabinet welds shall be done by gas Tungsten arc TIG process only. ER5356 aluminum alloy bare welding electrodes conforming to AWS A5.10 requirements shall be used for welding on aluminum. Procedures, welders and welding operators shall conform to the requirements and practices in AWS B3.0 and C5.6 for aluminum. Internal cabinet welds shall be done by gas metal arc MIG or gas Tungsten arc TIG process.

4. Aluminum Surface Protection: The aluminum surface protection shall be either MILL FINISH or ANTI-GRAFFITI Paint.

    a. Anti-Graffiti Paint: The aluminum surface shall be cleaned, etched and rinsed. The cleaning and etching procedure shall be to immerse in inhabited alkaline cleaner at 71 degrees C for five minutes (Oakite 61A, Diversey 909 or equivalent in mix of the 6 to 8 ounces per gallon to distilled water). Rinse in cold water. Etch in a sodium solution at 66 degrees C for 5 minutes 90.5 ounce sodium fluoride plus 5 ounces of sodium hydroxide mix per gallon to distilled water. Rinse in cold water.

    b. Desmut in a 50% by volume nitric acid solution at 20 degrees C for 2 minutes. Rinse in cold water. Dry surfaces by preheating in an oven for 15 minutes at 400 degrees F. Remove and coat the surfaces using TCI Wheel Silver # 9811- 0110 with a minimum film build of not more than 2 mils total thickness. Place back into preheated oven for 10 minutes minimum at 360 degrees F to gel the base coat. Remove and coat the surfaces using TCI Anti-graffiti Clear # 9810-0231. Place back into oven and fully cure at 380 degrees F for 40 minutes.

5. Enclosure Door Frames and Door Seals: The enclosure door frames shall be double-flanged out on all four sides and shall have strikers to hold tension on, and to form a firm seal between, the door gasketing and the frame. The dimension between the door edge and the enclosure external surface when the door is closed and locked shall be 0.156 inch (+/-0.08 inches).

D. Gasketing: Gasketing shall be provided on all door openings and shall be dust-tight. Gaskets shall be 0.25 inches minimum thickness closed cell neoprene or silicone (BOYD R- 108480 or equal) and shall be permanently bonded to the metal. A gasket top and side channels shall be provided to support the top gasket on the door to prevent gasket gravitational fatigue.

E. Cage Mounting Supports: Cage mounting supports shall be provided on either side, level with the bottom edge of the door opening, for horizontal support and bolt attachment; side cage supports provided for the bracket cage supports; and bracket cage support attachments.

F. Lifting Eyes and Exterior Bolt Heads: The housing shall be provided with 2 lifting eyes for placing the cabinet on its foundation. Each eye opening shall have a minimum diameter of 0.75 inch. Each eye shall be able to support the weight load of 1000 lbs. All bolt heads shall be tamperproof type.

G. Door Latches and Locks: The latching handles shall have provision for padlocking in the closed position. Each handle shall be 0.75 inch minimum diameter stainless steel with a minimum of 0.50 inch shank. The padlocking attachment shall be placed at 4 inch from the handle shank center. An additional 4 inch minimum gripping length shall be provided.

1. Latch/Lock Mechanism: The latching mechanism shall be a three-point draw roller type. The pushrods shall be turned edgewise at the outward supports and have a cross section of 0.25 inch thick by 0.75 inch wide minimum. Rollers shall have a minimum diameter of 0.875 inch with nylon wheels and steel ball bearings. When the door is closed and latched, the door shall be locked. The lock and lock support shall be rigidly mounted on the door. The lock shall be mounted in the upper quadrant, above the handle when in its fully open position. In the locked position, the bolt throw shall extend a minimum of 0.25 inch (+/-0.03125 inches) into the latch cam area. A seal shall be provided to prevent dust or water entry through the lock opening.

2. Lock & Keys: The locks shall be Corbin 2 type. One key shall be supplied with each lock. The keys shall be removable in the locked position only. The locks shall have rectangular, spacing loaded bolts.

    a. The bolt shall have a 0.281 inch throw and shall be 0.75 inch wide by 0.375 inch thick.

    b. Tolerance is 0.035 inch. A swing away cover shall be placed over the key entrance to protect the lock mechanism.

3. Cam: The center latch cam shall be fabricated of a minimum thickness of 0.188 inch aluminum, or 11 gauge steel. The bolt surface shall horizontally cover the cam thickness. The cam shall be structured to only allow the door to open when the handle is moved toward the center of the door.

H. Housing Ventilation: Housing ventilation shall include intake, exhaust, filtration, and continuous running fan assembly or a thermostat controlled fan.

1. Intake & Filter: The louvered vent depth shall be a maximum of 0.25 inch. A removable and reusable air filter shall be housed behind the door vents. The filter filtration area shall cover the vent opening area. A filter shell shall be provided that fits over the filter providing mechanical support for the filter. This shell shall be louvered to direct the incoming air downward. The shell sides and top shall be bent over a minimum of 0.25 inch to house the filter. The filter resident in its shell shall be held firmly in place with a bottom trough and spring-loaded upper clamp. No incoming air shall bypass the filter. The bottom filter shall be formed into a waterproof sump with drain holes to the outside housing. The filter shall be 16 inch wide by 12 inch high by 0.875 inch thick. The filter shall be an ECO-AIR Product E35S or equal.

    a. The intake (including filter with shell) and exhaust areas shall pass a minimum of 120 cubic feet of air per minute for Housing 2; and 26 cubic feet of air per minute for Housing 1.

2. Fan: Each electric fan shall be equipped with ball or roller bearings and shall have a minimum capacity of 100 cubic feet of free air delivery per minute. The fan shall be mounted within the housing and protected with a finger guard. The fan should be powered from 120 Vac.

I. Hinges: Stainless steel hinges (two bolts per leaf) shall be provided to bolt the enclosure to the doors. Housing 2 shall have four hinges per door, and Housing 1 shall have three hinges per door. Each hinge shall be 3.5 inch minimum length and have a fixed pin. The pin ends shall be welded to hinge and ground smooth. The pins and bolts shall be covered by the door edge and not accessible when the door is closed. A ground strap between the door and the main cabinet housing shall be required when 120 VAC components are mounted on the door.

J. Door Catches: Front and rear doors shall be provided with catches to hold the door open at both 90 and 165 (+/- 10) Degrees. The catch minimum diameter shall be 0.375 inch aluminum rods. The catches must be capable of holding the door open at 90 degrees in a 60 mph wind acting at an angle perpendicular to the plane of the door.

K. Police Panel: A police panel assembly shall be provided to allow limited control access. The panel door shall be equipped with a lock and master police key. The front and back of the panel shall be enclosed with a rigid metal covering so that no parts having live voltage are exposed. The panel assembly shall have a drain to prevent water from collecting within the assembly. The drain shall be channeled to the outside. The cabinets shall have one switch provided and labeled "SIGNALS ON - OFF" and one switch provided and labeled "FLASH / AUTO". The MANUAL CONTROL ENABLE ON-OFF switch and a receptacle for the INTERVAL ADVANCE cord shall be provided. An INTERVAL ADVANCE cord, six feet in length, shall be provided.

1. The police panel switches shall be individually wired through factory molded connectors which allow the switches to be disconnected and not usable, as desired by the City. These connectors shall be wired in such a way to provide full cabinet operation when any or all police panel switches are connected or disconnected. The police door shall be a treasure type lock Cobin No. R357SGS series, or approved equivalent.

L. Rack Cage: A standard rack cage shall be installed inside the housing for mounting of the ATC Controller unit and cabinet assemblies. The EIA rack portion of the cage shall consist of four continuous, adjustable equipment mounting angles. The mounting angle nominal thickness shall be 11- gauge plated steel. The mounting angles shall be tapped with 10-32 threads with EIA universal spacing. The mounting angle shall comply with standard EIA-310-E and shall be supported at the top and bottom by either welded or bolted support angles to form a cage. The mounting angles shall provide holes to mount the side panels.

1. Clearance between Rails: Clearance between rails for mounting assemblies shall be 17.75 inch.

2. Cage Connection: The cage shall be bolted to the cabinet at four points via the housing cage supports and four points via associated spacer brackets (top and bottom).

3. Cage Location: The cage(s) shall be centered within the cabinet door opening(s).

M. Drawer Shelf Unit: A telescopic slide out drawer to storage document shall be provided. The Drawer Shelf Unit shall be mounted across the EIA rails and shall have a non-conductive top, locking provision when fully extended and lip or handle for pulling.

N. Fiber Optic Termination Panel: A fiber optic termination panel shall be supplied with each cabinet configuration. See fiber optic termination panel details. Figure 16.

O. Power Strip: Only applicable to the ATC Cabinet 350 version, 1U Rack Mounted Power Strip, 120V, 15A, 5-15P, 6 Outlets. Locking switch cover to prevent accidental shutoff.

P. Cabinet Light: The cabinet shall have LED cabinet lights activated by door switches and equipped with a manual switch and fuse. ATC Cabinet Housing 1 shall have two (2) LED cabinet lights, and ATC Cabinet Housing 2 shall have four (4) LED cabinet lights.

Q. UPS Battery shelf: Only applicable to the ATC Cabinet 350 version, a full-depth pull-out battery shelf shall be provided. It shall be mounted across the EIA rails and have a minimum load capacity of 300 lbs.

2.07 ASSEMBLIES

A. General. All ATC cabinets shall have the following equipment which shall be completely removable from the cabinet without removing any other equipment and using only a slotted or Phillips screwdriver: Service Assembly (SA), Input Assembly (IA), Output Assembly (OA), SB1/SB2 and DC/Clean Power Bus, Field Input Termination Assembly (FITA), and Field Output Termination Assembly (FOTA).

B. ATC Cabinet Assemblies

1. Output Assembly (OA) – 16-Channel or 32-Channel

a. Output Assembly - (16-Channel Option)

(1) The Output Assembly shall be an EIA-310E rack mounted assembly. The Output Assembly shall house eight Model 2202-HV Universal High-Density Switch Pack / Flasher Units (HDSP-FU) providing forty eight load circuits.

(2) One resident Model 2218 Serial Interface Unit (SIU2) shall provide interface and control.

(3) The Output Assembly shall house a CMUip-2212-HV Cabinet Monitor Unit (CMUip), Main Contactor, Stop Time Switch, Flash / Auto Switch, four Circuit Breakers and Momentary 24VDC Bypass Switch.

b. Output Assembly - (32-Channel Option)

(1) The Output Assembly shall be an EIA-310E rack mounted assembly. The Output Assembly shall house sixteen Model 2202-HV Universal High-Density Switch Pack / Flasher Units (HDSP-FU) providing ninety six load circuits.

(2) Two resident Model 2218 Serial Interface Units (SIU2) shall provide interface and control.

(3) The Output Assembly shall house a CMUip-2212-HV Cabinet Monitor Unit (CMUip), the Main Contactor, Stop Time Switch, Flash / Auto Switch, eight Circuit Breakers and Momentary 24VDC Bypass Switch.

2. Field Output Termination Assembly (FOTA) (16-Channel)

a. The 16-Channel Field Output Termination Assembly shall be coupled with the 16-Channel Output Assembly and shall house eight Model 2205 High-Density Flash Transfer Relays (HDFTR).

b. The HDFTR and Flash Program Blocks (FPB) shall be provided to control and select the color (red, yellow, or dark) during ATC Cabinet Flash mode.

c. Transient Protectors shall be provided at the field terminals for the protection of the HDSP-FU when requested.

d. Provide one Field Output Termination Assembly with a 16-Channel Output Assembly. Provide two Feld Output Termination Assemblies with a 32-Channel Output Assembly.

3. HDSP Suppressor

a. The HDSP Suppressor shall be modular and pluggable. The unit shall be epoxy encapsulated and equipped with 9-position 5.08 mm Phoenix Contact connector or approved equal. The unit shall be able to protect 6 circuits. The device operating voltage shall be 120 VAC and clamping voltage shall be 340 VAC. The unit dimensions shall be 2" H x 0.7" W x 2" D. The unit shall have a status indicator in the form of a LED illuminated during normal operation.

4. Field Output Termination Assembly Breakout Panel

a. A Field Output Termination Assembly ITS style breakout panel with terminal strips must be incorporated to support the FOTA for the landing of field wiring in the cabinet. Shall be one panel per 16 Channels. Used only in the ATC Cabinet 350 version. See Figure 7, ITS Style Field Output Termination Assembly.

5. Input Assembly (IA) – 24-Channel or 48-Channel

a. Input Assembly - (24-Channel Option)

(1) The Input Assembly shall be an EIA-310E rack mounted assembly providing twelve slots of 22/44 pin PCB sockets. A Model 2218 Serial Interface Unit (SIU2) shall be provided in its location mated to a DIN 96-pin connector. The SIU2 shall provide interface and control between the ATC Controller and the input units via system SB1/SB2. This Input Assembly shall be wired for a mix of twelve 2-channel and 4-channel devices.

b. Input Assembly - (48-Channel Option)

(1) The Input Assembly shall be an EIA-310E rack mounted assembly providing twelve slots of 22/44 pin PCB sockets. Two Model 2218 Serial Interface Units (SIU2) shall be provided in its location mated to a DIN 96-pin connector. The SIU2 shall provide interface and control between the ATC Controller and the input units via system SB1/SB2. The Input Assembly shall be capable of supporting twelve 4-channel devices. This Input Assembly shall be wired for a mix of twelve 2-channel and 4-channel devices.

6. Field Input Termination Assembly (FITA) – 24 Channel

    a. The 24-Channel Field Input Termination Assembly shall be coupled with the 24-Channel Input Assembly and shall have positions for landing 24, two-wire inputs and their associated earth ground wires. The Field Input Termination Assembly shall have positions for 12 Detection Module Suppressors. The Detection Module Suppressors shall be supplied with the cabinet if procurement requires. The 24-Channel Field Input Termination Assembly shall be mounted across the EIA rails and it shall swing down to provide access to the back of the assemblies mounted in the opposite side. Two 24-Channel Field Input Termination Assembly shall be coupled with the 48-Channel Input Assembly.

7. Detection Module Suppressor

    a. The Detection Module Suppressor shall be modular and pluggable. The unit shall be epoxy encapsulated and equipped with 6-position 5.08 mm Phoenix Contact or approved equal connector. The unit shall be able to protect 6 circuits. The device operating voltage shall be 75 Vac and clamping voltage shall be 130 Vdc. The device dimensions shall be 2” H x 0.7” W x 1.2” D.

8. Service Assembly (SA)

    a. Service Assembly - (1-Flasher)

        (1) The Service Assembly shall be modular and shall be mounted on the lower right side of the EIA when viewed from the front. It shall house: a Model 2202-HV Universal HDSP-FU, EDCO SHA-1250 or approved equal, BBS landing wire terminals, GFCI, Convenient Outlets, 4 HDFU output fuses, and Circuit Breakers.

    b. Service Assembly - (2-Flasher)

        (1) The Service Assembly shall be modular and shall be mounted on the lower right side of the EIA when viewed from the front. It shall house: two Model 2202-HV Universal HDSP-FU, EDCO SHA-1250 or approved equal, BBS landing wire terminals, GFCI, Convenient Outlets, 8 HDFU output fuses, and Circuit Breakers.

9. SB1/SB2 and DC Power Bus

a. SB1/SB2 and DC Power Bus shall include eight DB25 connectors to interconnect the SB1/SB2 communication ports of the assemblies and controller. It shall include a termination circuit at the end of the connections (S8) to prevent radio frequency signal reflection. Termination Circuit must be integral component in the serial bus assembly and not removeable. SB1/SB2 and DC Power Bus shall include one Phoenix plug block or equal to bring the DC power to the SB1/SB2 and DC Power Bus; such power shall be distributed to the ATC Cabinet Assemblies through seven Phoenix receptacle blocks or equal. All unused phoenix receptacles must be populated with male plugs for future use. The copper traces for the DC voltages shall support at least 10 Amps.

b. The SB1/SB2 and DC Power Bus shall be mounted in the EIA rails and it shall swing out to provide access to the back of the assemblies mounted in the opposite side.

10. AC Clean Power Bus

a. The AC Clean Power Bus shall include eight single NEMA 5-15 receptacles, to provide AC clean power to the ATC Cabinet Assemblies, the controller and Cabinet Power Supply. It shall be mounted on the EIA rails and it shall swing out to provide access to the back of the assemblies mounted in opposite side.

11. "J" Panel Assemblies

a. The "J" Panels shall be mirror images of each other when mounted in the cabinet cage. They shall be bolted to the cage with the matching shelf unit bolted to the panel. Two ten position minimum AC-Raw and equipment ground copper bus bars shall be provided on the lower right position of the J panel when viewed from the rear door for interconnect to the service panel and provide the termination for AC-Raw and equipment ground wiring within the cage and cabinet.

12. Auxiliary I/O Assembly

a. An optional Auxiliary Unit that provides a minimum 21 general purpose inputs and a minimum 8 general purpose outputs, and a connection to Logic Ground (-24 VDC). It shall be 19" Rack Mounted, contain an integrated SIU which provides the interface to the ATC cabinet, and a LED indication on the front panel.

b. The Auxiliary I/O Assembly shall provide functionality similar to a NEMA TS1 D Connector Panel allowing for 24 VDC inputs and outputs to be available o and from the controller. It will be used to send special function outputs from the controller to cabinet devices or to receive inputs from cabinet devices to the controller (e.g. UPS relay alarms, blank-out sign relay panels, or detection inputs). All necessary serial bus and power cabling shall be provided to connect the assembly to the cabinet busses. Used only in the ATC Cabinet 350 version based on intersection design needs.

2.08 CABINET CONFIGURATIONS

A. General. The ATC Cabinets must consist of a package of items needed to carry out a specific application. Cabinet Versions provided here are examples of possible cabinet configurations.

B. Cabinet Traffic Signal Application

1. The City of Houston has two (2) different ATC Cabinet configurations based on the ITS Housing #2 type enclosure and the ITS Housing #3 type enclosure from the ITS Cabinet Standards, v01.02.17b, and henceforth referred to as ATC Cabinet 356 version (or ATC 356) and ATC Cabinet 350 version (or ATC 350), respectively. Reference article 2.06.C, Cabinet Housing Configurations.

2. Traffic Signal Cabinet Application:

a. ATC Cabinet 356 version: 2-Door Configuration Cabinet with”336/346” Base, Adaptor Mount

b. ATC Cabinet 350 version: 4-Door Configuration Cabinet with “P/R” Base Ground Mount

Table 1
Example Cabinet Configurations

Item #	Package Items	ATC 350	ATC 356
	Housing 1 – Cage #2	-	1
	Housing 2 – Two (2) Cage #1	1	-
	"J" Panel Cage #1	4	-
	"J" Panel Cage #2	-	2
	Service Assembly – 1-Flasher Service Assembly – 2-Flasher	- 1	1 -
	AC Clean Power Bus	1	1
	SB1 / SB2 and DC Power Bus	1	1
	Output Assembly – 16-Channel Output Assembly – 32-Channel	- 1	1 -
	Field Output Termination Assembly (16 Channel)	2	1
	Field Output Termination Assembly Breakout Panel (ITS Style)	2	-
	Input Assembly – 24 Channel Input Assembly – 48 Channel	- 1	1 -
	Field Input Termination Assembly *	1	1
	Auxiliary I/O Assembly **	1	-
	Auxiliary Display Unit (ADU)	1	1
	LED – Cabinet Lights	4	2
	Drawer Assembly	2	1
	Fiber Optic Termination Panel	1	1
	Shelf Controller	1	1
	Full-Depth Shelf	2	-
	UPS Battery Shelf	2	-
	Power Strip	1	-

* Field Wire Support Bracket required with each Assembly
** Optional, based on intersection needs at the City's discretion

2.09 SPECIAL EQUIPMENT AND ATERIALS

A. Provide each major assembly with the following:

1. The ATC Cabinet shall also be supplied with the following components:

a. Output Assembly

(1) Output Assembly (16-Channel):

(a) (1-8ea **) Model 2202-HV HDSP-FU

(b) (1 ea) Model 2218 SIU2

(c) (1 ea) Model 2212-HV CMUip

(2) Output Assembly (32-Channel):

(a) (1-16ea **) Model 2202-HV HDSP-FU

(b) (2 ea) Model 2218 SIU2

(c) (1 ea) Model 2212-HV CMUip

b. Field Output Termination Assembly (16-Channel):

(1) (1-8 ea **) Model 2205 HDFTR

(2) (1-8 ea **) Transient Protector

(3) (16 ea) Red Flash Program Blocks

(4) (4 ea) Yellow Flash Program Blocks

(5) (4 ea) White Flash Program Blocks

c. Input Assembly

(1) Input Assembly (24-Channel):

(a) (1 ea) Model 2218 SIU2

(2) Input Assembly (48-Channel):

(a) (2 ea) Model 2218 SIU2

d. Service Assembly

(1) Service Assembly (1-Flasher):

(a) (1 ea) Model 2202-HV HDSP-FU

(b) (1 ea) EDCO SHA-1250 or approved equal

(2) Service Assembly (2-Flasher):

(a) (2 ea) Model 2202-HV HDSP-FU

(b) (1 ea) EDCO SHA-1250 or approved equal

** Quantity at the end user's discretion.

PART 3 EXECUTION – Not Used

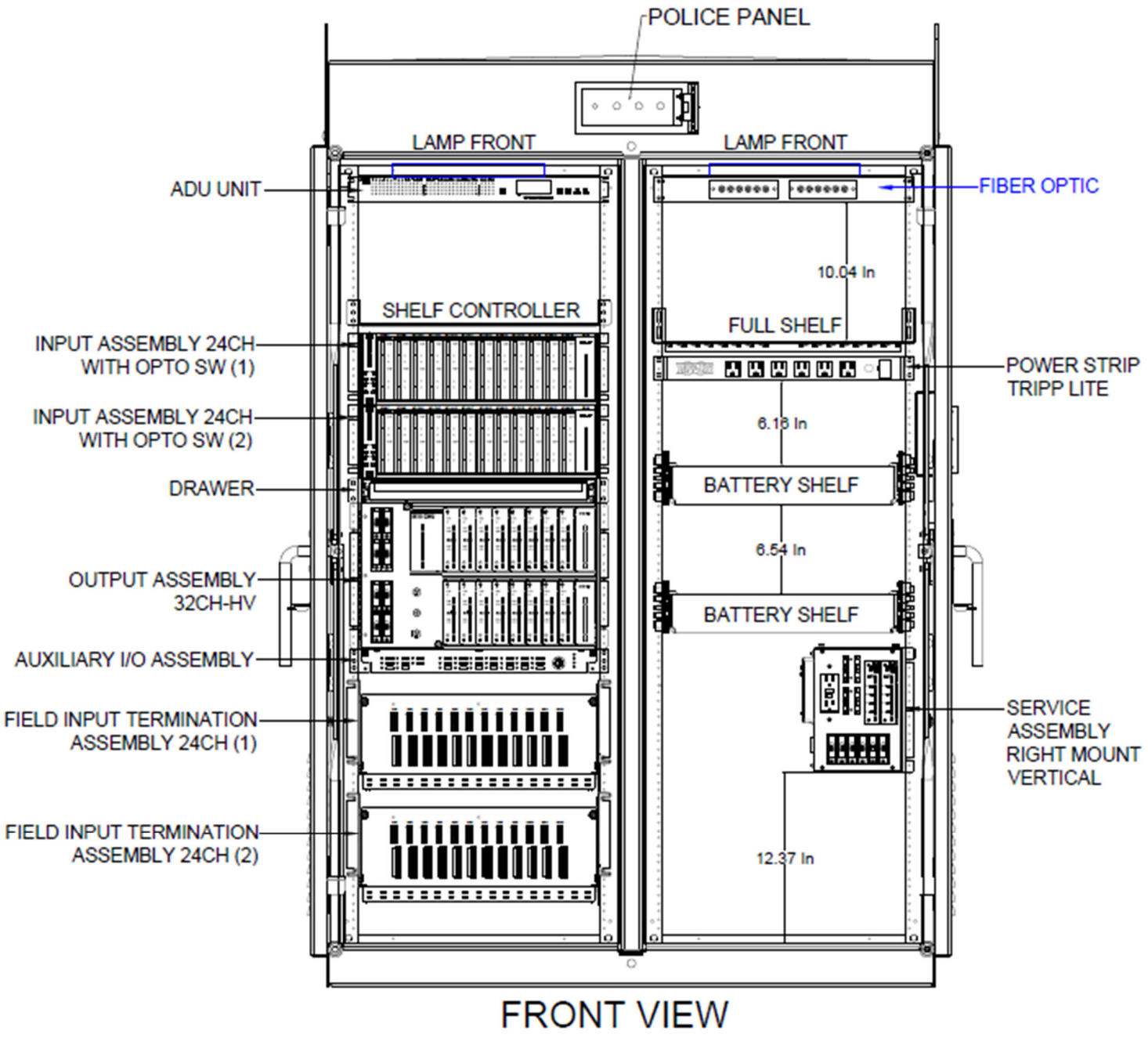


Figure 1
Cabinet Layout – ATC Cabinet 350 version (FRONT)

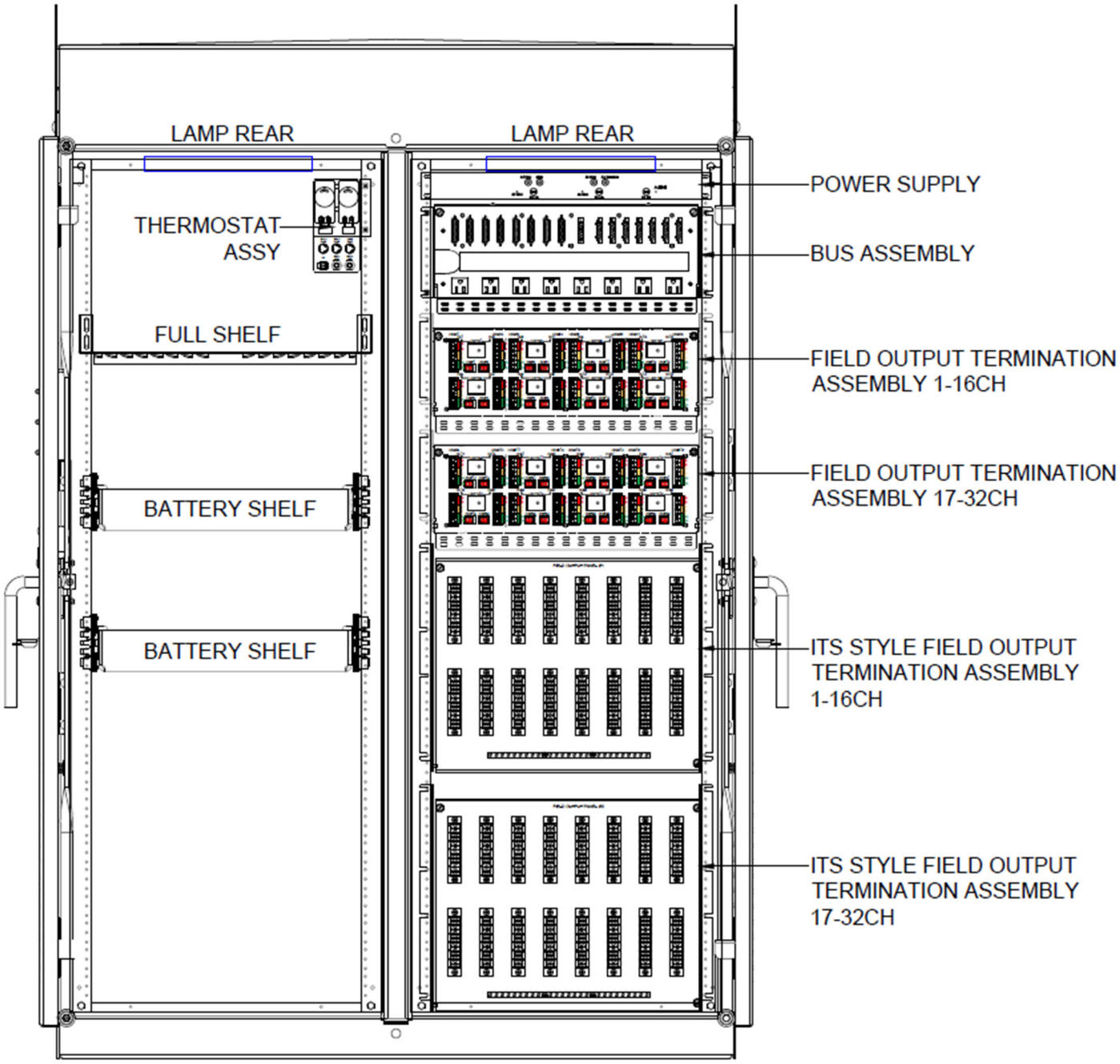


Figure 2
Cabinet Layout – ATC Cabinet 350 version (REAR)

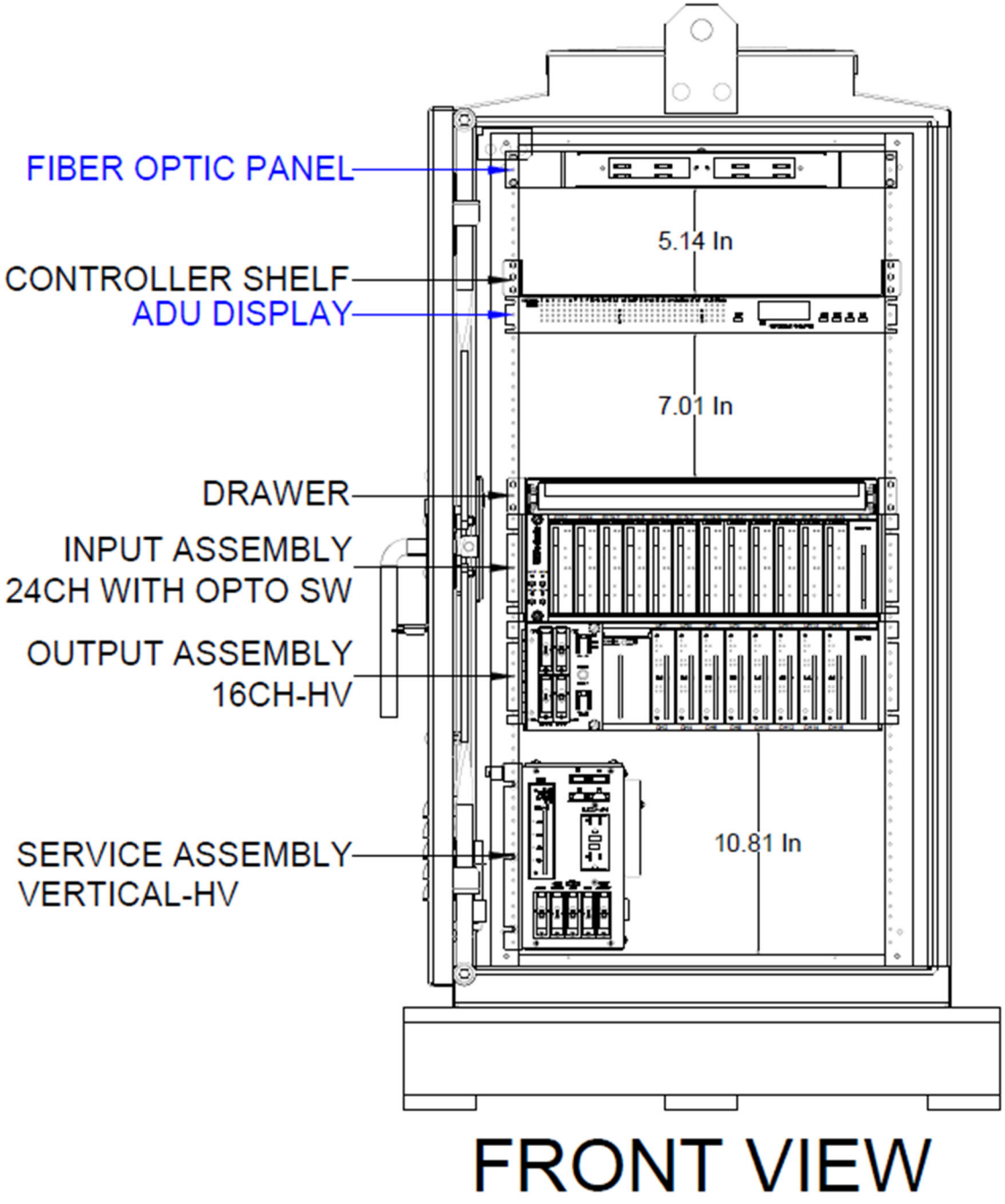


Figure 3
Cabinet Layout – ATC Cabinet 356 version (FRONT)

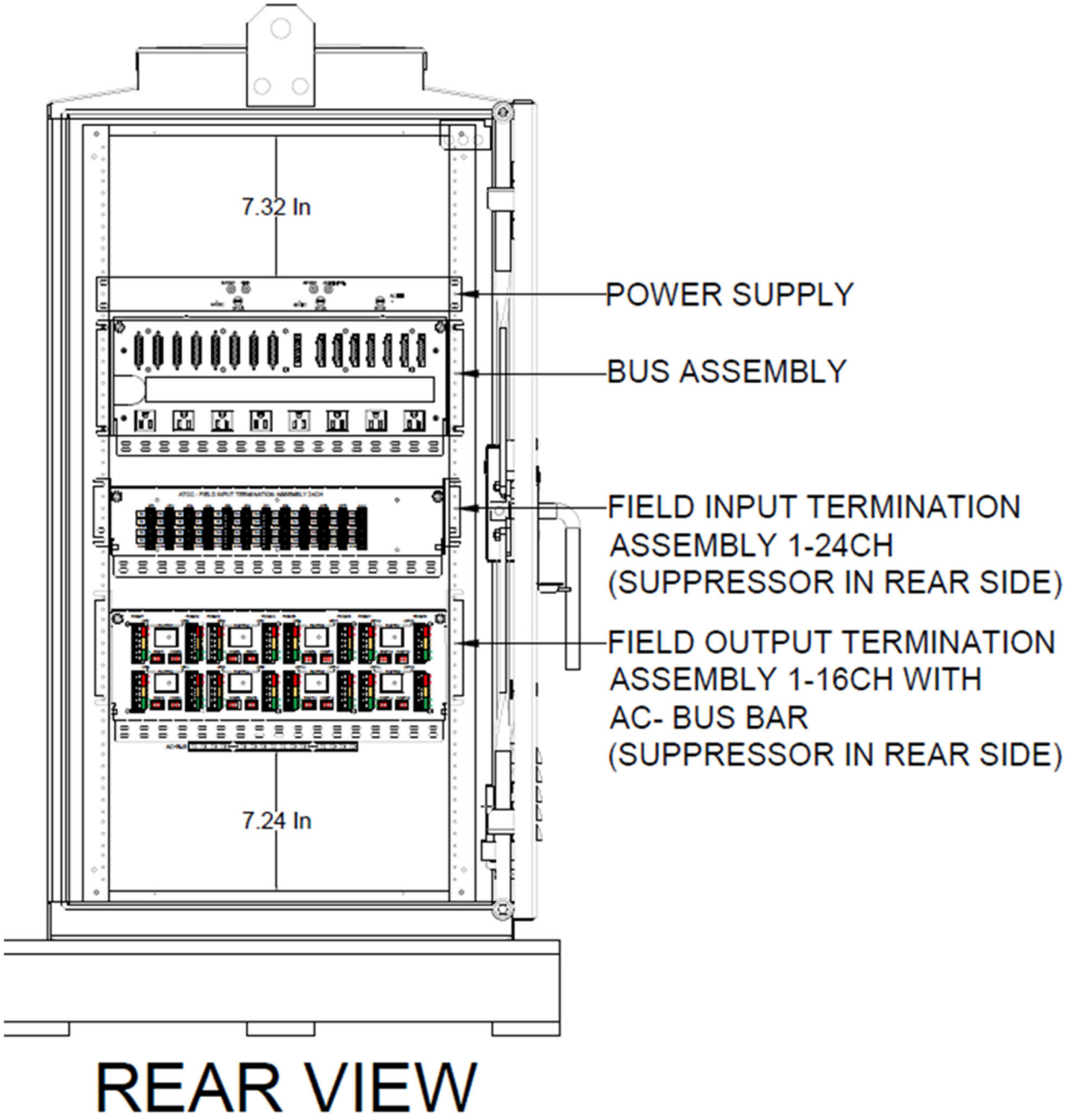


Figure 4
Cabinet Layout – ATC Cabinet 356 version (REAR)

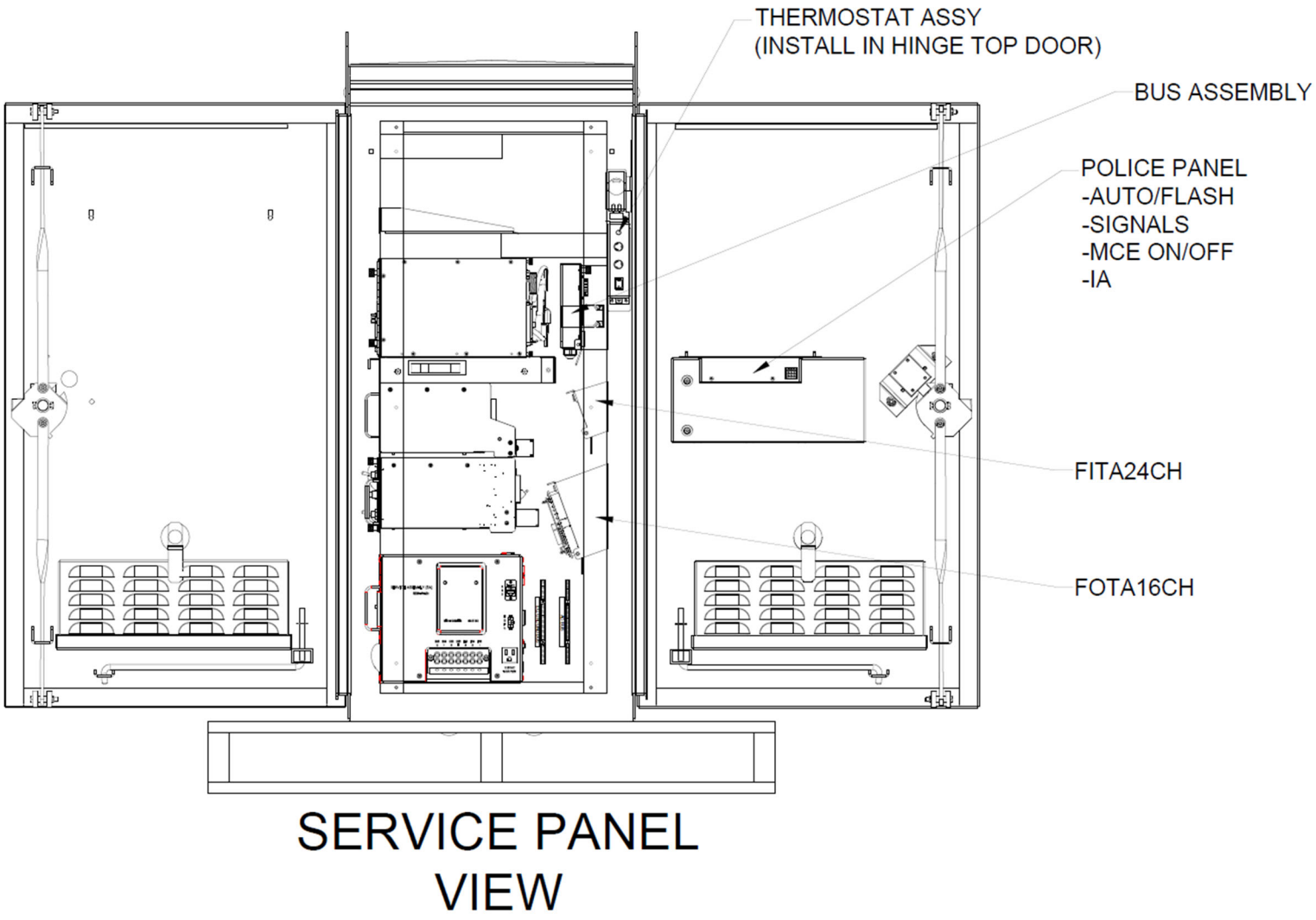


Figure 5
Cabinet Layout – ATC Cabinet 356 version (Left Side)

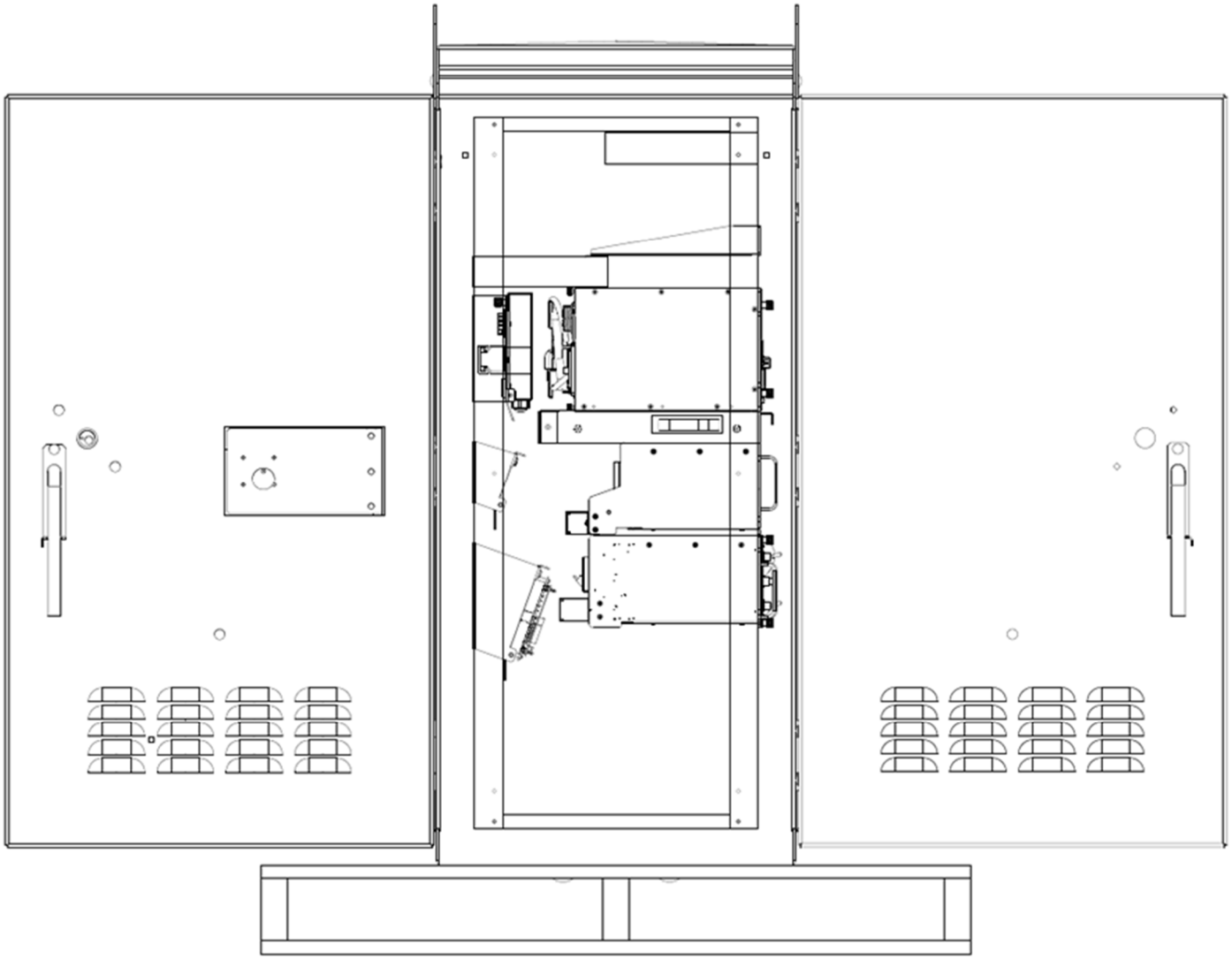
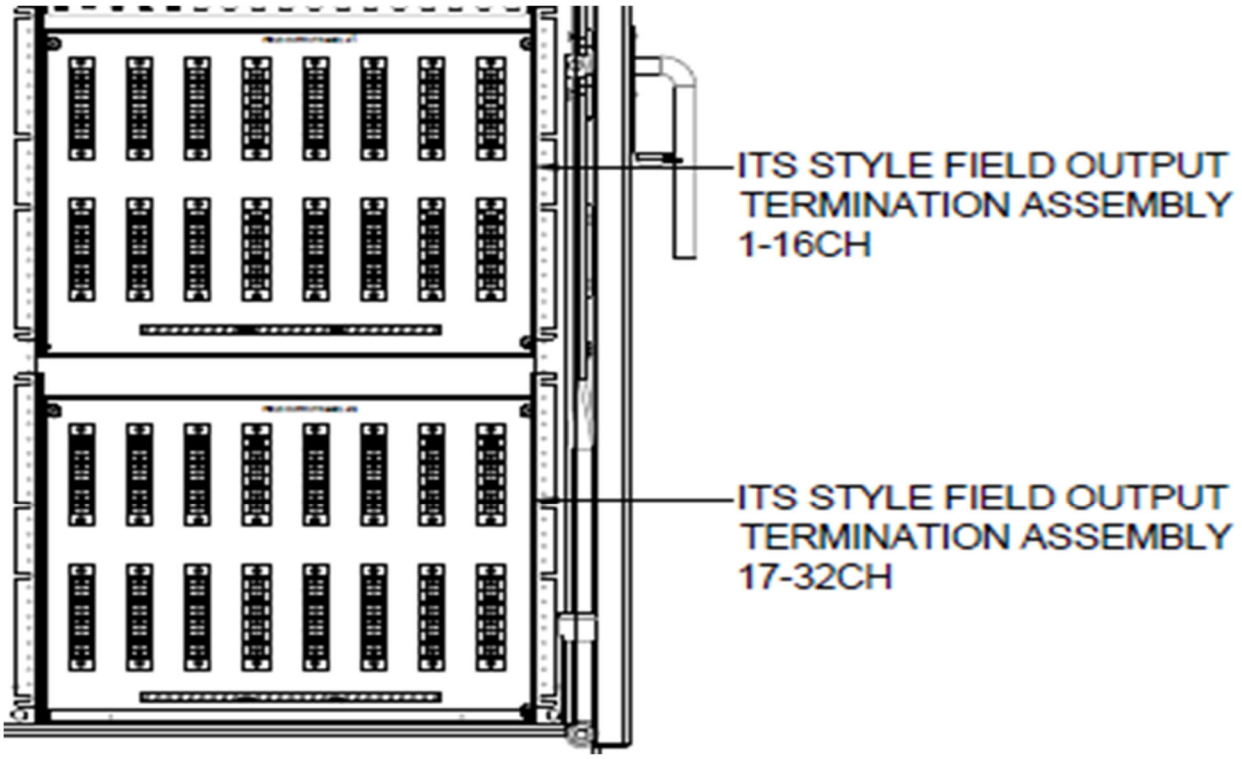


Figure 6
Cabinet Layout – ATC Cabinet 356 version (Right Side)



1. The terminal blocks are Magnum A48130604 or approved equal with (6) #10 feed thru brass nickel plated screw lug positions, rated 60V, 35 amperes, and designed to prevent twisting in the housing.
2. The panel shall be made of .090, 5052 Aluminum material
3. Output panel #1 is silkscreened for phase 1 thru 16 with the terminal number and signal head face color as per drawings.
4. Output panel #2 is silkscreened for phases 17 thru 32 with the terminal number and signal head face color as per drawings.
5. The thumb screws that hold the panel to the angle brackets are TSD screws #8/32
6. The cables from the Output Assemblies to the Output Panels shall be long enough to install the output panels at the bottom of the 19” rack.
7. The cables from the Output Assemblies to the Output Panels must be labeled with permanent markings showing phase(s) that are attached to the output panel.

Figure 7
ITS Style Field Output Termination Assembly Breakout Panel

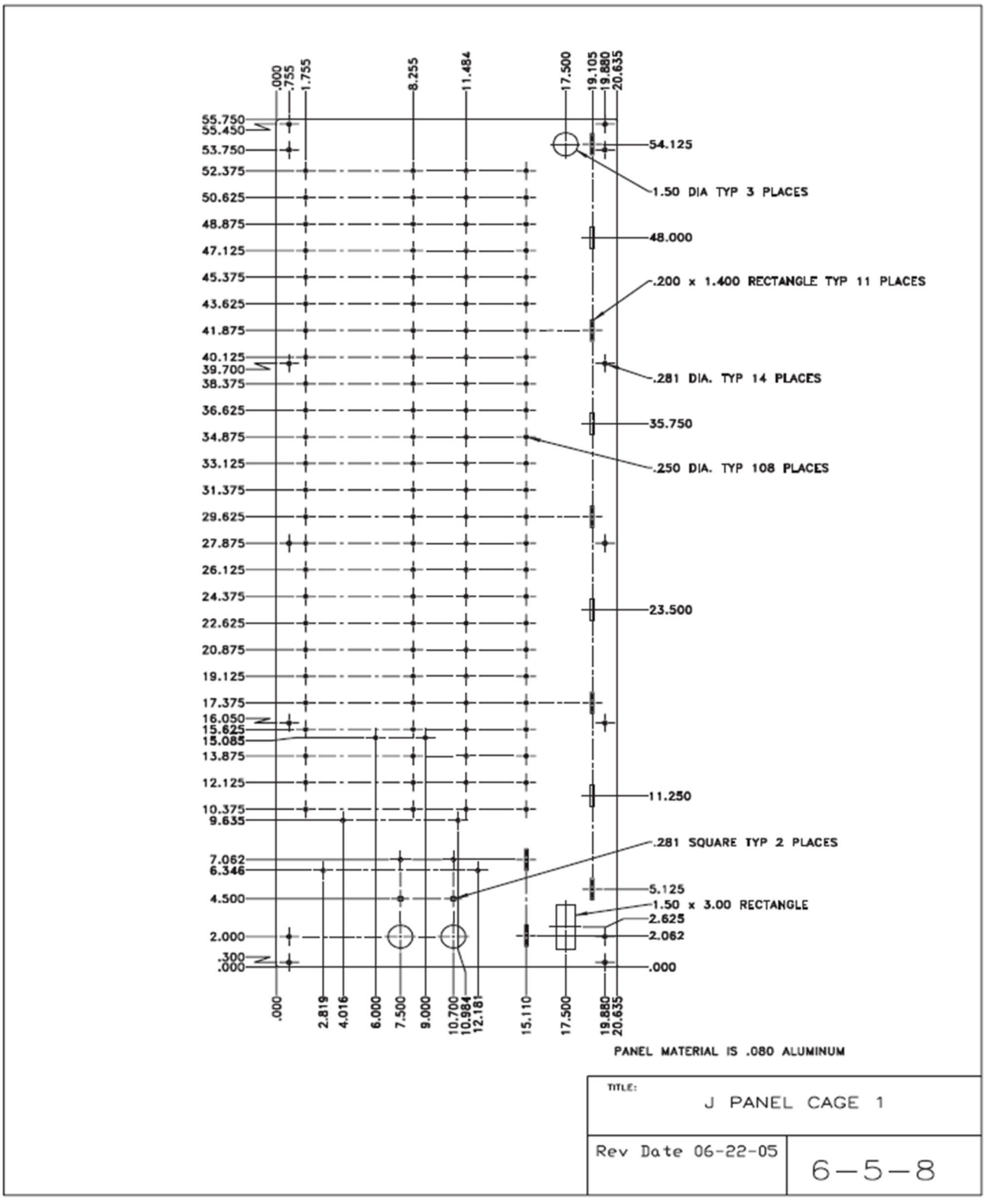


Figure 8
"J" Panel – Cage 1

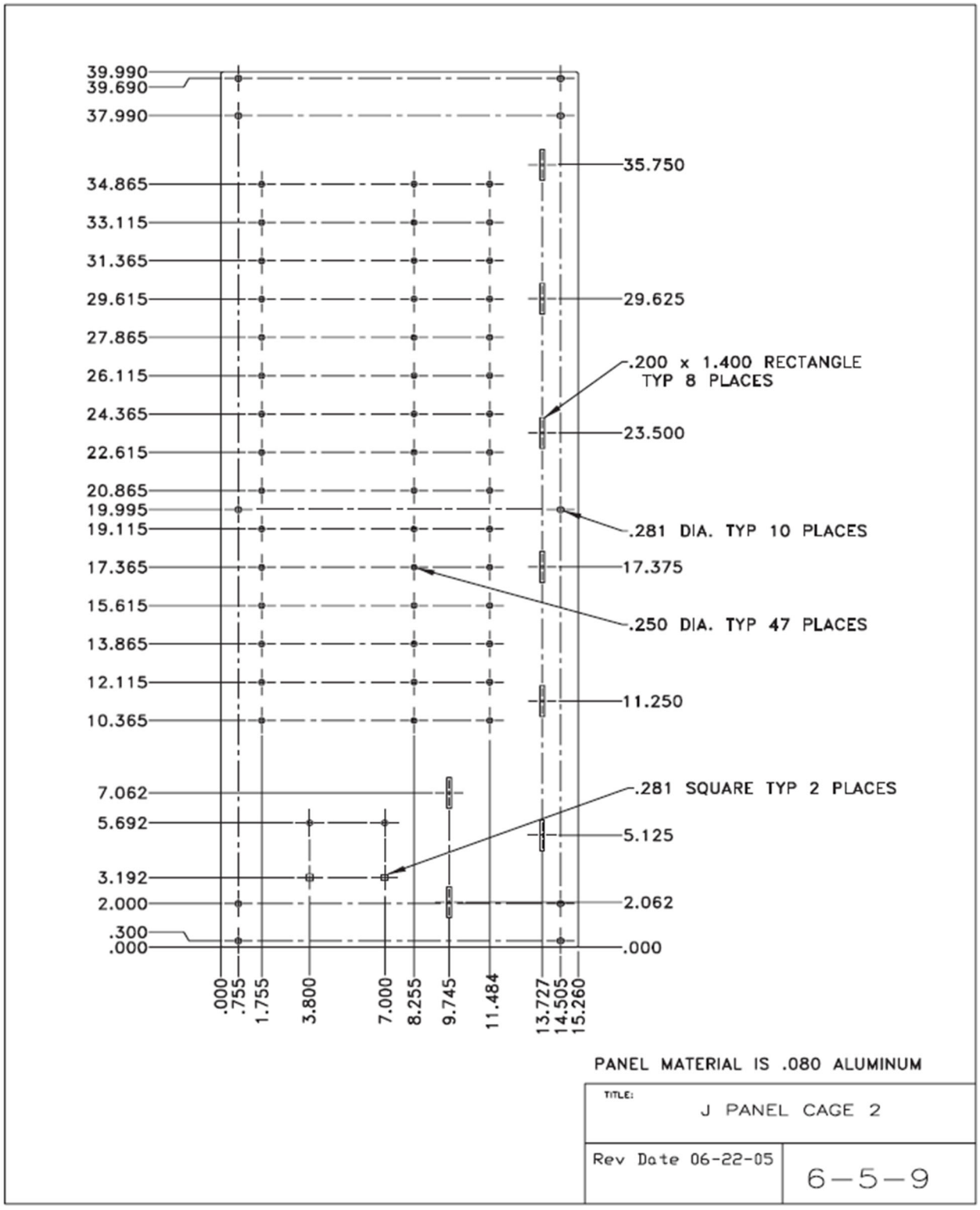


Figure 9
"J" Panel – Cage 2

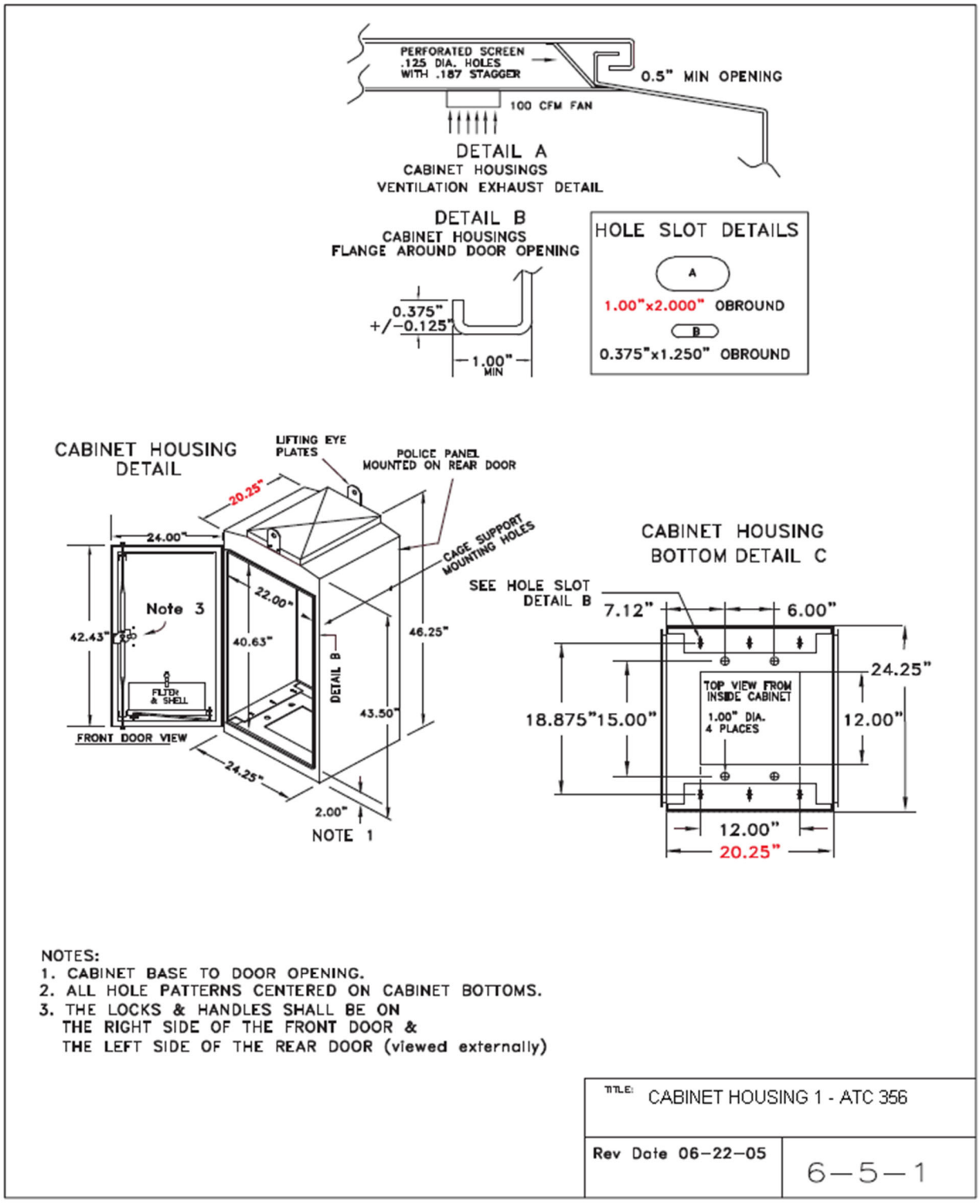


Figure 10
Cabinet Housing 1 – ATC Cabinet 356 version

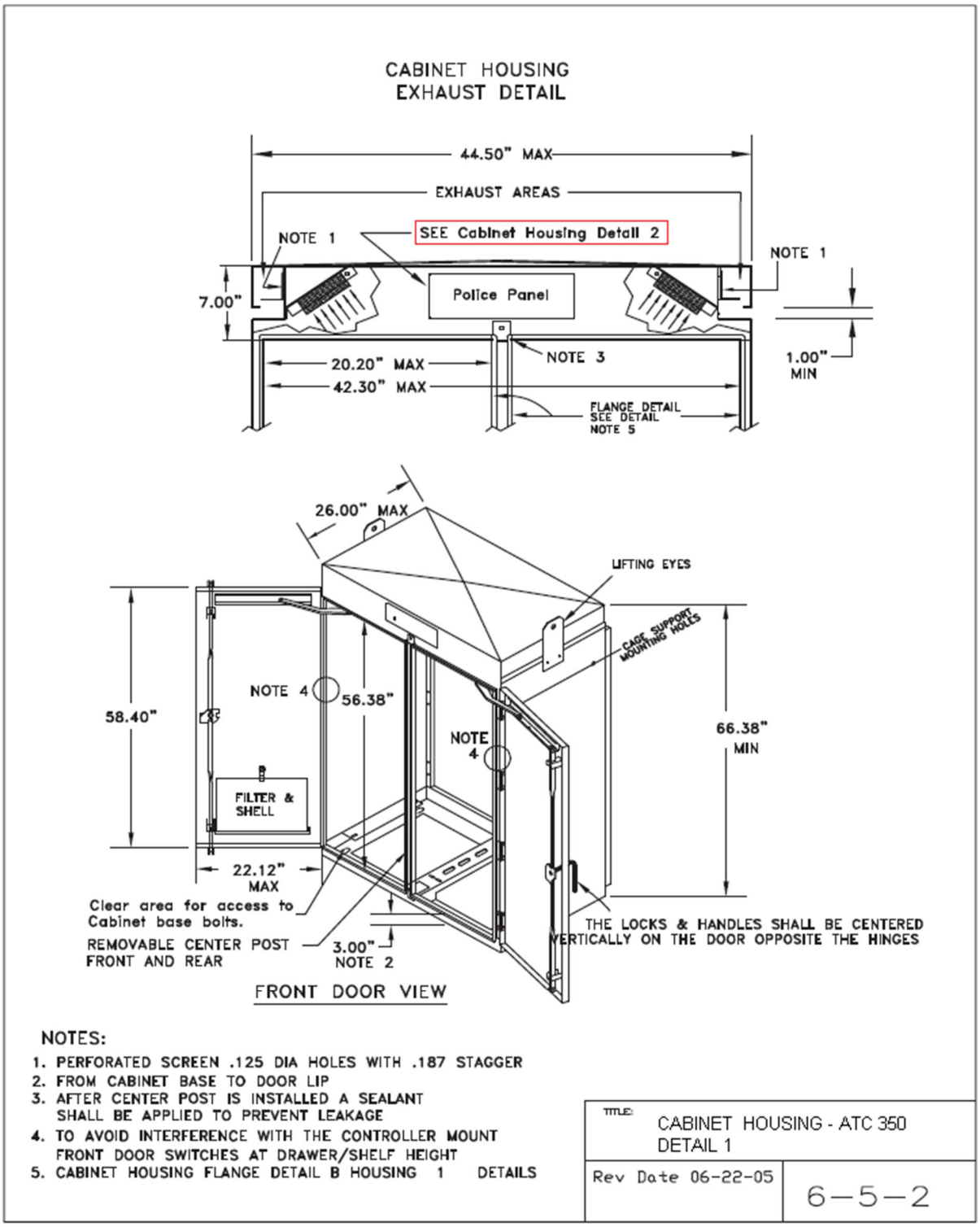


Figure 11
Cabinet Housing 2 – ATC Cabinet 350 version
Detail 1

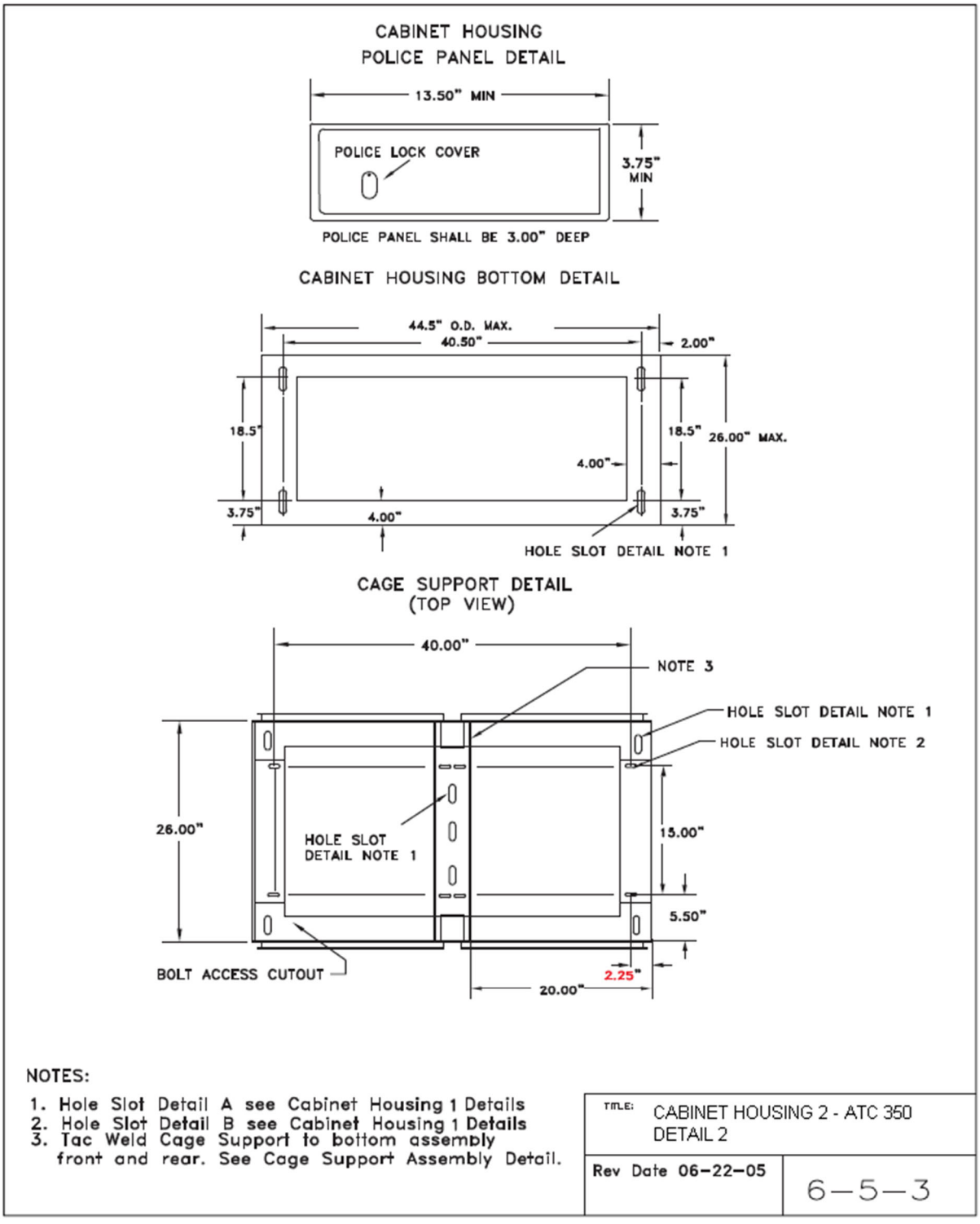


Figure 12
Cabinet Housing 2 – ATC Cabinet 350 version
Detail 2

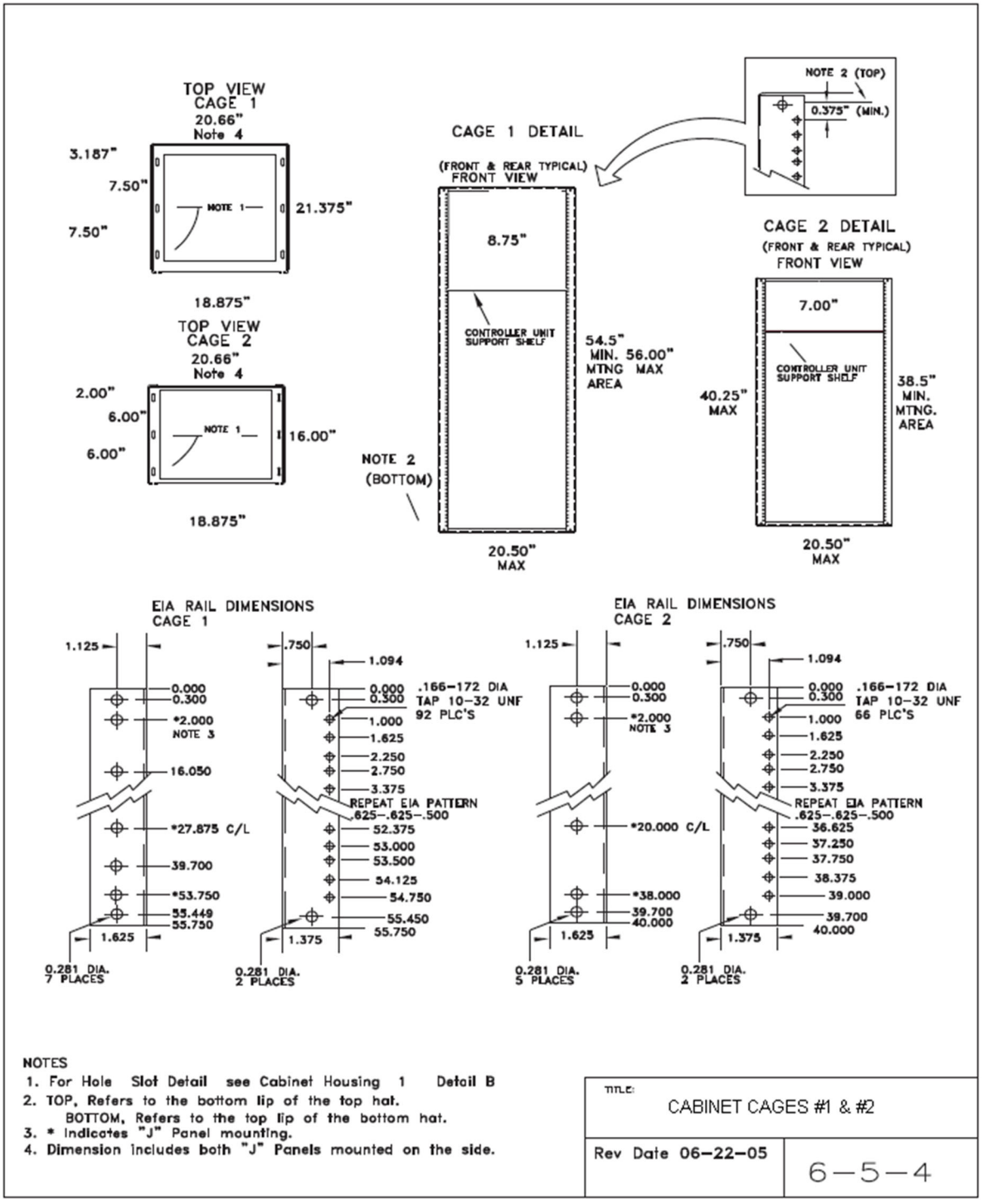


Figure 13
Cabinet Cages #1 & #2

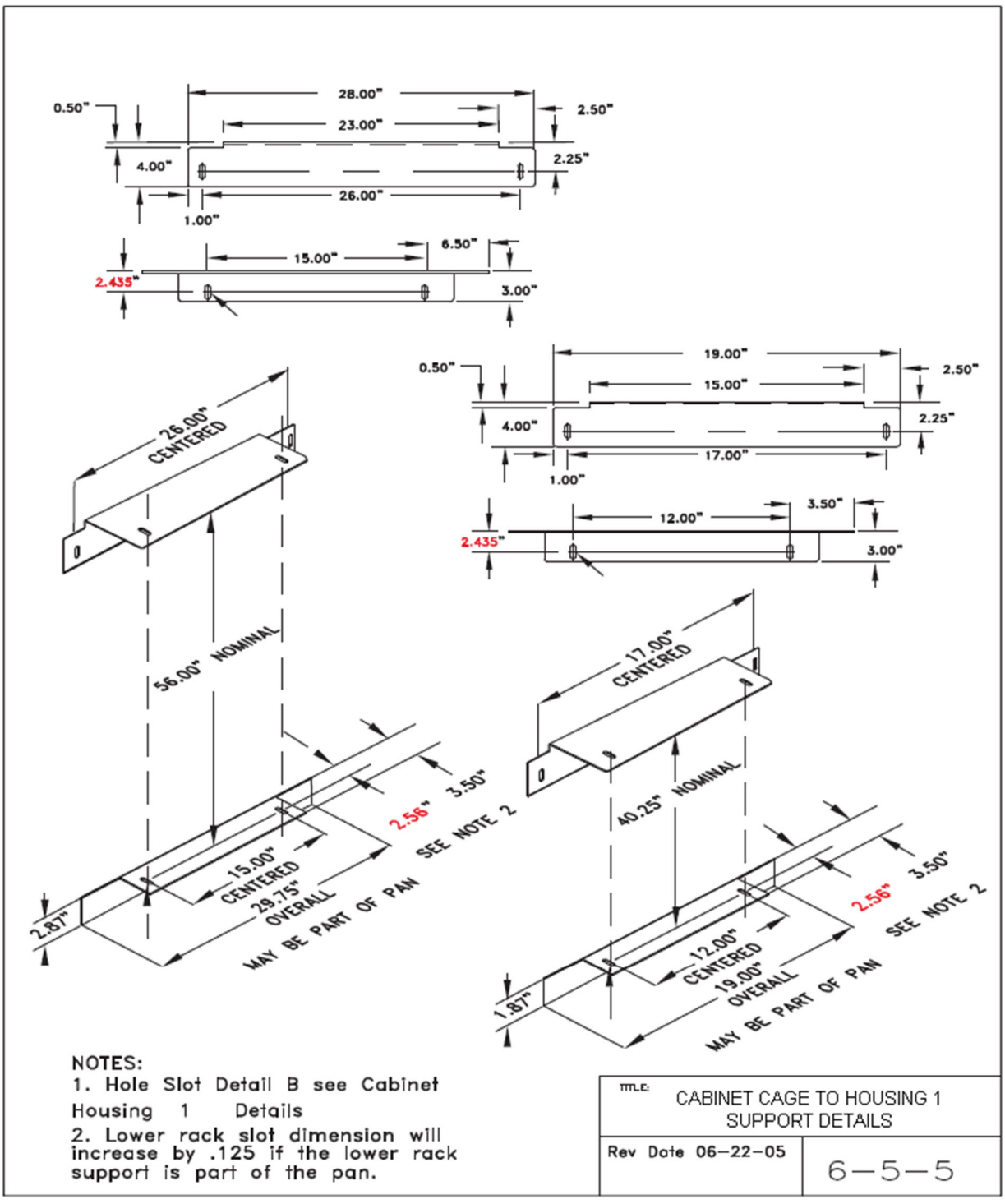


Figure 14
Cabinet Cage to Housing 1 – ATC Cabinet 356 version Support Details

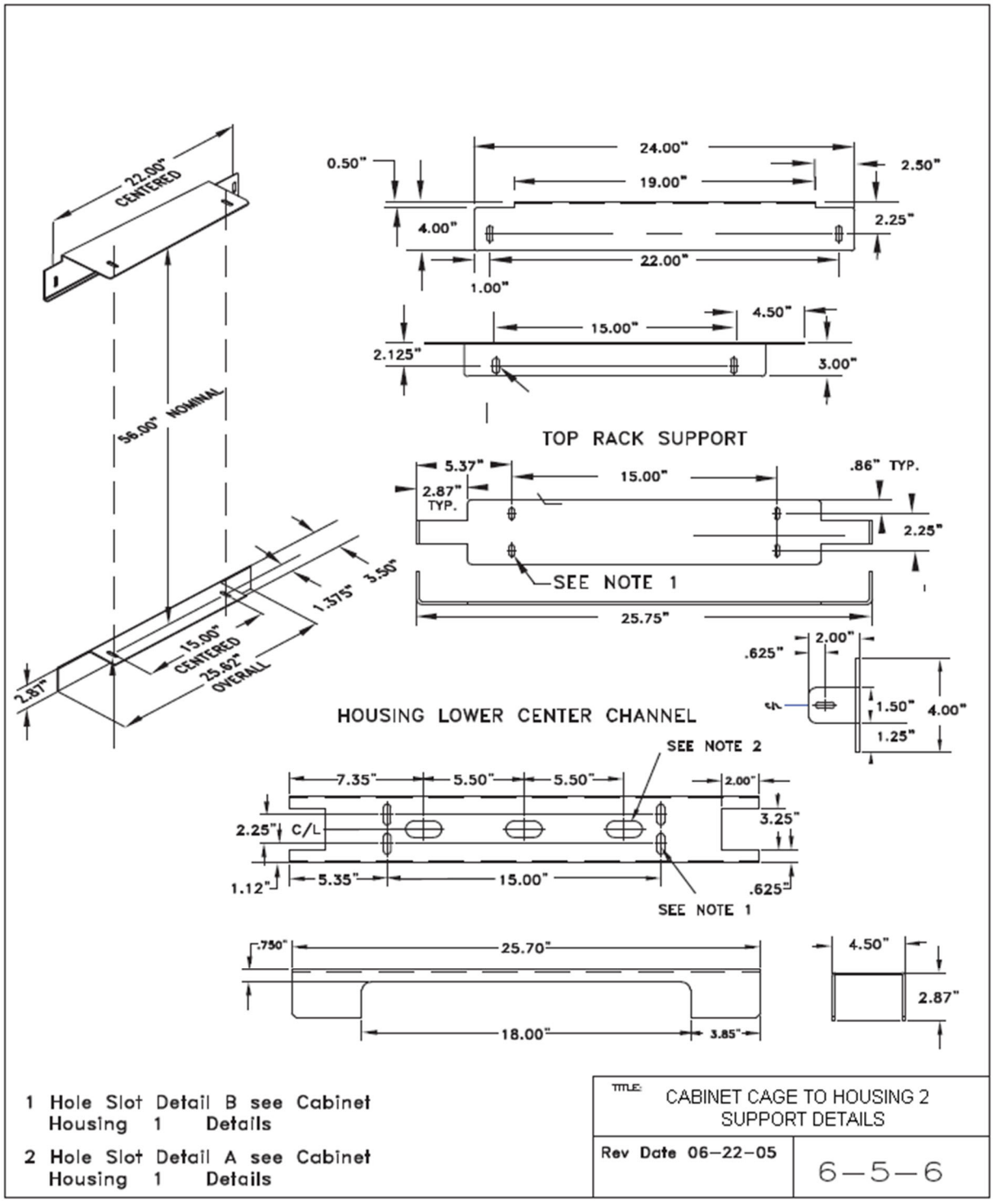


Figure 15
Cabinet Cage to Housing 2 – ATC Cabinet 350 version
Support Details

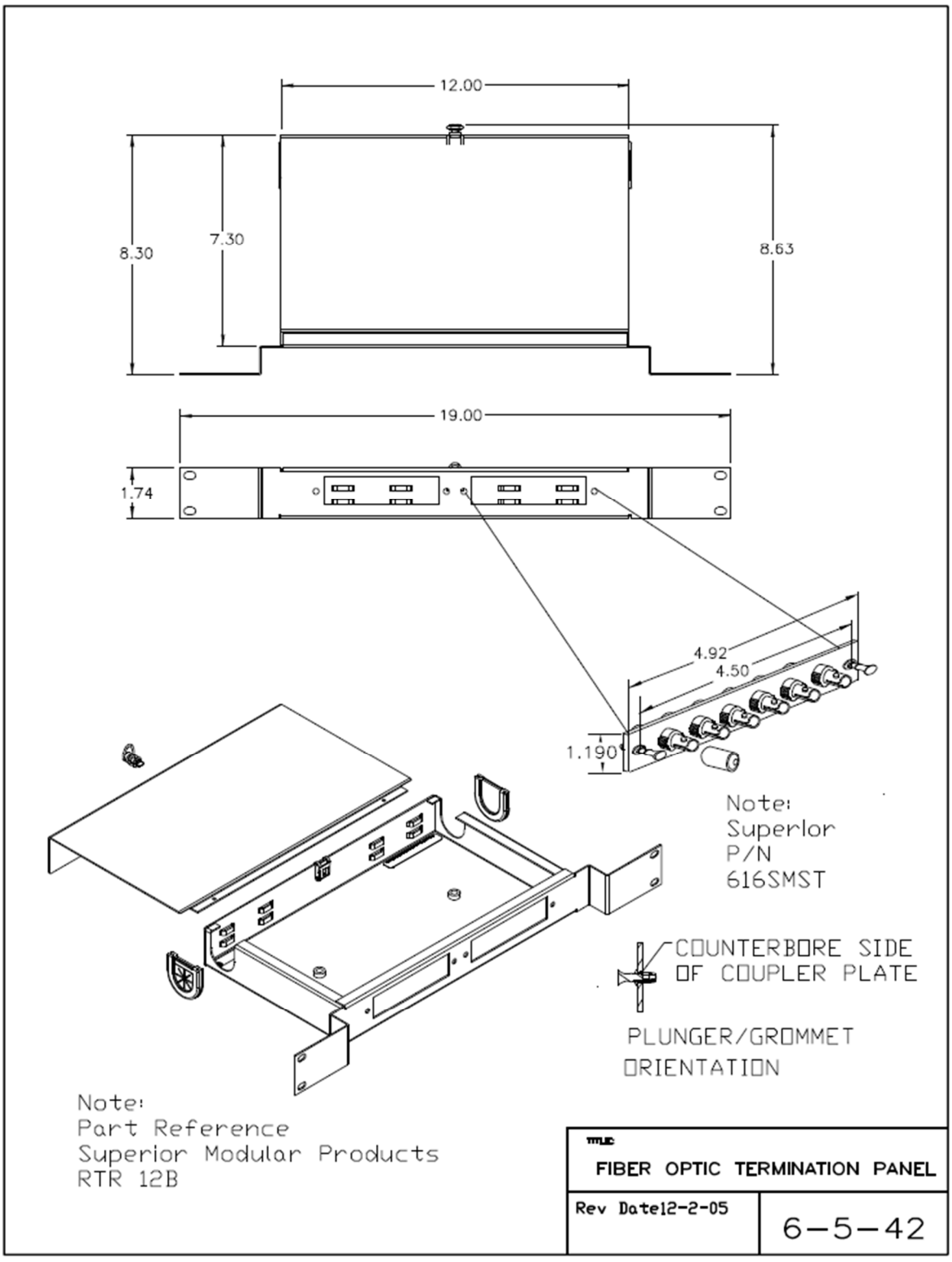


Figure 16
Fiber Optic Termination Panel
Provide P/N 616SMSC

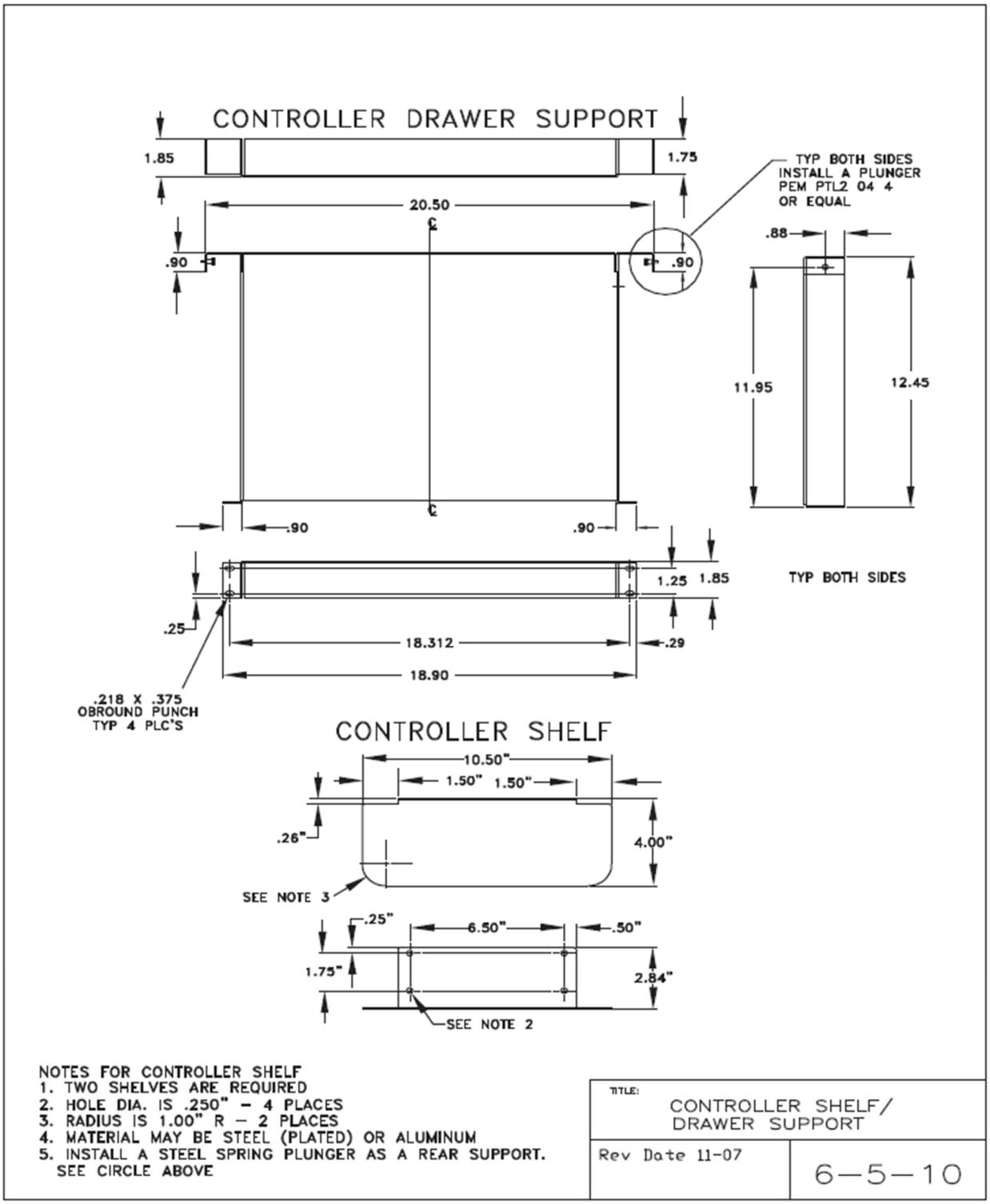
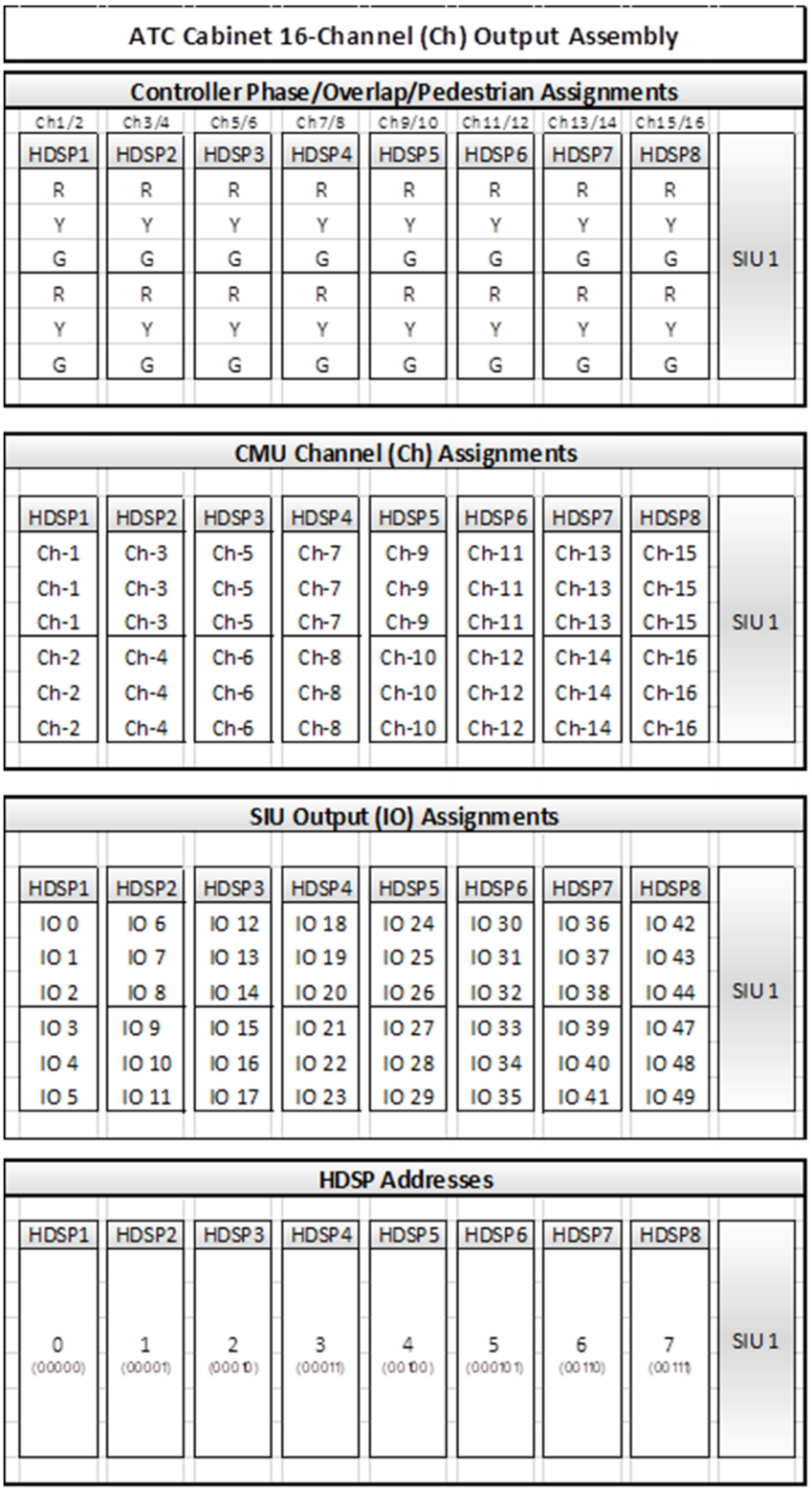


Figure 17
Controller Shelf/Drawer Support Assembly



ATC Cabinet 16-Channel (Ch) Output Assembly

Controller Phase/Overlap/Pedestrian Assignments

Ch1/2	Ch3/4	Ch5/6	Ch7/8	Ch9/10	Ch11/12	Ch13/14	Ch15/16	
HDSP1	HDSP2	HDSP3	HDSP4	HDSP5	HDSP6	HDSP7	HDSP8	
R	R	R	R	R	R	R	R	
Y	Y	Y	Y	Y	Y	Y	Y	
G	G	G	G	G	G	G	G	SIU 1
R	R	R	R	R	R	R	R	
Y	Y	Y	Y	Y	Y	Y	Y	
G	G	G	G	G	G	G	G	

CMU Channel (Ch) Assignments

HDSP1	HDSP2	HDSP3	HDSP4	HDSP5	HDSP6	HDSP7	HDSP8	
Ch-1	Ch-3	Ch-5	Ch-7	Ch-9	Ch-11	Ch-13	Ch-15	
Ch-1	Ch-3	Ch-5	Ch-7	Ch-9	Ch-11	Ch-13	Ch-15	
Ch-1	Ch-3	Ch-5	Ch-7	Ch-9	Ch-11	Ch-13	Ch-15	SIU 1
Ch-2	Ch-4	Ch-6	Ch-8	Ch-10	Ch-12	Ch-14	Ch-16	
Ch-2	Ch-4	Ch-6	Ch-8	Ch-10	Ch-12	Ch-14	Ch-16	
Ch-2	Ch-4	Ch-6	Ch-8	Ch-10	Ch-12	Ch-14	Ch-16	

SIU Output (IO) Assignments

HDSP1	HDSP2	HDSP3	HDSP4	HDSP5	HDSP6	HDSP7	HDSP8	
IO 0	IO 6	IO 12	IO 18	IO 24	IO 30	IO 36	IO 42	
IO 1	IO 7	IO 13	IO 19	IO 25	IO 31	IO 37	IO 43	
IO 2	IO 8	IO 14	IO 20	IO 26	IO 32	IO 38	IO 44	SIU 1
IO 3	IO 9	IO 15	IO 21	IO 27	IO 33	IO 39	IO 47	
IO 4	IO 10	IO 16	IO 22	IO 28	IO 34	IO 40	IO 48	
IO 5	IO 11	IO 17	IO 23	IO 29	IO 35	IO 41	IO 49	

HDSP Addresses

HDSP1	HDSP2	HDSP3	HDSP4	HDSP5	HDSP6	HDSP7	HDSP8	
0 (00000)	1 (00001)	2 (00010)	3 (00011)	4 (00100)	5 (00101)	6 (00110)	7 (00111)	SIU 1

Figure 18
ATC Cabinet 16-Channel Output Assembly (OA)

ATC Cabinet 24-Channel Input Assembly #1 (7/15/2016)

SIU Input (IO) Assignments

2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	
IO 6	IO 8	IO 10	IO 12	IO 14	IO 16	IO 18	IO 20	IO 22	IO 24	IO 26	IO 28	SIU 9
IO 7	IO 9	IO 11	IO 13	IO 15	IO 17	IO 19	IO 21	IO 23	IO 25	IO 27	IO 29	
	*IO 6	*IO 8	*IO 10	*IO 12	*IO 14	*IO 16	*IO 18	*IO 20	*IO 22	*IO 24	*IO 26	
	*IO 7	*IO 9	*IO 11	*IO 13	*IO 15	*IO 17	*IO 19	*IO 21	*IO 23	*IO 25	*IO 27	

SIU Input (Ch) Assignments

2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	
Ch-1	Ch-3	Ch-5	Ch-7	Ch-9	Ch-11	Ch-13	Ch-15	Ch-17	Ch-19	Ch-21	Ch-23	SIU 9
Ch-2	Ch-4	Ch-6	Ch-8	Ch-10	Ch-12	Ch-14	Ch-16	Ch-18	Ch-20	Ch-22	Ch-24	
	*Ch-1	*Ch-3	*Ch-5	*Ch-7	*Ch-9	*Ch-11	*Ch-13	*Ch-15	*Ch-17	*Ch-19	*Ch-21	
	*Ch-2	*Ch-4	*Ch-6	*Ch-8	*Ch-10	*Ch-12	*Ch-14	*Ch-16	*Ch-18	*Ch-20	*Ch-22	

* If 4-ch device being used

ATC Cabinet 24-Channel Input Assembly #2

SIU Input (IO) Assignments

2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	
IO 6	IO 8	IO 10	IO 12	IO 14	IO 16	IO 18	IO 20	IO 22	IO 24	IO 26	IO 28	SIU 10
IO 7	IO 9	IO 11	IO 13	IO 15	IO 17	IO 19	IO 21	IO 23	IO 25	IO 27	IO 29	
	*IO 6	*IO 8	*IO 10	*IO 12	*IO 14	*IO 16	*IO 18	*IO 20	*IO 22	*IO 24	*IO 26	
	*IO 7	*IO 9	*IO 11	*IO 13	*IO 15	*IO 17	*IO 19	*IO 21	*IO 23	*IO 25	*IO 27	

SIU Input (Ch) Assignments

2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	2-Ch Card	
Ch-1	Ch-3	Ch-5	Ch-7	Ch-9	Ch-11	Ch-13	Ch-15	Ch-17	Ch-19	Ch-21	Ch-23	SIU 10
Ch-2	Ch-4	Ch-6	Ch-8	Ch-10	Ch-12	Ch-14	Ch-16	Ch-18	Ch-20	Ch-22	Ch-24	
	*Ch-1	*Ch-3	*Ch-5	*Ch-7	*Ch-9	*Ch-11	*Ch-13	*Ch-15	*Ch-17	*Ch-19	*Ch-21	
	*Ch-2	*Ch-4	*Ch-6	*Ch-8	*Ch-10	*Ch-12	*Ch-14	*Ch-16	*Ch-18	*Ch-20	*Ch-22	

Figure 19
ATC Cabinet 24-Channel Input Assembly (IA)

Pin	Description	Pin	Description	Pin	Description
A1	+24 VDC in	B1	+24 VDC in	C1	Input / Output 47
A2	Input / Output 0	B2	Input / Output 1	C2	Input / Output 48
A3	Input / Output 2	B3	Input / Output 3	C3	Input / Output 49
A4	Input / Output 4	B4	Input / Output 5	C4	Input / Output 50
A5	Input / Output 6	B5	Input / Output 7	C5	Input / Output 51
A6	Input / Output 8	B6	Input / Output 9	C6	Input / Output 52
A7	Input / Output 10	B7	Input / Output 11	C7	Input / Output 53
A8	Input / Output 12	B8	Input / Output 13	C8	SB1 TxD +
A9	Input / Output 14	B9	Input / Output 15	C9	SB1 TxD -
A10	Input / Output 16	B10	Input / Output 17	C10	SB1 RxD +
A11	Input / Output 18	B11	Input / Output 19	C11	SB1 RxD -
A12	Input / Output 20	B12	Input / Output 21	C12	SB1 TxC +
A13	Input / Output 22	B13	Input / Output 23	C13	SB1 TxC -
A14	Input / Output 24	B14	Input / Output 25	C14	SB1 RxC +
A15	Input / Output 26	B15	Input / Output 27	C15	SB1 RxC -
A16	Input / Output 28	B16	Input / Output 29	C16	LINESYNC +
A17	Input / Output 30	B17	Input / Output 31	C17	LINESYNC -
A18	Input / Output 32	B18	Input / Output 33	C18	NRESET +
A19	Input / Output 34	B19	Input / Output 35	C19	NRESET -
A20	Input / Output 36	B20	Input / Output 37	C20	ASSEMBLY ADR
A21	Input / Output 38	B21	Input / Output 39	C21	INBUS RTS
A22	Input / Output 40	B22	Input / Output 41	C22	SB2 TxD +
A23	Input / Output 42	B23	Input / Output 43	C23	SB2 TxD -
A24	Input / Output 44	B24	Input / Output 45	C24	SB2 RxD +
A25	Input / Output 46	B25	Opto Input 1	C25	SB2 RxD -
A26	Opto Input 2	B26	Opto Input 3	C26	SB2 TxC +
A27	Opto Input 4	B27	Opto Input Ground	C27	SB2 TxC -
A28	Address – 0	B28	Address – 1	C28	SB2 RxC +
A29	Address – 2	B29	Address – 3	C29	SB2 RxC -
A30	INBUS TxD	B30	INBUS RxD	C30	INBUS TxC
A31	Equipment Ground	B31	AC Line Reference	C31	INBUS RxC
A32	24 VDC Ground	B32	24 VDC Ground	C32	SIU/BIU

Figure 20
Model 2218 Serial Interface Unit (SIU) Connector

Pin	A (Bottom Row)	C (Middle Row)	E (Top Row)
2	Ch 1 Red In	Ch 1 Yellow In	Ch 1 Green In
4	Ch 2 Red In	Ch 2 Yellow In	Ch 2 Green In
6	+24VDC	DC Ground	Address 4
8	Equipment Ground	Neutral	Neutral
10	SB #3 Rx+	SB #3 Tx+	Address Common
12	SB #3 Rx-	SB #3 Tx-	Address 3
14	Address 0	Address 1	Address 2
16	Ch 1 Red Sense	Ch 1 Red Out	Ch 1 Red Out
18	Ch 1 Yellow Sense	Ch 1 Yellow Out	Ch 1 Yellow Out
20	Ch 1 Green Sense	Ch 1 Green Out	Ch 1 Green Out
22	Ch 2 Red Sense	Ch 2 Red Out	Ch 2 Red Out
24	Ch 2 Yellow Sense	Ch 2 Yellow Out	Ch 2 Yellow Out
26	Ch 2 Green Sense	Ch 2 Green Out	Ch 2 Green Out
28	LV+ Signal	LV+ Signal	LV+ Signal
30	HV+ Signal	HV+ Signal	HV+ Signal
32	LV+ MAINS	Neutral	HV+ MAINS

Model 2202-HV High-Density Switch Pack (HDSP) Connector
(DIN 41612 Type E series, 48-pin connector)

Pin	A (Bottom Row)	C (Middle Row)	E (Top Row)
2	Reserved	Reserved	Ch 1 Aux In
4	Ch 2 Aux In	Reserved	Reserved
6	+24VDC	DC Ground	Address 4
8	Equipment Ground	Neutral	Neutral
10	SB #3 Rx+	SB #3 Tx+	Address Common
12	SB #3 Rx-	SB #3 Tx-	Address 3
14	Address 0	Address 1	Address 2
16	FL#1-1 Sense	FL#1-1 Out	FL#1-1 Out
18	FL#1-2 Sense	FL#1-2 Out	FL#1-2 Out
20	Ch 1 Aux Sense	Ch 1 Aux Out	Ch 1 Aux Out
22	Ch 2 Aux Sense	Ch 2 Aux Out	Ch 2 Aux Out
24	FL#2-1 Sense	FL#2-1 Out	FL#2-1 Out
26	FL#2-2 Sense	FL#2-2 Out	FL#2-2 Out
28	LV+ Signal	LV+ Signal	LV+ Signal
30	HV+ Signal	HV+ Signal	HV+ Signal
32	LV+ MAINS	Neutral	HV+ MAINS

Model 2202-HV High-Density Flasher Unit (HDFU) Connector
(DIN 41612 Type E series, 48-pin connector)

Figure 21
Model 2202-HV High-Density Switch Pack (HDSP)
& High-Density Flasher Unit (HDFU) Connectors

CMU2

PIN	FUNCTION	PIN	FUNCTION
1A	+24vdc	1B	
2A	+12vdc	2B	ExtReset in
3A	DC gnd	3B	
4A		4B	
5A		5B	
6A		6B	
7A	SB1 TXD+	7B	SB1 TXD-
8A	SB1 RXD+	8B	SB1 RXD-
9A	SB1 TXC+	9B	SB1 TXC-
10A	SB1 RXC+	10B	SB1 RXC-
11A		11B	
12A		12B	
13A		13B	
14A		14B	
15A	LineSync+	15B	LineSync-
16A	NReset+	16B	NReset-
17A	PwrDwn+	17B	PwrDwn-
18A	SB3 TX+	18B	SB3 TX-
19A	SB3 RX+	19B	SB3 RX-
20A	SB3 TXC+	20B	SB3 TXC-
21A	LF status	21B	LF status
22A	LF status out	22B	LF status out
23A	signals ON	23B	
24A	MC coil	24B	
25A	MC sec	25B	
26A	FTR coil	26B	
27A	FDS	27B	
28A	RDS	28B	
29A		29B	
30A		30B	+48VDC
31A	EQ gnd	31B	
32A		32B	DC- bus

Figure 22
Model 2212-HV Cabinet Monitor Unit (CMUip) Connector

PIN#	AT THE CONTROLLER	AT THE SIU	PIN#	AT THE CONTROLLER	AT THE SIU
1	SB1 TXD+	SB1 RXD+	14	SB1 TXD-	SB1 RXD-
2	SB1 RXD+	SB1 TXD+	15	SB1 RXD-	SB1 TXD-
3	SB1 TXC+	SB1 RXC+	16	SB1 TXC-	SB1 RXC-
4	SB1 RXC+	SB1 TXC+	17	SB1 RXC-	SB1 TXC-
5	SB2 TXD+	SB2 RXD+	18	SB2 TXD-	SB2 RXD-
6	SB2 RXD+	SB2 TXD+	19	SB2 RXD-	SB2 TXD-
7	SB2 TXC+	SB2 RXC+	20	SB2 TXC-	SB2 RXC-
8	SB2 RXC+	SB2 TXC+	21	SB2 RXC-	SB2 TXC-
9	LINE SYNC+	LINE SYNC+	22	LINE SYNC-	LINE SYNC+
10	NRESET+	NRESET+	23	NRESET-	NRESET-
11	PWR DWN+		24	PWR DWN-	
12	+5VDC ISO		25	EQ GND	
13	ISO GND	DC GND			

SB1/SB2 Connector (DB 25)

Pin	Function
1	Reserved
2	Reserved
3	Neutral (AC- Raw)
4	RxDATA +
5	RxDATA -
6	Neutral (AC- Raw)
7	TxDATA +
8	TxDATA -

Serial Bus 3 (RJ-45) Connector

Pin	Function
1	+48VDC
2	48VDC Ground**
3	+24VDC
4	+12VDC (PS-2216-2412 only)
5	24/12 VDC Ground
6	Chassis Ground

Model 2216-24 Cabinet Power Supply (CPS) Connector
(Phoenix Contact #1825161)

Figure 23
SB1/SB2 , SB3 , and Model 2216-24 Cabinet Power Supply (CPS) Connectors

END OF SECTION

SECTION 16640

CATHODIC PROTECTION FOR PIPELINES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for cathodic protection systems on steel, ductile iron and concrete cylinder pipe in water and sewer pipeline projects using rectifiers and deep anodes.

B. Requirements for sacrificial anode cathodic protection on steel, ductile iron and concrete cylinder pipes and metallic fittings in plastic pipe systems using zinc and/or magnesium anodes.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 15640 - Joint Bonding and Electrical Isolation

D. Section 15641 - Corrosion Control Test Stations

1.03 UNIT PRICES

A. This item will be measured and paid for as a lump sum item for the job.

B. Payment will be full compensation for all labor, equipment, materials and supervision for the installation of the cathodic protection system, complete in place including rectifier systems with deep anode groundbed and junction boxes, sacrificial anodes, power feed hookups, and all excavation, backfill, field welding, connections, adjustments, testing, cleanup, and other related work necessary for construction as shown on the drawings and specified herein.

C. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ASTM B 418 - Standard Specification for Cast and Wrought Galvanic Zinc Anodes.

B. ASTM C 94 - Standard Specification for Ready Mixed Concrete.

C. ASTM A 518 – Standard Specification for Corrosion-Resistant High-Silicon Iron Castings.

D. ASTM D 1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

E. ASTM D 4239 – Standard Test Methods for Sulfur in the Analysis Sample of Coal and Coke using High Temperature Tube Furnace Combustion Methods.

F. ASTM D 5192 – Standard Practice for Collection of Coal Samples from Core.

G. AWWA M9 Manual - Concrete Pressure Pipe.

H. CSA – Canadian Standards Association, Standard C22.2, No. 66 and No. 107.

I. City of Houston Electrical Code.

J. NACE International SP0169 - Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems.

K. NACE International SP0572 - Recommended Practice for Design, Installation, Operation and Maintenance of Impressed Current Deep Groundbeds.

L. NEC 70 – National Electrical Code.

M. NEMA TC6 - PVC and ABS Plastic Utilities Duct for Underground Installation.

N. NEMA TC9 - Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation.

O. NEMA 4 – Type 3R Enclosures.

P. UL 83 - Thermoplastic-Insulated Wires.

Q. UL 467 - Bonding and Grounding Equipment.

R. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors.

S. UL 506 – Specialty Transformers.

1.05 SUBMITTALS

A. General: Submittals to conform to the requirements of Section 01330 - Submittal Procedures.

B. Design Drawings and Computations: Prepare by or under the direct supervision of a Professional Engineer, registered in the State of Texas with a minimum of ten years experience in cathodic protection design, all computations and drawings.

C. Catalog Cuts: Submit manufacturer's catalog cuts for each item. Include the manufacturer’s name on the catalog cuts. Provide sufficient information to show that the materials meet the requirements of the drawings and specifications. Where more than one item or catalog number appears on a catalog cut, clearly identify the item proposed.

D. Logs: Give the City of Houston representative a minimum of 48 hours notice prior to drilling the anode bore. Type and submit to the City of Houston representative, copies of detailed geological and resistance logs of each deep anode bore.

E. Rectifier Operation and Maintenance Manual: The rectifier manufacturer to include a complete operation and maintenance manual with each rectifier shipped to the job site. In addition to operating instructions, include a circuit diagram and spare parts list in the manual. Operate the rectifier under full load conditions at the factory and thoroughly inspect and test by the manufacturer prior to delivery to the job site. Report results of this testing on a manufacturer's quality control form and include in the operation manual. The rectifier manufacturer is to reference each operating manual by rectifier model number and individual serial number.

F. Report: Submit six (6) operating, monitoring and maintenance reports for the cathodic protection systems. Include all test data as required by Section 3.08, paragraph H. Include operating instructions, maintenance data, product data and test procedures in the manuals.

G. Drawings: Maintain as-built drawings of the cathodic protection installation during installation and construction. Revise drawings to show exact locations of all rectifiers, anodes, wiring, connections and terminal boxes. Properly identify all items of equipment and material. Submit the original as-built drawings to the City of Houston representative.

1.06 QUALITY CONTROL

A. Certification: Provide manufacturer's certification that all components of the cathodic protection system meet the requirements of the drawings and specifications. Reference the applicable section of the specifications and the applicable standard detail on the certification.

B. Drawings: The drawings for the cathodic protection system are diagrammatic and not scaled for exact locations unless scales are explicitly stated on the specific drawing. Determine exact locations by field conditions and non-interference with other utilities or mechanical and structural features. Note other existing utilities in the area and do not damage these utilities during excavation. Repair any damaged utilities to the satisfaction of the City of Houston at the Contractor's expense.

C. Inspection: All materials, fabrication and installations are subject to inspection and testing by the City of Houston or its designated representative.

PART 2 PRODUCTS

2.01 SACRIFICIAL ANODES - MAGNESIUM

A. Magnesium Anodes: Use high potential magnesium anodes. Follow the metallurgical composition of the magnesium anodes as listed below:

Element	Percent Composition
Aluminum	0.01 Maximum
Manganese	0.50 to 1.3
Copper	0.02 Maximum
Nickel	0.001 Maximum
Iron	0.03 Maximum
Other - (each)	0.05 Maximum
Other - (total)	0.30 Maximum
Magnesium	Balance

B. Magnesium Anode Current Capacity: Magnesium anodes require a current capacity of no less than 500 amp-hours per pound of magnesium.

C. Anode Backfill Material: Use chemical backfill material around all galvanic anodes. Backfill provides a reduced contact resistance to earth, provides a uniform environment surrounding the anode, retains moisture around the anode, and prevents passivation of the anode.

1. All galvanic anodes come prepacked in a backfill material conforming to the following composition:

   a. Ground hydrated gypsum: 75 percent

   b. Powdered bentonite: 20 percent

   c. Anhydrous sodium sulfate: 5 percent.

2. Have a grain size backfill such that 100 percent is capable of passing through a 20 mesh screen and 50 percent is retained by a 100 mesh screen.

3. Completely surround the anode with the backfill mixture within a cotton bag.

4. For standard cast magnesium ingots, the required weight of backfill follows:

Anode Weight (Pounds)	Backfill Weight (Pounds)	Total Weight (Pounds)
9	15	24
17	25	42
20	50	70
32	38	70
48	48	96
60	70	130

D. Anode Lead Wires:

1. Use a 20-foot length of No. 12 AWG solid copper wire equipped with TW or THW insulation for standard lead wires for a galvanic anode.

2. Color code all anode lead wires green when terminated in test stations.

E. Lead Wire Connection to Magnesium Anode:

1. Cast magnesium anodes with a galvanized steel core with the weight of the core not to exceed 0.10 pounds per linear foot.

2. Recess one end of the anode to expose the core for the lead wire connection.

3. Silver-solder the lead wire to the core and fully insulate the connection by filling the recess with an electrical potting compound.

2.02 SACRIFICIAL ANODES - ZINC

A. Zinc Anodes: Use high purity zinc anodes. The metallurgical composition of the zinc anodes conform to ASTM B 418, Type II and the following:

Element	Percent Composition
Aluminum	0.005 Maximum
Cadmium	0.003 Maximum
Iron	0.0014 Maximum
Lead	0.003 Maximum
Zinc	Balance

B. Zinc Anode Current Capacity: Zinc anodes require a current capacity of no less than 335 amp-hours per pound of zinc.

C. Anode Backfill Material: Use chemical backfill material around all galvanic anodes. Backfill provides a reduced contact resistance to earth, provides a uniform environment surrounding the anode, retains moisture around the anode, and prevents passivation of the anode.

1. All galvanic anodes come prepackaged in a backfill material conforming to the following composition:

a. Ground hydrated gypsum: 75 percent

b. Powdered bentonite: 20 percent

c. Anhydrous sodium sulfate: 5 percent.

2. Have a grain size backfill such that 100 percent is capable of passing through a 20 mesh screen and 50 percent is retained by a 100 mesh screen.

3. Completely surround the anode with the backfill mixture within a cotton bag.

4. For standard cast zinc ingots, the required weight of backfill follows:

Anode Weight (Pounds)	Backfill Weight (Pounds)	Total Weight (Pounds)
30	40	70
45	55	100
60	70	130

D. Anode Lead Wires: For the lead wire for the zinc anodes, use a 20-foot length of No. 12 AWG solid copper wire equipped with TW of THW insulation.

E. Lead Wire Connection to Zinc Anode:

1. Cast zinc anodes with a 1/4-inch diameter galvanized steel core.

2. Extend one end of the core beyond the anode for the lead wire connection.

3. Silver-solder the lead wire to the core and fully insulate the connection.

2.03 IMPRESSED CURRENT ANODES

A. Description: Use high silicon-chromium-iron anode centrifugally cast in tubular form in accordance with the following specifications.

1. Anode Alloy: The anode consists of Durichlor 51, high silicon, chromium iron. This alloy to be made in accordance with ASTM A 518, Grade 3 with nominal percentages as follows:

Chemical Composition

Element	Composition, Weight %
Carbon	0.70 - 1.10
Manganese	1.50, max
Silicon	14.20 - 14.75
Chromium	3.25 - 5.00
Molybdenum	20, max
Copper	0.50, max

2. Mechanical and Physical Properties: The mechanical and physical properties of the anode are as follows:

Tensile Strength (1/2" dia. bar) psi	15,000
Compressive Strength, psi	100,000
Hardness, Brinel	520
Density, gr/ml	7.0
Melting Point, °F	2300
Specific Resistance, micro-ohms-cm (20°C)	72
Coefficient of expansion, 32° to 212° F	7.33×10^6

3. Size: Conform to the following sizes for anode castings:

Type	Weight (pounds)	O.D. (inches)	Length (feet)
TA-2	46	2.19	7
TA-3	63	2.66	7
TA-4	85	3.75	7
TA-5	110	4.75	7

TA-2 anodes are required unless otherwise noted on the drawings.

B. Anode Lead Wire Connection:

1. Use a No. 8 AWG seven strand, copper conductor equipped with fluorinated polymer insulation for the lead wire for an impressed current anode. Require the length of the lead wire sufficient to reach the anode terminal box without splicing additional wire.

2. Attach the anode lead wire at the center of the anode. Have minimum pull-out strength of one and one-half times the breaking strength of the No. 8 AWG lead wire or 788 pounds for the center connection.

3. Do not exceed 0.004 ohms for the electrical contact resistance as measured across the lead wire-to-connector junction.

C. Impressed Current Anode Backfill: Use SC3 calcined fluid petroleum coke as manufactured by Loresco, Inc. to backfill impressed current anodes. Anode backfill properties to be as follows:

1. Typical Chemical Analysis:

Component	Percent Composition
Carbon (fixed)	99.35 minimum
Ash	0.6 maximum
Volatiles	0 (950° C)
Moisture	0.05

2. Physical Properties: Bulk density of 74 pounds/cubic foot.

3. Particle Analysis: Dust free with a maximum particle size of 1 mm.

2.04 VENT

A. Use plastic vent pipe from the bottom anode to the surface for dissipating gases to the atmosphere.

B. Require 1-inch diameter AllVent slotted pipe or plastic vent pipe with 1/8-inch holes drilled on 6-inch centers in the area of the anodes. Do not use slotted vent pipe or drill holes in the vent pipe above the anodes.

C. Extend the plastic vent pipe above grade, screen the vent outlet, and install in an inverted manner.

2.05 RECTIFIERS

A. Cathodic protection rectifiers to be air-cooled, tap adjust Super Custom model as manufactured by Universal Rectifiers, Corrpower or approved equal, conforming to NEMA MR-20-1958 and listed in CSA File No. 45382.

B. DC Output Ratings: Rate rectifiers as shown on the drawings. Supply units that are capable of operating at continuous, full rated output at an ambient temperature of 45° C, in full sunlight with an expected life in excess of 10 years.

C. AC Input Ratings: Full rated DC output shall be obtainable with an AC input voltage at 5% below the nominal value. Continuous AC input voltage at 10% above the nominal value shall not damage the transformer, the diode bridge assembly, or exceed any component rates. (Note: This shall apply provided that the rectifier has not been previously adjusted to exceed the maximum DC voltage or amperage rating of the unit.)

D. Cooling: Cool by natural air convection. Vent cabinets for natural air convection and screen against insects.

E. Voltage Adjustments: Provide adjustment of the output voltage by means of not less than 25 approximately equal steps of secondary taps from 5 percent of rated voltage to full-rated voltage.

F. Rectifying Elements: Rectifying elements to be silicon diodes sized as follows:

1. The Peak Inverse Voltage (PIV) of the diode shall be 300% of the maximum impressed voltage on the diode or 400 volts, whichever is greater.

2. Configure diodes into a full-wave bridge assembly. Size diodes to carry a minimum average current of one half of rated rectifier output.

3. Size heat sinks to keep diode junction temperatures less than 100° C at rated output and maximum ambient temperature.

4. Protect diodes against overload by means of semiconductor fuses, located in the transformer secondary leg to the diode bridge assembly.

5. Equip diodes with supplemental Metal Oxide Varistor (M.O.V.) surge arrestors at the diode bridge assembly sized to provide protection against secondary over- voltage surges.

G. AC Circuit Breakers: Provide input overload and short circuit protection by magnetic trip circuit breakers. Size the circuit breaker to hold 100 percent of rated load. It may trip between 101 percent and 125 percent of rated load, and must trip at 125 percent and above.

H. Surge Protection: Provide separate AC and DC surge protection by means of high energy Metal Oxide Varistors rated at 500 joules on the DC output and 750 joules on the AC input.

I. Electrical Panels: Construct electrical panels from a minimum thickness of 1/4" NEMA "XX" laminated phenolic, rated for Class "B" operation (105° C maximum). Equip rectifiers rated at 100 amperes DC or higher with panels constructed from a minimum sheet thickness of 1/4" "UTR" fiberglass reinforced laminate rated for Class "F" operation (155° C). Permanently silk-screen rectifier front panel identifications onto the panel.

J. Connection Hardware: Use only copper or high conductivity brass electrical hardware, suitably sized, and finished in electroless nickel plating for superior corrosion resistance. Tightly secure all connections with lock washers and nuts torqued to manufacturer's recommended specifications.

K. Enclosures:

1. Mount rectifier unit and anode junction panel in a single enclosure.

2. Enclosure to be free standing, NEMA 4X, 36” wide x 48” high x 24” deep, 12 gauge, type 304 stainless steel with lifting eyes.

3. Equip with single, louvered door with pad lockable, single handle. Provide drip shield and inside insect screen.

4. Include ground lug, sized for No. 6 AWG wire.

5. Place stickers on all four sides that read “Danger, High Voltage, Keep Out.”

6. Provide permanent engraved nameplate with black letters on white background that reads “Cathodic Protection Cabinet, Property of the City of Houston, In Case of Emergency, Call 311.”

L. Rectifier Instrumentation.

1. Equip rectifier with separate analog ammeter and voltmeter.

2. Meters to be a minimum of 3-1/2" size, with a minimum scale length of 2-7/8"

3. Meters to be 0 - 50 millivolts full scale deflection, taut-band movement with four- to-one swamping (i.e. internal meter resistance comprised of 25% winding resistance and 75% fully temperature compensated dropping resistor for wide temperature range performance).

4. Provide meters with accuracy + 2% full scale deflection at 25° C., temperature compensated to 0.085% per degree C.

5. Scale rectifier meters to have rated output no less than 70%, or greater than 85% of full scale deflection.

6. Meter shunts to be panel-mounted Holloway type "SW" style, with an accuracy of +0.25%.

M. Transformers: Construct transformers to meet UL 506, Specialty Transformers and the following:

1. Transformer designed as full isolation with separate isolated primary and secondary windings and a minimum efficiency of 95%.

2. Equip transformer secondary with a minimum of 25 steps of secondary voltage adjustment (5-COARSE, 5-FINE). Provide tap adjustment by means of tap bars.

3. Rate transformer materials and construction for Class "H" operation (180° C). Further enhance insulation materials by dipping in thermosetting varnish and baking.

4. Rate transformer for a minimum dielectric strength of 2250 volts applied for one minute between the windings and the core.

N. Potential Monitoring Connections: Provide two, machine screw, washers and hex nut connections on the front of the rectifier instrument panel. One to be labeled “Reference” and one to be labeled “Structure”.

O. Miscellaneous:

1. Supply rectifiers capable of operating on either 115 or 230 volt, single phase, 60 hertz AC input.

2. All cathodic protection rectifiers to be 100% quality control tested as outlined in this specification.

3. During manufacture, subject the rectifier to frequent visual and performance testing to assure a high degree of quality.

4. Subject rectifiers to 100% testing of the following rectifier electrical parameters:

   a. AC input voltage, current, apparent power and true power

   b. DC output current, voltage and power

   c. AC power factor

   d. AC to DC conversion efficiency

   e. Output ripple

   f. Correct operation of optional features such as interrupters, filters, etc.

5. Give each rectifier a final overall visual inspection prior to packaging.

2.06 ANODE JUNCTION PANEL

A. Enclosure: Mount the anode junction panel in the stainless steel rectifier enclosure as shown on the Drawing. Provide positive terminal, 0.01 ohm type RS Holloway shunts, and a minimum 3/16" thick, NEMA Grade "XX" phenolic panel. For size and terminal configurations, see Drawings.

B. Positive Cable: Use a single conductor, seven strand, copper with THHN insulation for the positive cable from the anode junction panel to the transformer-rectifier.

2.07 NEGATIVE CABLES

A. Cables: Use single conductor, seven-strand, copper with medium density, HMWPE insulation for the rectifier negative cables. The polyethylene to conform to ASTM D 1248, Type I, Class C, Grade 5.

B. Test Lead: The test lead to be No. 12 AWG, solid copper wire with white, TW or THW insulation and of sufficient length to extend from the protected structure to the rectifier without splicing.

2.08 PERMANENT REFERENCE ELECTRODES

A. Type: Provide a copper/copper sulfate, double membrane, ceramic cell in a geomembrane package, such as a Permacell Plus or approved equal.

B. Wire: Equip with No. 14 AWG stranded copper wire with blue HMWPE insulation of suitable length to extend from the pipeline to the rectifier without splicing.

2.09 THERMITE WELD EQUIPMENT

A. Charges and Molds: Use weld charges and molds sized as specified by the manufacturer for the specific wire size and surface configuration. Weld charges and molds to be Cadweld by Erico or Thermoweld by Continental Industries.

B. Limitation: For high strength steel pipelines, use only 15 gram Cadweld charges.

C. Weld Coating: Coat all bare metal and weld metal with Stopaq CZ tape.

D. Weld Cap: Cover the coated weld with a plastic weld cap.

2.10 AC POWER SERVICE

A. Products: All AC power components must meet local power company requirements.

B. Meter Base: Meter base to be 120/240-volt, single phase, 100-ampere.

C. Disconnect Switch: Provide fused disconnect switch in NEMA 1 enclosure. Mount on power pole below meter base.

D. Ground Rod: Ground rod must conform to the requirements of the utility company having jurisdiction.

E. Ground Wire and Clamp: Ground wire to be bare, No. 6 AWG solid copper wire. Use a bronze, bolt-on ground rod clamp.

F. Provide power pole with meter loop and meter base conforming to the requirements of the utility company having jurisdiction.

PART 3 EXECUTION

3.01 INSTALLATION OF SACRIFICIAL ANODES

A. Location: Install sacrificial anodes at locations where the anodes will operate at maximum effectiveness.

B. Placement: Install anodes in native soil, in a vertically augured hole as shown on the drawings. If a vertical installation of the anodes is not feasible, the anodes may be installed horizontally.

C. Backfilling: After the hole is augured, lower the packaged anode into the hole and firmly tamp the soil around the package so that it is in intimate contact with the package.

D. Lead Wire: Run lead wires from the anodes underground at a minimum depth of 36 inches. Connect the wires through a test station as indicated on the drawings.

E. Handling: Handle galvanic anodes carefully to avoid damaging anode materials and wire connections.

3.02 INSTALLATION OF DEEP ANODE GROUNDBEDS

A. Permits: A qualified well driller who is recognized as a fully experienced specialist in the installation of deep anode cathodic protection systems is required to perform the drilling and installation of the deep anode systems. The deep anode system installer is required to have a minimum of 5 years experience installing deep anode systems with a minimum of 10 successful deep well anode installations. The Contractor is required to obtain and submit all applications for well drilling permits required by any City, County or State agency.

B. Field Location: Contractor is responsible for verifying actual field conditions, location of underground structures, and assuring adequate physical separation from other structures and utilities. Location of the anode wells is approximate. Determine and verify the exact placement in the field with a representative of the City of Houston.

C. Anode Hole Drilling: The anode hole to be 8 inches diameter by 200 feet deep unless otherwise shown on the drawings. Perform drilling with rotary bit equipment designed specifically for this purpose. Use standard techniques (i.e. trough and vacuum truck) to capture and contain the drilling fluids, mud and cuttings at the top of the hole. Select the type and consistency of drilling fluids to be consistent with soil characteristics. Level the drilling rig to provide a round, straight and plumb anode hole.

D. Temporary Well Casing: Drilling of the holes may require the installation of temporary well casings. Remove all temporary casings by the end of the job.

E. Anode Hole Geological Logs: As the hole is drilled, maintain a record describing the depth and type of the geological formations encountered. Submit typed copies of the log as required by Section 1.05.D.

F. Anode Hole Resistance Log: Record an electric log of the hole using one of the anodes. Previously mark the anode lead wire in five-foot increments. Mark the anode lead wire for a distance equaling or exceeding the maximum anticipated depth of the hole. As the anode is lowered into the hole, perform a resistance log by impressing a minimum 12 volt DC urrent between the anode and a very well grounded structure such as the local AC power neutral network. Do not use Nilsson type soil resistance meters to perform this test. A recommended 12-volt DC power source is a heavy duty lead acid automobile battery. Lower the anode into the hole at ten foot increments, hold in place, and measure the voltage and current output of the DC current source. Record the data, type and submit as required under Section 1.05.D.

G. Vent Pipe Installation: Install the vent pipe in the hole with the first anode. Cap the bottom of the vent pipe. Cap the top of the vent pipe throughout the anode and coke breeze backfill installation procedure to prevent intrusion of foreign material. Do not allow drilling mud to enter in the vent pipe.

H. Anode Installation: The anode well to contain ten (10) tubular cast iron anodes spaced at 10 foot intervals on centers unless otherwise shown on the drawings. Center the anodes in the hole using anode centralizers. Install the anodes by lowering them individually into the hole by the lead wire. Mark the lead wires for the nominal anode depth. Record the final depth with the first anode in the hole (i.e. the bottom anode) identified as anode number one (1). Do not damage the anode lead during handling or lowering into the hole. Under no circumstances, clamp or pinch the anode lead wires around another object while lowering the anodes into the hole. If the insulation for any anode lead wires are cut, broken, or nicked during this operation or at any other time, reject the complete anode and remove from the job site immediately. Replace all damaged anodes at no additional expense to the City of Houston.

I. Anode Column Coke Backfill: Slurry the coke backfill above-grade and then pump into the hole after the anodes are installed. Pump the coke from the bottom of the hole up using a pipe that is the length of the anode hole. Do not use the vent pipe to pump the coke. Raise the pipe as the anode column is filled with coke. Remove the pipe from the hole after the coke installation operation is completed. Use a sufficient amount of backfill such that the coke breeze column extends a minimum of five feet above the top of the uppermost anode. Install the coke backfill uniformly with no voids around the anodes.

J. Vent Pipe: Terminate the 1-inch diameter internal vent pipe with a gooseneck fitting. Leave the top end of the vent pipe open to allow gases from the anode hole to exit.

K. Precautions: Take all necessary precautions to avoid entrance of foreign matter into the hole, movement of soil strata, or collapsing of the hole during the progress of the work. Should movement of soil strata or collapse of the drilled hole interfere with proper completion of the anode groundbed, recover the wires, anodes and vent pipe and ream or redrill the hole at no cost to the City of Houston.

L. Mud and Cuttings: Dispose of drilling mud, cuttings and other waste in accordance with the methods and procedures of the best recognized practices and comply with the rules and regulations of the State, City and County.

M. Completion: Seal anode hole with bentonite environmental earth seal. Terminate vent pipe and anode lead wires at rectifier.

3.03 INSTALLATION OF CATHODIC PROTECTION RECTIFIERS

A. Codes: Comply with the latest edition of the National Electrical Code (NEC) and with all City of Houston, and local power company codes and standards.

B. Mounting: Mount rectifiers on reinforced concrete pad as shown on the drawings. Place at elevation above the 100-year flood plain.

C. Identification: Equip rectifiers with permanent engraved nameplates to identify the units as "Cathodic Protection Cabinet, Property of City of Houston, In Case of Emergency Call 311."

D. Conduit: Place all wiring to the rectifier in rigid galvanized steel conduit when run above grade.

1. Use insulating bushings at the ends of all conduits.

2. Extend steel conduit 12 inches below grade.

E. Electrical Service: Provide AC electrical service for each rectifier unit. Furnish and install the necessary wiring, conduits, wires, meter sockets, splice boxes and equipment to the service connection as required by the local power company.

F. Completion: The installation is not considered complete until the AC and DC wiring is installed and the rectifier is capable of operating at full rated load. Install AC power such that the rectifier can be activated for test purposes.

3.04 INSTALLATION OF WIRE AND CABLE

A. Depth: Install all underground wires and cables at a minimum of 36 inches below final grade with a minimum separation of 6 inches from other underground structures.

B. Above-grade Conduit: Enclose all positive and negative cables, and anode lead wires in rigid galvanized steel conduit when above-grade.

1. Use insulating bushings at the ends of all conduits.

2. Extend conduit 12 inches below grade.

C. Below Grade Conduit: Enclose all cables and wires in grey electrical PVC conduit when below grade.

3.05 INSTALLATION OF ANODE LEAD JUNCTION BOXES

A. Location: Mount anode lead junction box inside cathodic protection cabinet as shown on drawings.

B. Anode Lead Panel: Mount anode lead panel to cabinet with machine screws, washers and hex nuts.

3.06 NEGATIVE CABLE AND TEST LEAD ATTACHMENT

A. Attach negative cables and test lead to the pipe by thermite welding.

B. Clean and dry the pipe to which the negative cables and test lead are to be attached.

C. Use a grinding wheel to remove all coating, mill scale, oxide, grease and dirt from the pipe over an area approximately 3 inches square. Clean the surface to bright metal.

D. Remove approximately one inch of insulation from each end of the wires to be thermite welded to the pipe, exposing clean, oxide-free copper for welding.

E. Using the proper size thermite weld mold as recommended by the manufacturer, place the wire between the graphite mold and the prepared metal surface. Use a copper sleeve crimped over the wire for all wires No. 12 AWG size.

F. Place the metal disk in the bottom of the mold.

G. Remove the cap from the weld charge container. Pour the contents into the mold. Squeeze the bottom of the weld charge container and spread ignition powder over the charge.

H. Close the mold cover and ignite the starting powder with a flint gun. Hold the mold firmly in place until all of the charge has burned and the weld has cooled slightly.

I. Remove the thermite weld mold and gently strike the weld with a hammer to remove the weld slag. Pull on the wire to assure a secure connection. If the weld is not secure or the wire breaks, repeat the procedure.

J. If the weld is secure, coat all bare metal and weld metal with Stopaq CZ tape.

3.07 PERMANENT REFERENCE CELL

A. Location: When not shown on the Drawings, locate the permanent reference cell near the negative structure connection.

B. Placement: Remove the permanent reference cell from the shipping package and place below the springline and one foot away from the pipeline. Make certain that the reference electrode is completely surrounded by the special backfill material in the geomembrane package.

C. Backfill the reference electrode with six inches of select, native soil and compact by hand. Moisten the soil for good compaction. Saturate the backfilled reference cell with 5 gallons of water.

D. Wiring: Run continuous lengths of the blue reference cell wiring, and the white test lead to the rectifier unit in the same trench as the negative cable. Do not nick or otherwise damage the wire insulation.

3.08 POST INSTALLATION TESTING OF THE CATHODIC PROTECTION SYSTEMS

A. General: Inspect, energize, and adjust the cathodic protection as soon as possible after the equipment has been installed.

B. Energization: Perform the energizing of the cathodic protection system by a Corrosion Engineer to achieve compliance with the referenced corrosion control standards set forth by AMPP and/or AWWA.

C. Notice: Prior to native state, polarized potential testing, and commissioning of the system, give a minimum of 48 hours notice to the City of Houston, Engineering Project Manager to facilitate observation of the tests by a City Representative.

D. Method: The Corrosion Engineer shall:

1. Measure native state pipe-to-soil potentials at all test stations, permanent reference cells, electrical isolation devices, and locations of exposed pipe prior to energizing the cathodic protection system.

2. Measure casing-to-soil potentials and foreign line potentials, prior to energizing the cathodic protection system.

3. Energize the cathodic protection system and adjust the DC current output such that the pipe-to-soil potentials near the cathodic protection current source (either transformer-rectifier or sacrificial anodes) is approximately -1000 millivolts to a copper sulfate electrode (CSE). Record the DC voltage and current of the power supply.

4. Allow sufficient time for the pipeline to polarize.

5. Using a current interrupter, cycle the power supply “On” and “Off”.

6. Record “On” and “Instant Off” potentials at all water pipeline test stations, permanent reference cells, electrical isolation devices, locations of exposed pipe, casings and foreign pipelines.

7. For steel and ductile iron pipe, adjust the cathodic protection power supplies to satisfy the criteria of a minimum 100 millivolts of polarization or an “Instant Off” potential at least as negative as -850 millivolts CSE.

8. For concrete cylinder pipe, adjust the cathodic protection power supplies to achieve a minimum 100 millivolt of polarization without any “Instant Off” potentials more negative than -1000 millivolts CSE.

9. Record all final adjustments of the DC power supplies.

10. Verify that all electrical isolation devices are operating properly including flange isolators, and casing spacers.

11. Verify that interference does not exist with foreign pipelines. Perform joint tests and mitigate any interference detected.

E. After initial energization and after rectifiers have been adjusted as necessary for compliance with NACE RP-0169 (latest revision), perform a walk-through inspection with City Engineer to verify that all corrosion control components have been installed in accordance with project drawings and specifications.

F. Make a punch list of outstanding work identified during walk-through inspection. Once Contractor has completed all work on punchlist, pipeline will be allowed to polarize for 30 days before final testing. Perform final testing and adjustment after 30-day polarization period. Repair deficiencies discovered during final testing at Contractor's expense and at no additional cost to City of Houston.

G. Equipment: All cathodic protection testing instruments to be in proper working order and calibrated according to factory specifications.

H. Report: Submit a written report in accordance with Section 1.05, Submittals. Include all test data, resistance and geologic logs, the rectifier O&M Manual and the As-Built Drawings.

END OF SECTION

SECTION 16641

CATHODIC PROTECTION FOR EXISTING TANK BOTTOMS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for impressed current cathodic protection systems for the bottom (soil side) of steel water storage tanks that are constructed at grade level.

B. Specifications for manually controlled transformer-rectifiers and deep anodes.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 13111 – Cathodic Protection for Water Tank Interiors (Sacrificial Anode)

D. Section 13112 – Cathodic Protection for Water Tank Interiors (ICCP)

E. Section 15640 – Joint Bonding and Electrical Isolation

F. Section 16640 – Cathodic Protection for Pipelines

G. Section 16642 – Cathodic Protection for Plant Piping

1.03 UNIT PRICES

A. This item will be measured and paid for as a lump sum item for the job.

B. Payment will be full compensation for all labor, equipment, materials and supervision for the installation of the cathodic protection system, complete in place including rectifier systems with deep anode groundbed and junction boxes, reference cells, power feed hookups, and all excavation, drilling, backfill, field welding, connections, adjustments, testing, cleanup, and other related work necessary for construction as shown on the drawings and specified herein.

C. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ASTM C 94 - Standard Specification for Ready-Mixed Concrete

B. ASTM D 1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

C. ASTM A 518 – Standard Specification for Corrosion-Resistant High-Silicon Iron Casting

D. ASTM D 4239 – Standard Test Methods for Sulfur in the Analysis Sample of Coal and Coke using High-Temperature Tube Furnace Combustion

E. ASTM D 5192 – Standard Practice for Collection of Coal Samples from Core

F. NEC 70 - National Electrical Code

G. City of Houston Electrical Code

H. NACE International SP0193 - External Cathodic Protection of On-Grade Metallic Storage Tank Bottoms

I. NACE International SP0169 - Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems

J. NACE International SP0572 - Recommended Practice for Design, Installation, Operation and Maintenance of Impressed Current Deep Groundbeds

K. NEMA TC6 - PVC and ABS Plastic Utilities Duct for Underground Installation

L. NEMA TC9 - Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation

M. NEMA 4 - Type 3R Enclosures

N. UL 83 - Thermoplastic-Insulated Wires

O. UL 467 - Bonding and Grounding Equipment

P. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors

1.05 SUBMITTALS

A. General: Submittals to conform to the requirements of Section 01330 – Submittal Procedures.

B. Design Drawings and Computations: Prepare by or under the direct supervision of a Corrosion Engineer who is a Professional Engineer, registered in the State of Texas with a minimum of ten years experience in cathodic protection design.

C. Catalog Cuts: Submit manufacturer's catalog cuts for each item. Include the manufacturer's name on the catalog cuts. Provide sufficient information to show that the materials meet the requirements of the drawings and specifications. Where more than one item or catalog number appears on a catalog cut, clearly identify the item proposed.

D. Logs: Give the City of Houston representative a minimum of 48 hours notice prior to drilling the anode bore. Type and submit to the City of Houston representative, copies of detailed geological and resistance logs of each deep anode bore.

E. Rectifier Operation and Maintenance Manual: The rectifier manufacturer to include a complete operation and maintenance manual with each rectifier shipped to the job site. In addition to operating instructions, include a circuit diagram and spare parts list in the manual. Operate the rectifier under full load conditions at the factory and thoroughly inspect and test by the manufacturer prior to delivery to the job site. Report results of this testing on a manufacturer's quality control form and include in the operation manual. The rectifier manufacturer to reference each operating manual by rectifier model number and individual serial number.

F. Operating and Maintenance Manual: Submit six (6) operating, monitoring and maintenance manuals for the cathodic protection systems. The manuals shall include operating instructions, maintenance data, product data and test procedures.

G. Drawings: Maintain as-built drawings of the corrosion control system during installation and construction. Revise drawings to show exact locations of all wiring, connections and terminal boxes. Properly identify all items of equipment and material. Submit the original as-built drawings to the City of Houston representative.

1.06 QUALITY CONTROL

A. Certification: Provide manufacturer's certifications that all components of the cathodic protection systems meet the requirements of the drawings and specifications. Reference the applicable section of the specifications and the applicable standard details on the certification.

B. Drawings: The drawings for the cathodic protection systems are diagrammatic and not to be scaled for exact locations unless scales are explicitly stated on the specific drawing. Determine exact locations by field conditions and non-interference with other utilities or mechanical and structural features. Note other existing utilities in the area and do not damage these utilities during excavation. Repair any damaged utilities to the satisfaction of the City of Houston at the Contractor's expense.

C. Inspection: All materials, fabrication and installations are subject to inspection and testing by the City of Houston or its designated representative.

PART 2 PRODUCTS

2.01 IMPRESSED CURRENT ANODES

A. Description: Use high silicon-chromium-iron anode centrifugally cast in tubular form in accordance with the following specifications.

1. Anode Alloy: The anode to consist of Durichlor 51, high silicon, chromium iron. This alloy to be made in accordance with specification ASTM A 518, Grade 3 with nominal percentages as follows:

Chemical Composition	
Element	Composition, Weight %
Carbon	0.70 - 1.10
Manganese	1.50, max
Silicon	14.20 - 14.75
Chromium	3.25 - 5.00
Molybdenum	0.20, max
Copper	0.50, max

2. Mechanical and Physical Properties: The mechanical and physical properties of the anode are as follows:

Tensile Strength (1/2" dia. bar) psi 15,000
Compressive Strength, psi 100,000
Hardness, Brinell.....520
Density, gr/ml 7.0
Melting Point, °F.....2300
Specific Resistance, micro-ohms-cm (20°C) 72
Coefficient of expansion, 32° to 212° F ..... 7.33 X 10^6

3. Size: Conform to the following sizes for anode castings:

Type	Weight (pounds)	O.D. (inches)	Length (feet)
TA-2	46	2.19	7
TA-3	63	2.66	7
TA-4	85	3.75	7
TA-5	110	4.75	7

TA-2 anodes are required unless otherwise noted on the drawings.

B. Anode Lead Wire Connection:

1. Use a No. 8 AWG seven strand, copper conductor equipped with fluorinated polymer insulation for the lead wire for an impressed current anode. Require the length of the lead wire sufficient to reach the anode terminal box without splicing additional wire.

2. Attach the anode lead wire at the center of the anode. Have minimum pull-out strength of one and one-half times the breaking strength of the No. 8 AWG lead wire or 788 pounds for the center connection.

3. Do not exceed 0.004 ohms for the electrical contact resistance as measured across the lead wire-to-connector junction.

C. Anode Backfill: Use SC 3 calcined petroleum coke, as manufactured by Loresco Inc., to backfill impressed current anodes. Anode backfill shall conform to the following:

1. Typical Chemical Analysis.

Component	Percent Composition
Carbon (fixed)	99.35 minimum
Ash	0.6 maximum
Volatiles	0 (950° C)
Moisture	0.05

2. Physical Properties.

Bulk Density 74 pounds/cubic foot

3. Particle Analysis.

Dust free with a maximum particle size of 1 mm.

2.02 VENT

A. Use plastic vent pipe from the bottom anode to the surface for dissipating gases to the atmosphere.

B. Require 1-inch diameter AllVent slotted pipe or plastic vent pipe with 1/8-inch holes drilled on 6-inch centers in the area of the anodes for the vent. Do not use slotted vent pipe or drill holes in the vent pipe above the anodes.

C. Extend the plastic vent pipe above grade, screen the vent outlet, and install in an inverted manner.

2.03 RECTIFIERS

A. Cathodic protection rectifiers to be air-cooled, tap adjust Super Custom model as manufactured by Corrpower, Universal Rectifiers or approved equal, conforming to NEMA MR-20-1958 and listed in the CSA File No. 45382.

B. DC Output Ratings: Rate rectifiers as shown on the drawings. Supply units that are capable of operating at continuous, full rated output at an ambient temperature of 45° C, in full sunlight with an expected life in excess of 10 years.

C. AC Input Ratings: Obtain full rated DC output, with an input voltage +10 percent of the nominal rated input.

D. Cooling: Cool by natural air convection. Vent cabinets for natural air convection and screen against insects.

E. Voltage Adjustments: Provide adjustment of the output voltage by means of not less than 25 approximately equal steps of secondary taps from 5 percent of rated voltage to full- rated voltage.

F. Rectifying Elements: Rectifying elements to be silicon diodes sized as follows:

1. Rate diode voltage at 400 volts minimum for rectifier outputs up to 100 VDC, and 800 volts minimum for rectifiers with outputs from 100 to 200 VDC.

2. Configure diodes into a full-wave bridge assembly. Size diodes to carry a minimum average current of one half of rated rectifier output.

3. Size heat sinks to keep diode junction temperatures less than 100° C at rated output and maximum ambient temperature.

4. Protect diodes against overload by means of semiconductor fuses, located in the transformer secondary leg to the diode bridge assembly.

5. Equip diodes with supplemental Metal Oxide Varistor (M.O.V.) surge arrestors at the diode bridge assembly sized to provide protection against secondary over- voltage surges.

G. AC Circuit Breakers: Provide input overload and short circuit protection by magnetic trip circuit breakers. Size the circuit breaker to hold 100 percent of rated load. It may trip between 101 percent and 125 percent of rated load and must trip at 125 percent and above.

H. Surge Protection: Provide separate AC and DC surge protection by means of high energy Metal Oxide Varistors rated at 500 joules on DC output and 750 joules on the AC output.

I. Electrical Panels: Construct electrical panels from a minimum thickness of 1/4" NEMA "XX" laminated phenolic, rated for Class "B" operation (105° C maximum). Equip rectifiers rated at 100 amperes DC or higher with panels constructed from a minimum sheet thickness of 1/4" "UTR" fiberglass reinforced laminate rated for Class "F" operation (155° C). Permanently silk-screen rectifier front panel identifications onto the panel.

J. Connection Hardware: Use only copper or high conductivity brass electrical hardware, suitably sized, and finished in electroless nickel plating for superior corrosion resistance. Tightly secure all connections with lock washers and nuts torqued to manufacturer's recommended specifications.

K. Enclosures:

1. Construct enclosures from a minimum 12 gauge wiped coat mill galvanized steel, finished in 3 - 5 mils polyester fusion bonded powder coating.

2. Use stainless steel hinges and cabinet assembly bolts.

3. Equip enclosures with a pad-lockable draw latch manufactured from 12-gauge steel, finished in zinc-dichromate plating. A draw latch required to accommodate a 3/8 inch shackle padlock.

4. Equip enclosures (or rectifier frame) with a grounding lug sized to accommodate up to a No. 6 AWG conductor.

5. Provide separate conduit knockouts for AC and DC; conveniently located and adequately sized for input and output conduit connectors.

6. Furnish cabinet with suitable channel brackets for wall or pole mounting.

7. Equip rectifier with slide-out chassis and hinged door for access to the front and a minimum of one side of the cabinet.

8. Place stickers on sides that read “Danger, High Voltage, Keep out.”

L. Rectifier Instrumentation.

1. Equip rectifier with separate analog ammeter and voltmeter.

2. Meters to be a minimum of 3-1/2" size, with a minimum scale length of 2-7/8".

3. Meters to be 0 - 50 millivolts full scale deflection, taut-band movement with four-to-one swamping (i.e. internal meter resistance comprised of 25% winding resistance and 75% fully temperature compensated dropping resistor for wide temperature range performance).

4. Provide meters with accuracy + 2% full scale deflection at 25° C., temperature compensated to 0.085% per degree C.

5. Scale rectifier meters to have rated output no less than 70%, or greater than 85% of full scale deflection.

6. Meter shunts to be panel-mounted Holloway type "SW" style, with an accuracy of +0.25%.

M. Transformers: Construct transformers to meet UL 506, Specialty Transformers and the following:

1. Transformer designed as full isolation with separate isolated primary and secondary windings with a minimum efficiency of 95%.

2. Equip transformer secondary with a minimum of 25 steps of secondary voltage adjustment (5-COARSE, 5-FINE). Provide tap adjustment by means of tap bars.

3. Rate transformer materials and construction for Class "H" operation (180° C). Further enhance insulation materials by dipping in thermosetting varnish and baking.

4. Rate transformer for a minimum dielectric strength of 2250 volts applied for one minute between the windings and the core.

N. Current Interrupters: Include a built-in current interrupter rated in accordance with the capacity of the rectifier unit. Equip the interrupter with a solid-state timer with independently adjustable "On" and "Off" times. Equip interrupter with a switch to enable the operator to operate the rectifier in an interrupt or continuous mode of output.

O. Miscellaneous:

1. Supply rectifiers capable of operating either on 115 or 230 volt, single phase, 60 hertz AC input.

2. All cathodic protection rectifiers to be 100% quality control tested as outlined in this specification.

3. During manufacture, subject the rectifier to frequent visual and performance testing to assure a high degree of quality.

4. Subject rectifiers to 100% testing of the following rectifier electrical parameters:

a. AC input voltage, current, apparent power and true power

b. DC output current, voltage and power

c. AC power factor

d. AC to DC conversion efficiency

e. Output ripple

f. Correct operation of optional features such as interrupters, filters, etc

5. Give each rectifier a final overall visual inspection prior to packaging.

2.04 DC CABLES

A. Cables: Use seven strand, copper conductors with high molecular weight polyethylene (HMWPE) insulation for the rectifier positive and negative cables.

2.05 THERMITE WELD EQUIPMENT

A. Charges and Molds: Use weld charges and molds sized as specified by the manufacturer for the specific wire size and surface configuration. Weld charges and molds to be Cadweld by Erico or Thermoweld by Continental Industries.

B. Weld Coating: Use Kop-Coat Coating as manufactured by Carboline or approved equal.

C. Weld Cap: Cover the coated weld with a plastic weld cap.

PART 3 EXECUTION

3.01 INSTALLATION OF DEEP ANODE GROUNDBEDS

A. Permits: A qualified well driller who is recognized as a fully experienced specialist in the installation of deep anode cathodic protection systems is required to perform the drilling and installation of the deep anode systems. The deep anode system installer is required to have a minimum of 5 years experience installing deep anode systems with a minimum of 10 successful deep well anode installations. The Contractor is required to obtain and submit all applications for well drilling permits required by any City, County, State agency.

B. Field Location: Contractor is responsible for verifying actual field conditions, location of underground structures, and assuring adequate physical separation from other structures or utilities. Location of the anode wells is approximate. Determine and verify the exact placement in the field with a representative of the City of Houston.

C. Anode Hole Drilling: The anode hole to be 8 inches in diameter by 200 feet deep. Perform drilling with rotary bit equipment designed specifically for this purpose. Use standard techniques (i.e. trough and vacuum truck) to capture and contain the drilling fluids, mud and cuttings at the top of the hole. Select the type and consistency of drilling fluids to be consistent with soil characteristics. Level the drilling rig to provide a round, straight and plumb anode hole.

D. Temporary Well Casing: Drilling of the holes may require the installation of temporary well casings. Driller to remove all temporary casings by the end of the job.

E. Anode Hole Geological Logs: As the hole is drilled, the driller to maintain a detailed, formal record describing the depth and type of the geological formations encountered. Submit typed copies of the log as required by 1.05.D.

F. Anode Hole Resistance Log: Record an electric log of the hole using one of the anodes. Previously mark the anode lead wire in five-foot increments. Mark the anode lead wire for a distance equaling or exceeding the maximum anticipated depth of the hole. As the anode is lowered into the hole, perform a resistance log by impressing a minimum 12 volt DC current between the anode and a very well grounded structure such as the local AC power neutral network. Do not use Nilsson type soil resistance meters to perform this test. A recommended 12-volt DC power source is a heavy duty lead acid automobile battery. Lower the anode into the water or drilling mud filled hole at ten foot increments, hold in place, and measure the voltage and current output of the DC current source. Record the data, type and submit as required under Section 1.05.D.

G. Vent Pipe Installation: Install the vent pipe in the hole with the first anode. Cap the bottom of the vent pipe. Cap the top of the vent pipe throughout the anode and coke breeze backfill installation procedure to prevent intrusion of foreign material. Do not allow intrusion of drilling mud into the vent pipe.

H. Anode Installation: The anode well to contain tubular cast iron anodes spaced at 10 foot intervals on centers as shown on the drawings. Center the anodes in the hole using anode centralizers. Install the anodes by lowering them individually into the hole by the lead wire. Mark the lead wires for the nominal anode depth. Record the final depth with the first anode in the hole (i.e. the bottom anode) identified as anode number one (1). Do not damage the anode lead wires during handling or lowering into the hole. Under no circumstances, clamp or pinch the anode lead wires around another object while lowering the anodes into the hole. If the insulation for any anode lead wire is cut, broken or nicked during this operation or at any other time, reject the complete anode assembly remove from the job site immediately. Replace all damaged anodes at no additional expense to the City of Houston.

I. Anode Column Coke Backfill: Slurry the coke backfill above-grade and then pump into the hole after the anodes are installed. Pump the coke from the bottom of the hole up using a pipe that is the length of the anode hole. Do not use the vent pipe to pump the coke into the hole. Raise the pipe as the anode column is filled with coke. Remove the pipe from the hole after the coke installation operation is completed. Use a sufficient amount of backfill such that the coke breeze column extends a minimum of five feet above the top of the uppermost anode. Use extreme care during installation of the coke backfill so that no voids remain around the anodes.

J. Vent Pipe: Terminate the 1-inch diameter internal vent pipe with a gooseneck fitting. Leave the top end of the vent pipe open to allow gases from the anode hole to exit.

K. Precautions: Take all necessary precautions to avoid entrance of foreign matter into the hole, movement of any soil strata, or collapsing of the drilled hole during the progress of the work. Should movement of soil strata or collapse of the drilled hole interfere with proper completion of the anode groundbed, recover the wires, anodes and vent pipe and ream or redrill the hole at no cost to the City.

L. Mud and Cuttings: Dispose of drilling mud, cuttings and other waste in accordance with the methods and procedures of the best recognized practices and comply with the rules and regulations of the State, City and County.

M. Completion: Seal anode hole with bentonite environmental earth seal. Terminate vent pipe and anode lead wires at rectifier.

3.02 INSTALLATION OF CATHODIC PROTECTION RECTIFIERS

A. Codes: Comply with the latest edition of the National Electrical Code (NEC) and with all City of Houston, and local codes and standards.

B. Mounting: Pole mount cathodic protection rectifiers. The pole may be omitted and the rectifier mounted on a building wall or other available permanent structure, if approved by the City of Houston or its designated representative. Install rectifiers at a minimum height of 4 feet above final grade.

C. Identification: Equip rectifiers with permanent engraved nameplates to identify the units as “Cathodic Protection Rectifier, Property of City of Houston, In Case of Emergency Call 311.”

D. Conduit: Place all wiring to the rectifier in rigid galvanized steel conduit when run above grade.

1. Use insulating bushings at each end of all conduit runs.

2. Extend steel, rigid conduit 12 inches below grade.

E. Electrical Service: Provide AC electrical service for each rectifier unit. Furnish and install the necessary wiring, conduits, wires, meter sockets, splice boxes and equipment to the service connection as required by the local power company.

F. Completion: The installation is not considered complete until the AC and DC wiring is installed and the rectifier is capable of operating at full rated load. Install AC power such that the rectifier can be activated for test purposes. Leave the power off after test.

3.03 INSTALLATION OF WIRE AND CABLE

A. Depth: Install all underground wires and cables at a minimum of 36 inches below final grade with a minimum separation of 12 inches from other underground structures.

B. Above Grade Conduit: Enclose all positive and negative cables in rigid galvanized steel conduit when above-grade.

1. Use insulating bushings at the ends of all conduit runs.

2. Extend conduit 12 inches below grade.

C. Below Grade Conduit: Enclose all cable and wires in grey electrical PVC conduit when below grade.

3.04 INSTALLATION OF JUNCTION TERMINAL BOXES

A. Location: Install junction terminal boxes immediately adjacent to the rectifier to allow ready access for testing. Install at a minimum height of 3 feet above grade.

B. Concrete Pad: Set junction terminal boxes in a Portland cement concrete pad. The concrete pad to be a minimum of 12 inches in diameter and no less than 24 inches deep. Extend the concrete surface approximately 3 inches above grade.

C. Conduit: Enclose all cathodic protection wiring between the junction box and the rectifier in rigid, galvanized steel conduit. Use insulating bushings at the ends of all conduit to prevent damage to wire insulation.

3.05 NEGATIVE CABLE ATTACHMENT

A. Attach negative cables to the tank by thermite welding.

B. Clean and dry the tank surface to which the wires are to be attached.

C. Use a grinding wheel to remove all coating, mill scale, oxide, grease and dirt from an area approximately 3 inches square. Clean the surface to bright metal.

D. Remove approximately 1 inch of insulation from each end of the wires to be thermite welded to the chime of the tank exposing clean, oxide-free copper for welding.

E. Using the proper size thermite weld mold as recommended by the manufacturer, place the wire between the graphite mold and the prepared metal surface. Use a copper sleeve crimped over the wire for all wires No. 12 AWG.

F. Place the metal disk in the bottom of the mold.

G. Place the thermite weld charge in the mold. Squeeze the bottom of the weld charge container to spread ignition powder over the charge.

H. Close the mold cover and ignite the starting powder with a flint gun. Hold the mold firmly in place until all of the charge has burned and the weld has cooled slightly.

I. After the exothermic reaction, remove the thermite weld mold and gently strike the weld with a hammer to remove the weld slag. Pull on the wire to assure a secure connection. If the weld is not secure or the wire breaks, repeat the procedure.

J. If the weld is secure, coat all bare metal and weld metal with Stopaq CZ Tape.

3.06 INSTALLATION TESTING OF THE CATHODIC PROTECTION SYSTEMS

A. General: After the system has been installed, inspect, energize, and adjust as necessary to achieve compliance with accepted corrosion control standard set forth by AMPP, the cathodic protection system as soon as possible.

B. Energization: Perform the initial energizing of the cathodic protection system by a Corrosion Engineer.

C. Notice: Prior to native state, polarized potential testing, and commissioning of the system, give a minimum of 48 hours notice to the City of Houston, Engineering Project Manager to facilitate observation of the tests by a City Representative.

D. Method: The Corrosion Engineer shall:

1. Observe native state and polarized (Instant Off) tank-to-soil potentials to ensure that cathodic protection is being provided to the tank bottom in accordance with accepted AMPP criteria.

2. Record tank-to-soil potential measurements on the permanent reference electrode and around the perimeter of the tank.

3. Determine if interference exists on nearby structures and, if so, take steps to find a satisfactory solution to the problem.

E. Verification and Responsibilities

1. Correct, at contractor’s expense, any deficiencies in materials or installation procedures discovered during the post-installation inspection.

2. Provide written documentation of any deficiencies discovered during the post installation inspection.

F. Equipment: All cathodic protection testing instruments to be in proper working order and calibrated according to factory specifications.

G. Report: Submit a written report in accordance with Section 1.05, Submittals. Include all test data, resistance and geologic logs, rectifiers and cathodic protection system O & M Manuals and the As-Built drawings.

END OF SECTION

SECTION 16642

CATHODIC PROTECTION FOR PLANT PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for cathodic protection systems on steel, ductile iron and concrete cylinder pipe in water pipeline projects for using rectifiers and deep anode groundbeds.

B. Requirements for sacrificial anode cathodic protection on steel, ductile iron, concrete cylinder and metallic fittings in plastic pipe systems using zinc and/or magnesium anodes.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

C. Section 15640 – Joint Bonding and Electrical Isolation.

D. Section 15641 – Corrosion Control Test Stations.

1.03 UNIT PRICES

A. This item will be measured and paid for as a lump sum item for the job.

B. Payment will be full compensation for all labor, equipment, materials and supervision for the installation of the cathodic protection system, complete in place including rectifier systems with deep anode groundbed and junction boxes, sacrificial anodes, power feed hookups, and all excavation, backfill, field welding, connections, adjustments, testing, cleanup, and other related work necessary for construction as shown on the drawings and specified herein.

C. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ASTM C 94 - Standard Specification for Ready-Mixed Concrete

B. ASTM A 518 - Standard Specification for Corrosion-Resistant High-Silicon Iron Castings

C. ASTM B 418 - Standard Specification for Cast and Wrought Galvanic Zinc Anodes.

D. ASTM D 1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

E. ASTM D 4239 – Standard Test Methods for Sulfur in the Analysis Sample of Coal and Coke using High Temperature Tube Furnace Combustion Methods.

F. ASTM D 5192 – Standard Practice for Collection of Coal Samples from Core.

G. AWWA M9 Manual - Concrete Pressure Pipe

H. CSA – Canadian Standards Association, Standard C22.2, No. 66 and No. 107

I. City of Houston Electrical Code

J. NACE International SP0169 - Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems.

K. NACE International SP0572 - Recommended Practice for Design, Installation, Operation and Maintenance of Impressed Current Deep Groundbeds.

L. NEC 70 – National Electrical Code

M. NEMA TC6 - PVC and ABS Plastic Utilities Duct for Underground Installation.

N. NEMA TC9 - Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation.

O. NEMA 4 – Type 3R Enclosures

P. UL 83 - Thermoplastic-Insulated Wires

Q. UL 467 - Bonding and Grounding Equipment

R. UL 486A - Wire Connectors and Soldering Lugs for Use with Copper Conductors

S. UL 506 – Specialty Transformers

1.05 SUBMITTALS

A. General: Submittals to conform to the requirements of Section 01330 – Submittal Procedures.

B. Design Drawings and Computations: Prepare by or under the direct supervision of a Professional Engineer, registered in the State of Texas with a minimum of ten years experience in cathodic protection design, all computations and drawings.

C. Catalog Cuts: Submit manufacturer's catalog cuts for each item. Include the manufacturer's name on the catalog cuts. Provide sufficient information to show that the materials meet the requirements of the drawings and specifications. Where more than one item or catalog number appears on a catalog cut, clearly identify the item proposed.

D. Logs: Give the City of Houston representative a minimum of 48 hours notice prior to drilling the anode bore. Type and submit to the City of Houston representative, copies of detailed geological and resistance logs of each deep anode bore.

E. Rectifier Operation and Maintenance Manual: The rectifier manufacturer to include a complete operation and maintenance manual with each rectifier shipped to the job site. In addition to operating instructions, include a circuit diagram and spare parts list in the manual. Operate the rectifier under full load conditions at the factory and thoroughly inspect and test by the manufacturer prior to delivery to the job site. Report results of this testing on a manufacturer's quality control form and include in the operation manual. The rectifier manufacturer to reference each operating manual by rectifier model number and individual serial number.

F. Report: Submit six (6) operating, monitoring and maintenance reports for the cathodic protection systems. Include all test data as required by Section 3.08, paragraph H. Include operating instructions, maintenance data, product data and test procedures in the manuals.

G. Drawings: Maintain as-built drawings of the cathodic protection installation during installation and construction. Revise drawings to show exact locations of all rectifiers, anodes, wiring, connections and terminal boxes. Properly identify all items of equipment and material. Submit the original as-built drawings to the City of Houston representative.

1.06 QUALITY CONTROL

A. Certification: Provide manufacturer's certification that all components of the cathodic protection system meet the requirements of the drawings and specifications. Reference the applicable section of the specifications and the applicable standard detail on the certification.

B. Drawings: The drawings for the cathodic protection system are diagrammatic and not scaled for exact locations unless scales are explicitly stated on the specific drawing. Determine exact locations by field conditions and non-interference with other utilities or mechanical and structural features. Note other existing utilities in the area and do not damage these utilities during excavation. Repair any damaged utilities to the satisfaction of the City of Houston at the Contractor's expense.

C. Inspection: All materials, fabrication and installations are subject to inspection and testing by the City of Houston or its designated representative.

PART 2 PRODUCTS

2.01 SACRIFICIAL ANODES - MAGNESIUM

A. Magnesium Anodes: Use high potential magnesium anodes. Follow the metallurgical composition of the magnesium anodes as listed below:

Element	Percent Composition
Aluminum	0.01 Maximum
Manganese	0.50 to 1.3
Copper	0.02 Maximum
Nickel	0.001 Maximum
Iron	0.03 Maximum
Other - (each)	0.05 Maximum
Other - (total)	0.30 Maximum
Magnesium	Balance

B. Magnesium Anode Current Capacity: Magnesium anodes require a current capacity of no less than 500 amp-hours per pound of magnesium.

C. Anode Backfill Material: Use chemical backfill material around all galvanic anodes. Backfill provides a reduced contact resistance to earth, provides a uniform environment surrounding the anode, retains moisture around the anode, and prevents passivation of the anode.

1. All galvanic anodes come prepacked in a backfill material conforming to the following composition:

   a. Ground hydrated gypsum: 75 percent

   b. Powdered bentonite: 20 percent

   c. Anhydrous sodium sulfate: 5 percent.

2. Have a grain size backfill such that 100 percent is capable of passing through a 20 mesh screen and 50 percent is retained by a 100 mesh screen.

3. Completely surround the anode with the backfill mixture within a cotton bag.

4. For standard cast magnesium ingots, the required weight of backfill follows:

Anode Weight (Pounds)	Backfill Weight (Pounds)	Total Weight (Pounds)
9	15	24
17	25	42
20	50	70
32	38	70
48	48	96
60	70	130

D. Anode Lead Wires:

1. Use a 20-foot length of No. 12 AWG solid copper wire equipped with TW or THW insulation for standard lead wires for a galvanic anode.

2. Color code all anode lead wires green when terminated in test stations.

E. Lead Wire Connection to Magnesium Anode:

1. Cast magnesium anodes with a galvanized steel core with the weight of the core not to exceed 0.10 pounds per linear foot.

2. Recess one end of the anode to expose the core for the lead wire connection.

3. Silver-solder the lead wire to the core and fully insulate the connection by filling the recess with an electrical potting compound.

2.02 SACRIFICIAL ANODES - ZINC

A. Zinc Anodes: Use high purity zinc anodes. The metallurgical composition of the zinc anodes conform to ASTM B 418, Type II and the following:

Element	Percent Composition
Aluminum	0.005 Maximum
Cadmium	0.003 Maximum
Iron	0.0014 Maximum
Lead	0.003 Maximum
Zinc	Balance

B. Zinc Anode Current Capacity: Zinc anodes require a current capacity of no less than 335 amp-hours per pound of zinc.

C. Anode Backfill Material: Use chemical backfill material around all galvanic anodes. Backfill provides a reduced contact resistance to earth, provides a uniform environment surrounding the anode, retains moisture around the anode, and prevents passivation of the anode.

1. All galvanic anodes come prepackaged in a backfill material conforming to the following composition:

a. Ground hydrated gypsum: 75 percent

b. Powdered bentonite: 20 percent

c. Anhydrous sodium sulfate: 5 percent.

2. Have a grain size backfill such that 100 percent is capable of passing through a 20 mesh screen and 50 percent is retained by a 100 mesh screen.

3. Completely surround the anode with the backfill mixture within a cotton bag.

4. For standard cast zinc ingots, the required weight of backfill follows:

Anode Weight (Pounds)	Backfill Weight (Pounds)	Total Weight (Pounds)
30	40	70
45	55	100
60	70	130

D. Anode Lead Wires: For the lead wire for the zinc anodes, use a 20-foot length of No. 12 AWG solid copper wire equipped with TW of THW insulation.

E. Lead Wire Connection to Zinc Anode:

1. Cast zinc anodes with a 1/4-inch diameter galvanized steel core.

2. Extend one end of the core beyond the anode for the lead wire connection.

3. Silver-solder the lead wire to the core and fully insulate the connection.

2.03 IMPRESSED CURRENT ANODES

A. Description: Use high silicon-chromium-iron anode centrifugally cast in tubular form in accordance with the following specifications.

1. Anode Alloy: The anode consists of Durichlor 51, high silicon, chromium iron. This alloy to be made in accordance with ASTM A 518, Grade 3 with nominal percentages as follows:

Chemical Composition

Element	Composition, Weight %
Carbon	0.70 - 1.10
Manganese	1.50, max
Silicon	14.20 - 14.75
Chromium	3.25 - 5.00
Molybdenum	0.20, max
Copper	0.50, max

2. Mechanical and Physical Properties: The mechanical and physical properties of the anode are as follows:

Tensile Strength (1/2" dia. bar) psi.	15,000
Compressive Strength, psi	100,000
Hardness, Brinell	520
Density, gr/ml	7.0
Melting Point, °F	2300
Specific Resistance, micro-ohms-cm (20°C)	72
Coefficient of expansion, 32° to 212° F	7.33 X 106

3. Size: Conform to the following sizes for anode castings:

Type	Weight (pounds)	OD (inches)	Length (feet)
TA-2	46	2.19	7
TA-3	63	2.66	7
TA-4	85	3.75	7
TA-5	110	4.75	7

TA-2 anodes are required unless otherwise noted on the drawings.

B. Anode Lead Wire Connection:

1. Use a No. 8 AWG seven strand, copper conductor equipped with a fluorinated polymer insulation for the lead wire for an impressed current anode. Require the length of the lead wire sufficient to reach the anode terminal box without splicing additional wire.

2. Attach the anode lead wire at the center of the anode. Have a minimum pull-out strength of one and one-half times the breaking strength of the No. 8 AWG lead wire or 788 pounds for the center connection.

3. Do not exceed 0.004 ohms for the electrical contact resistance as measured across the lead wire-to-connector junction.

C. Impressed Current Anode Backfill: Use SC3 calcined fluid petroleum coke as manufactured by Loresco, Inc. to backfill impressed current anodes. Anode backfill properties to be as follows:

1. Typical Chemical Analysis:

Component	Percent Composition
Carbon (fixed)	99.35 minimum
Ash	0.6 maximum
Volatiles	0 (950° C)
Moisture	0.05

2. Physical Properties: Bulk density of 64 pounds/cubic foot.

3. Particle Analysis: Dust free with a maximum particle size of 1 mm.

2.04 VENT

A. Use plastic vent pipe from the bottom anode to the surface for dissipating gases to the atmosphere.

B. Require 1-inch diameter AllVent slotted pipe or plastic vent pipe with 1/8-inch holes drilled on 6-inch centers in the area of the anodes. Do not use slotted vent pipe or drill holes in the vent pipe above the anodes.

C. Extend the plastic vent pipe above grade, screen the vent outlet, and install in an inverted manner.

2.05 RECTIFIERS

A. Cathodic protection rectifiers to be air-cooled, tap adjust Super Custom model as manufactured by Universal Rectifiers, Corrpower or approved equal, conforming to NEMA MR-20-1958 and listed in CSA File No. 45382.

B. DC Output Ratings: Rate rectifiers as shown on the drawings. Supply units that are capable of operating at continuous, full rated output at an ambient temperature of 45° C, in full sunlight with an expected life in excess of 10 years.

C. AC Input Ratings: Full rated DC output shall be obtainable with an AC input voltage at 5% below the nominal value. Continuous AC input voltage at 10% above the nominal value shall not damage the transformer, the diode bridge assembly, or exceed any component rates. (Note: This shall apply provided that the rectifier has not been previously adjusted to exceed the maximum DC voltage or amperage rating of the unit.)

D. Cooling: Cool by natural air convection. Vent cabinets for natural air convection and screen against insects.

E. Voltage Adjustments: Provide adjustment of the output voltage by means of not less than 25 approximately equal steps of secondary taps from 5 percent of rated voltage to full-rated voltage.

F. Rectifying Elements: Rectifying elements to be silicon diodes sized as follows:

1. The Peak Inverse Voltage (PIV) of the diode shall be 300% of the maximum impressed voltage on the diode or 400 volts, whichever is greater.

2. Configure diodes into a full-wave bridge assembly. Size diodes to carry a minimum average current of one half of rated rectifier output.

3. Size heat sinks to keep diode junction temperatures less than 100° C at rated output and maximum ambient temperature.

4. Protect diodes against overload by means of semiconductor fuses, located in the transformer secondary leg to the diode bridge assembly.

5. Equip diodes with supplemental Metal Oxide Varistor (M.O.V.) surge arrestors at the diode bridge assembly sized to provide protection against secondary over- voltage surges.

G. AC Circuit Breakers: Provide input overload and short circuit protection by magnetic trip circuit breakers. Size the circuit breaker to hold 100 percent of rated load. It may trip between 101 percent and 125 percent of rated load, and must trip at 125 percent and above.

H. Surge Protection: Provide separate AC and DC surge protection by means of high energy Metal Oxide Varistors rated at 500 joules on the DC output and 750 joules on the AC input.

I. Electrical Panels: Construct electrical panels from a minimum thickness of 1/4" NEMA "XX" laminated phenolic, rated for Class "B" operation (105° C maximum). Equip rectifiers rated at 100 amperes DC or higher with panels constructed from a minimum sheet thickness of 1/4" "UTR" fiberglass reinforced laminate rated for Class "F" operation (155° C). Permanently silk-screen rectifier front panel identifications onto the panel.

J. Connection Hardware: Use only copper or high conductivity brass electrical hardware, suitably sized, and finished in electroless nickel plating for superior corrosion resistance. Tightly secure all connections with lock washers and nuts torqued to manufacturer's recommended specifications.

K. Enclosures:

1. Construct enclosures from a minimum 12 gauge wiped coat mill galvanized steel, finished in 3 - 5 mils polyester fusion bonded powder coating.

2. Use stainless steel hinges and cabinet assembly bolts.

3. Equip enclosures with a pad-lockable draw latch manufactured from 12-gauge steel, finished in zinc-dichromate plating. A draw latch required to accommodate a 3/8 inch shackle padlock.

4. Equip enclosures (or rectifier frame) with a grounding lug sized to accommodate up to a No. 6 AWG conductor.

5. Provide separate conduit knockouts for AC and DC; conveniently located and adequately sized for input and output conduit connectors.

6. Furnish cabinet with suitable channel brackets for wall or pole mounting.

7. Equip rectifier with slide-out chassis and hinged door for access to the front and a minimum of one side of the cabinet.

8. Place stickers on sides that read “Danger, High Voltage, Keep Out.”

L. Rectifier Instrumentation.

1. Equip rectifier with separate analog ammeter and voltmeter.

2. Meters to be a minimum of 3-1/2" size, with a minimum scale length of 2-7/8".

3. Meters to be 0 - 50 millivolts full scale deflection, taut-band movement with four- to-one swamping (i.e. internal meter resistance comprised of 25% winding resistance and 75% fully temperature compensated dropping resistor for wide temperature range performance).

4. Provide meters with accuracy + 2% full scale deflection at 25° C., temperature compensated to 0.085% per degree C.

5. Scale rectifier meters to have rated output no less than 70%, or greater than 85% of full scale deflection.

6. Meter shunts to be panel-mounted Holloway type "SW" style, with an accuracy of +0.25%.

M. Transformers: Construct transformers to meet UL 506, Specialty Transformers and the following:

1. Transformer designed as full isolation with separate isolated primary and secondary windings and a minimum efficiency of 95%.

2. Equip transformer secondary with a minimum of 25 steps of secondary voltage adjustment (5-COARSE, 5-FINE). Provide tap adjustment by means of tap bars.

3. Rate transformer materials and construction for Class "H" operation (180° C). Further enhance insulation materials by dipping in thermosetting varnish and baking.

4. Rate transformer for a minimum dielectric strength of 2250 volts applied for one minute between the windings and the core.

N. Potential Monitoring Connections: Provide two machine screw, washers and hex nut connections on the front of the rectifier instrument panel. One to be labeled “Reference” and one to be labeled “Structure”.

O. Miscellaneous:

1. Supply rectifiers capable of operating on either 115 or 230 volt, single phase, 60 hertz AC input.

2. All cathodic protection rectifiers to be 100% quality control tested as outlined in this specification.

3. During manufacture, subject the rectifier to frequent visual and performance testing to assure a high degree of quality.

4. Subject rectifiers to 100% testing of the following rectifier electrical parameters:

   a. AC input voltage, current, apparent power and true power.

   b. DC output current, voltage and power.

   c. AC power factor.

   d. AC to DC conversion efficiency.

   e. Output ripple.

   f. Correct operation of optional features such as interrupters, filters, etc.

5. Give each rectifier a final overall visual inspection prior to packaging.

2.06 ANODE JUNCTION BOX

A. Enclosure: Mount the anode junction box enclosure near the rectifier as shown on the Drawings. Provide positive terminal, 0.01 ohm type RS Holloway shunts, and a minimum 3/16” thick, NEMA Grade “XX” phenolic panel. For size and terminal configurations, see Drawings.

B. Positive Cable: Use cable size #6 AWG, single conductor, seven strand, copper with THHN insulation for the positive cable from the junction box to the transformer-rectifier.

2.07 NEGATIVE CABLES

A. Cables: Use cable size #4 AWG, single conductor, seven-strand, copper with medium density, HMW/PE insulation for the rectifier negative cables. The polyethylene to conform to ASTM D 1248, Type I, Class C, Grade 5.

B. Test Lead: The test lead to be No. 12 AWG, solid copper wire with white, TW or THW insulation and of sufficient length to extend from the protected structure to the rectifier without splicing.

2.08 PERMANENT REFERENCE ELECTRODES

A. Type: Provide a copper/copper sulfate, double membrane, ceramic cell in a geomembrane package, such as a Permacell Plus or approved equal.

B. Wire: Equip with No. 14 AWG stranded copper wire with blue HMW/PE insulation of suitable length to extend from the pipeline to the rectifier without splicing.

2.09 THERMITE WELD EQUIPMENT

A. Charges and Molds: Use weld charges and molds sized as specified by the manufacturer for the specific wire size and surface configuration. Weld charges and molds to be Cadweld by Erico or Thermoweld by Continental Industries.

B. Limitation: For high strength steel pipelines, use only 15 gram Cadweld charges.

C. Weld Coating: Use Stopaq CZ tape to cover the welds.

2.10 AC POWER SERVICE

A. Products: All AC power components must meet local power company requirements.

B. Meter Base: Meter base to be 120/240-volt, single phase, 20-ampere.

C. Disconnect Switch: Provide fused disconnect switch in NEMA 1 enclosure. Mount on rectifier stub pole.

D. Ground Rod: Ground rod must conform to the requirements of the utility company having jurisdiction.

E. Ground Wire and Clamp: Ground wire to be bare, No. 6 AWG solid copper wire. Use a bronze, bolt-on ground rod clamp.

PART 3 EXECUTION

3.01 INSTALLATION OF SACRIFICIAL ANODES

A. Location: Install sacrificial anodes at locations where the anodes will operate at maximum effectiveness.

B. Placement: Install anodes in native soil, in a vertically augured hole as shown on the drawings. If a vertical installation of the anodes is not feasible, the anodes may be installed horizontally.

C. Backfilling: After the hole is augured, lower the packaged anode into the hole and firmly tamp the soil around the package so that it is in intimate contact with the package.

D. Lead Wire: Run lead wires from the anodes underground at a minimum depth of 36 inches. Connect the wires through a test station as indicated on the drawings.

E. Handling: Handle galvanic anodes carefully to avoid damaging anode materials and wire connections.

3.02 INSTALLATION OF DEEP ANODE GROUNDBEDS

A. Permits: A qualified well driller who is recognized as a fully experienced specialist in the installation of deep anode cathodic protection systems is required to perform the drilling and installation of the deep anode systems. The deep anode system installer is required to have a minimum of 5 years experience installing deep anode systems with a minimum of 10 successful deep anode groundbed installations. The Contractor is required to obtain and submit all applications for well drilling permits required by any City, County or State agency.

B. Field Location: Contractor is responsible for verifying actual field conditions, location of underground structures, and assuring adequate physical separation from other structures and utilities. Location of the anode groundbeds is approximate. Determine and verify the exact placement in the field with a representative of the City of Houston.

C. Anode Hole Drilling: The anode hole to be 8 inches diameter by 200 feet deep unless otherwise shown on the Drawings. Perform drilling with rotary bit equipment designed specifically for this purpose. Use standard techniques (i.e. trough and vacuum truck) to capture and contain the drilling fluids, mud and cuttings at the top of the hole. Select the type and consistency of drilling fluids to be consistent with soil characteristics. Level the drilling rig to provide a round, straight and plumb anode hole.

D. Temporary Well Casing: Drilling of the holes may require the installation of temporary well casings. Remove all temporary casings by the end of the job.

E. Anode Hole Geological Logs: As the hole is drilled, maintain a record describing the depth and type of the geological formations encountered. Submit typed copies of the log as required by Section 1.05.D.

F. Anode Hole Resistance Log: Record an electric log of the hole using one of the anodes. Previously mark the anode lead wire in five-foot increments. Mark the anode lead wire for a distance equaling or exceeding the maximum anticipated depth of the hole. As the anode is lowered into the hole, perform a resistance log by impressing a minimum 12 volt DC current between the anode and a very well grounded structure such as the local AC power neutral network. Do not use Nilsson type soil resistance meters to perform this test. A recommended 12-volt DC power source is a heavy duty lead acid automobile battery. Lower the anode into the hole at ten foot increments, hold in place, and measure the voltage and current output of the DC current source. Record the data, type and submit as required under Section 1.05.D.

G. Vent Pipe Installation: Install the vent pipe in the hole with the first anode. Cap the bottom of the vent pipe. Cap the top of the vent pipe throughout the anode and coke breeze backfill installation procedure to prevent intrusion of foreign material. Do not allow drilling mud to enter in the vent pipe.

H. Anode Installation: The anode groundbed must contain ten (10) tubular cast iron anodes spaced at 10 foot intervals on centers unless otherwise shown on the drawings. Center the anodes in the hole using anode centralizers. Install the anodes by lowering them individually into the hole. Mark the lead wires for the nominal anode depth. Record the final depth with the first anode in the hole (i.e. the bottom anode) identified as anode number one (1). Do not damage the anode lead during handling or lowering into the hole. Under no circumstances, clamp or pinch the anode lead wires around another object while lowering the anodes into the hole. If the insulation for any anode lead wires are cut, broken, or nicked during this operation or at any other time, reject the complete anode and remove from the job site immediately. Replace all damaged anodes at no additional expense to the City of Houston.

I. Anode Column Coke Backfill: Slurry the coke backfill above-grade and then pump into the hole after the anodes are installed. Pump the coke from the bottom of the hole up using a pipe that is the length of the anode hole. Do not use the vent pipe to pump the coke. Raise the pipe as the anode column is filled with coke. Remove the pipe from the hole after the coke installation operation is completed. Use a sufficient amount of backfill such that the coke breeze column extends a minimum of five feet above the top of the uppermost anode. Install the coke backfill uniformly with no voids around the anodes.

J. Vent Pipe: Terminate the 1-inch diameter internal vent pipe with a gooseneck fitting. Leave the top end of the vent pipe open to allow gases from the anode hole to exit.

K. Precautions: Take all necessary precautions to avoid entrance of foreign matter into the hole, movement of soil strata, or collapsing of the hole during the progress of the work. Should movement of soil strata or collapse of the drilled hole interfere with proper completion of the anode groundbed, recover the wires, anodes and vent pipe and ream or redrill the hole at no cost to the City of Houston.

L. Mud and Cuttings: Dispose of drilling mud, cuttings and other waste in accordance with the methods and procedures of the best recognized practices and comply with the rules and regulations of the State, City and County.

M. Completion: Seal anode hole with bentonite environmental earth seal. Terminate vent pipe and anode lead wires at rectifier.

3.03 INSTALLATION OF CATHODIC PROTECTION RECTIFIERS

A. Codes: Comply with the latest edition of the National Electrical Code (NEC) and with all City of Houston, and local power company codes and standards.

B. Mounting: Pole mount cathodic protection rectifiers. The pole may be omitted and the rectifier mounted on a building wall or other available permanent structure, if approved by the City of Houston or its designated representative. Install rectifiers at a minimum height of 4 feet above final grade.

C. Identification: Equip rectifiers with permanent engraved nameplates to identify the units as “Cathodic Protection Cabinet, Property of City of Houston, In case of Emergency Call 311”.

D. Conduit: Place all wiring to the rectifier in rigid galvanized steel conduit when run above grade.

1. Use insulating bushings at the ends of all conduits.

2. Extend steel conduit 12 inches below grade.

E. Electrical Service: Provide AC electrical service for each rectifier unit. Furnish and install the necessary wiring, conduits, wires, meter sockets, splice boxes and equipment to the service connection as required by the local power company.

F. Completion: The installation is not considered complete until the AC and DC wiring is installed and the rectifier is capable of operating at full rated load. Install AC power such that the rectifier can be activated for test purposes.

3.04 INSTALLATION OF WIRE AND CABLE

A. Depth: Install all underground wires and cables at a minimum of 36 inches below final grade with a minimum separation of 6 inches from other underground structures.

B. Above Grade Conduit: Enclose all positive and negative cables, and anode lead wires in rigid galvanized steel conduit when above-grade.

1. Use insulating bushings at the ends of all conduits.

2. Extend conduit 12 inches below grade.

C. Below Grade Conduit: Enclose all cable and wires in grey electrical PVC conduit when below grade.

3.05 INSTALLATION OF ANODE JUNCTION BOX

A. Location: Install junction terminal boxes immediately adjacent to the rectifier to allow ready access for testing. Install at a minimum height of 3 feet above grade.

B. Concrete Pad: Set junction terminal boxes in a Portland cement concrete pad. The concrete pad to be a minimum of 12 inches in diameter and no less than 24 inches deep. Extend the concrete surface approximately 3 inches above grade.

C. Conduit: Enclose all cathodic protection wiring between the junction box and the rectifier in rigid, galvanized steel conduit. Use insulating bushings at the ends of all conduit to prevent damage to wire insulation.

3.06 NEGATIVE CABLE AND TEST LEAD ATTACHMENT

A. Attach negative cables and test leads to the pipe (for the dielectrically coated steel and ductile iron pipe options) or to the "L" bracket (for the concrete cylinder pipe option) by thermite welding.

B. Clean and dry the pipe to which the negative cables and test lead are to be attached.

C. Use a grinding wheel to remove all coating, mill scale, oxide, grease and dirt from the pipe over an area approximately 3 inches square. Clean the surface to bright metal.

D. Remove approximately one inch of insulation from each end of the wires to be thermite welded to the pipe, exposing clean, oxide-free copper for welding.

E. Using the proper size thermite weld mold as recommended by the manufacturer, place the wire between the graphite mold and the prepared metal surface. Use a copper sleeve crimped over the wire for all wires No. 12 AWG size.

F. Place the metal disk in the bottom of the mold.

G. Remove the cap from the weld charge container. Pour the contents into the mold. Squeeze the bottom of the weld charge container and spread ignition powder over the charge.

H. Close the mold cover and ignite the starting powder with a flint gun. Hold the mold firmly in place until all of the charge has burned and the weld has cooled slightly.

I. Remove the thermite weld mold and gently strike the weld with a hammer to remove the weld slag. Pull on the wire to assure a secure connection. If the weld is not secure or the wire breaks, repeat the procedure.

J. If the weld is secure, coat all bare metal and weld metal with Stopaq CZ tape.

3.07 PERMANENT REFERENCE CELL

A. Location: When not shown on the Drawings, locate the permanent reference cell near the negative structure connection.

B. Placement: Remove the permanent reference cell from the shipping package and place below the springline and one foot away from the pipeline. Make certain that the reference electrode is completely surrounded by the special backfill material in the geomembrane package. Fully saturate the geomembrane package with water.

C. Backfill the reference electrode with six inches of select, native soil and compact by hand. Moisten the soil, if necessary, for good compaction.

D. Wiring: Run continuous lengths of the blue reference cell wiring, and the white test lead to the rectifier unit in the same trench as the negative cable. Do not nick or otherwise damage the wire insulation.

3.08 POST INSTALLATION TESTING OF THE CATHODIC PROTECTION SYSTEMS

A. General: Inspect, energize, and adjust the cathodic protection as soon as possible after the equipment has been installed.

B. Energization: Perform the energizing of the cathodic protection system by a Corrosion Engineer to achieve compliance with the referenced corrosion control standards set forth by AMPP and/or AWWA.

C. Notice: Prior to native state, polarized potential testing, and final testing of the system give a minimum of 48 hours notice to the City of Houston, Engineering to facilitate observation of the tests by a City of Houston representative.

D. Method: The Corrosion Engineer to:

1. Measure native state pipe-to-soil potentials at all test stations, permanent reference cells, electrical isolation devices, and locations of exposed pipe prior to energizing the cathodic protection system.

2. Measure casing-to-soil potentials and foreign line potentials, prior to energizing the cathodic protection system.

3. Energize the cathodic protection system and adjust the DC current output such that the pipe-to-soil potentials near the cathodic protection current source (either transformer-rectifier or sacrificial anodes) is approximately -1000 millivolts to a copper sulfate electrode (CSE). Record the DC voltage and current of the power supply.

4. Allow sufficient time for the pipeline to polarize.

5. Using a current interrupter, cycle the power supply “On” and “Off”.

6. Record “On” and “Instant Off” potentials at all water pipeline test stations, permanent reference cells, electrical isolation devices, locations of exposed pipe, casings and foreign pipelines.

7. For steel and ductile iron pipe, adjust the cathodic protection power supplies to satisfy the criteria of a minimum 100 millivolts of polarization or an “Instant Off” potential at least as negative as -850 millivolts CSE.

8. For concrete cylinder pipe, adjust the cathodic protection power supplies to achieve a minimum 100 millivolt of polarization without any “Instant Off” potentials more negative than -1000 millivolts CSE.

9. Record all final adjustments of the DC power supplies and individual anode outputs.

10. Verify that all electrical isolation devices are operating properly including flange isolators, and casing spacers.

11. Verify that interference does not exist with foreign pipelines. Perform joint tests and mitigate any interference detected.

E. After initial energization and after rectifiers have been adjusted as necessary for compliance with NACE RP-0169-2002, perform a walk-through inspection with City of Houston Project Manager to verify that all corrosion control components have been installed in accordance with project drawings and specifications.

F. Make a punch list of outstanding work identified during walk-through inspection. Once Contractor has completed all work on punchlist, pipeline will be allowed to polarize for 30 days before final testing. Perform final testing and adjustment after 30-day polarization period including “On” and “Instant Off” potentials. Repair deficiencies discovered during final testing at Contractor’s expense and at no additional cost to the City of Houston, Should additional testing be required after final testing, cost of additional testing to be paid by contractor.

G. Equipment: All cathodic protection testing instruments to be in proper working order and calibrated according to factory specifications.

H. Report: Submit a written report in accordance with Section 1.05, Submittals. Include all test data, resistance and geologic logs, the rectifier and cathodic protection system O&M Manuals and the As-Built Drawings.

END OF SECTION

SECTION 16644

CATHODIC PROTECTION FOR CLARIFIERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for sacrificial anode cathodic protection on internal metallic components of clarifier units using zinc anodes.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 UNIT PRICES

A. This item will be measured and paid for as a lump sum item for the job.

B. Payment will be full compensation for all labor, equipment, materials and supervision for the installation of the cathodic protection system, complete in place including zinc anodes, field welding, cleanup, and other related work necessary for construction as shown on the drawings and specified herein.

C. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ASTM B 418 – Specification for Cast and Wrought Galvanic Zinc Anodes

B. NACE International SP0192 - Recommended Practice, Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Water Storage Tanks

1.05 SUBMITTALS

A. General: Submittals to conform to the requirements of Section 01330 - Submittals Procedures

B. Catalog Cuts: Submit manufacturer's catalog cuts for each item. Include the manufacturer's name on the catalog cuts. Provide sufficient information to show that the materials meet the requirements of the drawings and specifications. Where more than one item or catalog number appears on a catalog cut, clearly identify the item proposed.

C. Certificate of Compliance: Provide a Certificate of Compliance from the anode foundry documenting the heat numbers and chemical analysis of the high purity zinc.

D. Clarifier Manufacturer Attestation: The clarifier manufacturer to review the cathodic protection anode placement and provide a written statement that the anodes will not interfere with the operation of the clarifier.

E. Drawings: Maintain as-built drawings of the cathodic protection installation during installation and construction. Revise drawings to show exact locations of all anodes. Submit the original as-built drawings to the City of Houston representative.

1.06 QUALITY CONTROL

A. Certification: Provide manufacturer's certification that all components of the cathodic protection system meet the requirements of the drawings and specifications. Reference the applicable section of the specifications and the applicable standard detail on the certification.

B. Drawings: The drawings for the cathodic protection system are diagrammatic and not scaled for exact locations. Determine exact locations by field conditions and non-interference with mechanical and structural features.

C. Inspection: All materials, fabrication and installations are subject to inspection and testing by the City of Houston or its designated representative.

PART 2 PRODUCTS

2.01 SACRIFICIAL ANODES - ZINC

A. Zinc Anode: Use zinc anodes, Model GA-BTZ-27, as manufactured by Galvotec Alloys, Inc. or approved equal.

B. Zinc Anode Metallurgy: Use high purity zinc anodes. The metallurgical composition of the zinc anodes conform to ASTM B 418, Type II and the following:

Element	Percent Composition
Aluminum	0.005 Maximum
Cadmium	0.003 Maximum
Iron	0.0014 Maximum
Lead	0.003 Maximum
Zinc	Balance

C. Zinc Anode Current Capacity: Zinc anodes require a current capacity of no less than 335 amp-hours per pound of zinc.

D. Specify diameter of rod.

PART 3 EXECUTION

3.01 INSTALLATION OF SACRIFICIAL ANODES

A. Location: Install sacrificial anodes at the approximate locations shown on the Drawings in accordance with the Anode Schedule which designates the number of anodes to be placed in each area.

B. Preparation: Remove the galvanizing from rod core of the anode at the point of connection to the clarifier. Clean the clarifier member to bright metal.

C. Weld: Weld a minimum of 1-1/2” on each end of the core to the clarifier components as shown on the drawings.

D. Coating Repair: After welding, repair the coating in the weld area.

E. Galvanized Mechanisms: Do not install anodes if clarifier components are galvanized.

3.02 PROJECT COMPLETION

A. Inspection: Contact the City of Houston or its designated representative to inspect the installation following attachment of all anodes.

B. Deficiencies: Correct any deficiencies in materials or installation discovered during the inspection.

C. Drawings: Submit as-built drawings to the City of Houston or its designated representative as required under Section 1.05, Submittals.

END OF SECTION

SECTION 16645

CATHODIC PROTECTION FOR WET WELLS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Requirements for sacrificial anode cathodic protection on internal metallic components of wet well units using zinc anodes.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 01330 – Submittal Procedures

1.03 UNIT PRICES

A. This item will be measured and paid for as a lump sum item for the job.

B. Payment will be full compensation for all labor, equipment, materials and supervision for the installation of the cathodic protection system, complete in place including zinc anodes, field welding, cleanup, and other related work necessary for construction as shown on the drawings and specified herein.

C. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ASTM B 418 - Standard Specification for Cast and Wrought Galvanic Zinc Anodes.

B. NACE International SP0196 - Recommended Practice, Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Water Storage Tanks.

C. NACE International SP0176 - Corrosion Control of steel fixed offshore platforms associated with petroleum production.

1.05 SUBMITTALS

A. General: Submittals will conform to the requirements of Section 01330 – Submittal Procedures.

B. Catalog Cuts: Manufacturer’s catalog cuts will be submitted for each item. The catalog cuts will include the manufacturer's name and will provide sufficient information to show that the materials meet the requirements of the drawings and specifications. Where more than one item or catalog number appears on a catalog cut, clearly identify the item proposed.

C. Certificate of Compliance: Provide a Certificate of Compliance from the anode foundry documenting the heat numbers and chemical analysis of the high purity zinc.

1.06 QUALITY CONTROL

A. Provide manufacturer's certification that all components of the cathodic protection system meet the requirements of the drawings and specifications. The certification will reference the applicable section of the specifications and the applicable standard detail.

B. All materials, fabrication and installations are subject to inspection and testing by the City of Houston or its designated representative.

C. The drawings for the cathodic protection system are diagrammatic and will not be scaled for exact locations. Field conditions, non-interference with mechanical and structural features shall determine exact locations.

PART 2 PRODUCTS

2.01 SACRIFICIAL ANODES – ZINC

A. Zinc Anodes: Zinc anodes will be Model HZ-30 as manufactured by Galvotec Alloys Inc.

B. Zinc Anode Metallurgy: High purity zinc anodes will be used. The metallurgical composition of the zinc anodes shall be conform to ASTM B-418, Type II and the following:

Element	Percent Composition
Aluminum	0.005 Maximum
Cadmium	0.003 Maximum
Iron	0.0014 Maximum
Lead	0.003 Maximum
Zinc	Balance

C. Zinc Anode Current Capacity: Zinc anodes will have a current capacity of no less than 335 amp-hours per pound of zinc.

D. Anode Lead Wires: The standard lead wire for a galvanic anode shall be a 20 foot length of No. 12 AWG solid copper wire equipped with TW or THW insulation.

E. Lead Wire Connection to Zinc Anode:

1. Zinc anodes will be cast with a galvanized steel core with the weight of the core not to exceed 0.10 pounds per linear foot.

2. One end of the anode will be recessed to expose the core for the lead wire connection.

3. The lead wire will be silver-soldered to the core and the connection fully insulated by filling the recess with an electrical potting compound.

2.02 THERMITE WELD EQUIPMENT

Materials required for thermite welding and coating of the welds are described in the following sections.

A. Charges and Molds: Weld charges and mold size will be specified by the manufacturer for the specific surface configuration. Care will be taken during installation to be sure correct charges are used. Welding charges and molds will be the product of a manufacturer regularly engaged in the production of such materials.

B. Weld Coating: Coat all bare metal and weld metal with Stopaq CZ tape or coat with epoxy coating, applied to piping.

C. Protections: Cover anodes to keep coating applied to piping from covering anodes.

PART 3 EXECUTION

3.01 INSTALLATION OF SACRIFICIAL ANODES

A. Location: Sacrificial anodes will be installed at the approximate locations where the anodes will operate at maximum effectiveness.

B. Placement: Each anode will be installed horizontally on the concrete floor of the wet well as shown on the drawings.

C. Handling: Galvanic anodes will be handled to avoid damaging anode materials and wire connections.

3.02 PROJECT COMPLETION

A. Inspection: Contact the City of Houston or its designated representative to inspect the installation following attachment of all anodes.

B. Deficiencies: Contractor will correct, at the Contractor’s expense, any deficiencies in materials or installation discovered during the inspection.

END OF SECTION

SECTION 16709

COMMUNICATIONS CONDUIT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Communications conduit with inner ducts.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. This item will be measured by the linear foot of "Communications Conduit" installed. Each linear foot shall include: conduit (HDPE and Rigid Steel), inner duct, tracer wire, pull tape, marking tape / posts and all incidentals. Conduit shall be measured horizontally along the surface from center of communications service box to center of communications service box or other terminating point. Risers shall be measured as the amount of conduit extending from the ground surface.

2. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Communications Conduit." The price shall be full compensation for furnishing and installing conduit; for trenching, boring, excavating, furnishing and placing backfill, replacing pavement structure, sod, riprap, curbs or other surfaces; for marking location of conduit (when required); for furnishing and installing all fittings, junction boxes, special radius sweeps, and expansion joints, conduit straps; and for all labor, tools, equipment and incidentals necessary to complete the work.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ASTM D 882 - Standard Test Method for Tensile Properties of Thin Plastic Sheeting

B. ASTM D 2103 - Standard Specification for Polyethylene Film and Sheeting

C. ASTM D 2261 - Standard Test Method for Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant-Rate-of-Extension Tensile Testing Machine)

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide new materials that comply with the details shown on the plans and the requirements of this specification.

B. High Density Polyethylene (HDPE) Conduit

1. Conduit for fiber optic cable shall be Schedule 80 HDPE conduit having a 4 inch internal diameter. The outer HDPE conduit provides a shell of high tensile and compression strength. The outer conduit is orange in color. Conduit shall terminate without bends if possible.

2. Bends shall be rigid steel conduit; having a minimum radius of 10 times the nominal diameter of the conduit (30 degree maximum bends - 90 degree bends are prohibited unless approved by City of Houston Engineers). The exterior of the steel bends shall be double wrapped with 10-mil PVC tape.

3. HDPE conduit shall be joined by solvent-weld method in accordance with the conduit manufacturer's recommendation. No reducer couplings shall be used unless specifically indicated on the drawings.

4. All riser conduit shall be Rigid Metal Conduit.

C. Inner duct

1. All HDPE Conduit shall be installed with four (4) one inch (1") polyethylene inner ducts. These inner ducts shall be smooth on both the inside and outside to facilitate pulling the inner duct into the conduit and pulling future fiber optic cable into the inner duct. Each inn duct has a designated purpose and shall be provided in each of the following colors:

a. blue (City traffic operations)

b. yellow (public safety)

c. red (City IT)

d. green(other)

2. A minimum of one foot of the inner duct shall extend beyond the end of the conduit inside of the communications service box. All inner duct shall have 1,250 lb. pull tape.

D. Marking Tape / Posts

1. Underground marking tape will be used in all areas where trenching is utilized to install underground conduit. Use marking tape in conjunction with marking posts and marking discs.

2. The technical specifications of underground marking tape are identified below, along with applicable testing methods necessary to establish that a cable submitted for approval meets these specifications.

TEST PROPERTY	THRESHOLD SPECIFICATION	REQUIREMENTS
Standard Weight	ASTM D2103	20 lbs/100 feet
Thickness – Overall	ASTM D2103	4 mil
3 in. Tensile Break – MD	ASTM D882	35 lbs/ft
3 in. Tensile Strength – MD	ASTM D882	4 kpsi
3 in. Tensile Break – TD	ASTM D882	38 lbs/ft
3 in. Tensile Strength – TD	ASTM D882	5 kpsi
Elongation – MD – MD	ASTM D882	530 %
Elongation – TD – TD	ASTM D882	660 %
Tear Strength	ASTM D2261	1.5 lbs/ft

3. Underground marking tape will be a 3-inch wide, tear resistant, corrosion resistant elastic PVC orange tape, imprinted with the legend “CITY OF HOUSTON BURIED CABLE – CALL TRAFFIC OPERATIONS at 311”. This legend will be printed every three (3) feet in black letters.

4. Underground cable marking posts are required and will be installed everywhere feasible and practical in all areas where fiber optic cable is installed in underground conduit. This is the preferred method of marking, since it is very visible. Marking posts should be placed every 500 feet in urban area, and every 1000 feet in suburban areas, as well as at every intersection corner and every change in direction. Exception would be locations like downtown where all surfaces are paved, where discs would be more practical.

5. Use marking discs set in concrete or pavement where the use of marking posts is not feasible and practical, i.e., areas such as downtown where everything is paved and for aesthetics.

6. Technical specifications of underground marking posts are identified below.

   a. Line Markers will be made from ultraviolet-stabilized High Density Polyethylene (HDPE)

   b. Minimum 3-1/2" O.D. tubular design

   c. Text will be hot-stamped into the fittings with an extra u-v clear coat.

   d. Crossing casing vents will be used to help maintain atmosphere conditions.

   e. Line markers will require no maintenance after installation

PART 3 EXECUTION

3.01 CONSTRUCTION METHODS

A. General

1. Place conduit in accordance with the lines, grades, and details shown on the plans or as directed. Conduit shall be buried a minimum of 30 inches deep underground unless otherwise shown on the plans. Fit conduit and inner duct terminations with bushings or bell ends.

2. Prior to installation of inner duct/cables, pull a spherical template of at least 75% of the inside diameter of the conduit/inner duct through the conduit/inner duct to ensure that it is free from obstruction. Cap or plug empty conduit places for future use.

3. Conduit shall have 30 degree sweeps into communications service boxes or cabinets. Conduit bends shall have a minimum radius of 18 inches.

4. When installing the multi-duct conduit, the outer shell and inner duct shall be continuous (without splices) up to 800 feet from communication service box to communication service box.

5. Where existing surfacing is removed for placing conduit, repair by backfilling with material equal in composition and density to the surrounding areas. Immediately repair any damaged infrastructure including sidewalks, driveways, riprap, etc. to equivalent conditions prior to construction.

6. Any obstructions to the trenching / boring operation such as utilities, structures, sprinkler systems, etc. are to be protected from damage by the contractor during construction and until the work is completed. In the event of damage, the contractor shall be responsible for the repair / replacement at the contractor's expense with materials and methods which leave the damaged items in as good or better condition than original. Immediately after installation of conduit, backfill pits, excavation or trenches.

B. Trenching

1. No trenching shall be allowed within 5 feet of a tree. Where the depth of conduit changes, the trench bottom shall have a slope of 3 / 1 (horizontal / vertical) to accommodate the depth change.

C. Boring / Jacking / Directional Drilling

1. Boring shall be the preferred method of excavation unless specified otherwise in the plans. When indicated on the plans, conduit crossing existing pavement shall be placed by jacking and boring methods. The boring and jacking method used shall be approved by the Engineer prior to commencing work.

2. Excavate suitable pits for conducting boring operations (clearly mark/protect excavation to avoid injury by public). Pits shall be kept 2 feet clear outside of the pavement edge. Install conduit so there is no interference with street operation or no structure is weakened or damaged.

3. Unless otherwise specified in the plans, the method and equipment used in jacking casing or pipe shall be optional with the contractor, provided that the proposed method is approved by the Engineer. Heavy duty jacks suitable for forcing pipe through the embankment shall be provided by the contractor. Uniform pressure shall be applied from all jacks. Pressure shall be transmitted evenly around the ring of the pipe through an approved jacking head.

4. Once boring / jacking operations have begun, the boring / jacking shall be continuous, without interruption, insofar as practicable, to prevent the pipe from becoming firmly set in the embankment.

5. Material excavated ahead of the pipe shall be removed through the pipe. Jetting will not be permitted except as approved by the Engineer. The diameter of the excavation shall conform as closely as practicable to the outside diameter and circumference of the pipe being jacked.

D. Tracer Wire

1. One (1) No. 6 AWG Green, unspliced THW/XHHW wire shall be installed in each conduit. The tracer wire shall be pulled inside of the fiber optic conduit in the voids outside of the inner ducts. All tracer wire shall be continuous – tied together inside communication service boxes with wire nuts. Lubricants used in pulling the tracer wire shall be water soluble. A minimum of 5-feet of wire shall be coiled, taped, labeled, and secured in the communications service box. The ends of all tracer wire, within a communications service box, shall be connected to a common lug to allow for locating multiple segments of conduit run with one setup of the detection equipment. For transition between underground and overhead cabling, coil the wire in the communications service box closest to the riser. Access fittings shall be used on risers without adjacent communication service boxes.

E. Pull Tape

1. Pull tape is required in all inner ducts. No pull ropes, twine, or pull strings will be used for the purpose of installation. Further, if the plans and specifications indicate pull tape for future use do not substitute pull ropes, twine or pull strings for pull tape.

2. Pull tape will be prefabricated woven polyester tape made from low friction, high abrasion resistant yarns providing a low coefficient of friction. Pull tapes will be prelubricated. Pull tapes will be printed with sequential footage markings for accurate measurement. Pull tapes will be ½ inch wide and have a minimum tensile strength of 1,250 pounds.

F. Sealing

1. After installation of cables and wires the conduits shall be sealed / plugged with a suitable compound so as to prevent the entrance of moisture or gases.

END OF SECTION

SECTION 16710

PULL BOXES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pull boxes of the various types and sizes required complete with lids.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Payment for this item will be measured as each ground box and or extension by type, complete in place. Concrete aprons, if required, will be measured as each pull box with concrete apron, complete, in place.

2. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Pull Boxes" of the various types and sizes specified. The price shall be full compensation for excavating and backfilling; for constructing, furnishing and installing the pull boxes and concrete rings when required; for concrete and reinforcing steel; and for all labor, tools, equipment and incidentals necessary to complete the work.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ASTM D 2444 – Standard Practice for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)

1.05 SUBMITTALS

A. Material Safety Data Sheets (MSDS) must be attached in a weather tight vessel on each order.

B. A certified copy of all test reports shall be signed and sealed by a registered State of Texas Professional Engineer and submitted prior to receipt of shipment.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide new materials that comply with the details shown on the plans and the requirements of this specification.

B. All pull boxes shall be constructed of polymer concrete consisting of sand and aggregate bound together with a polymer resin. Internal reinforcement may be provided by means of steel, fiberglass, or a combination of both. Chopped fiberglass, polyethylene, or polystyrene are not allowed for internal reinforcement.

C. The material used to shall have the following minimum allowable properties:

Compressive Strength:	10,000 psi
Flexural Strength:	7,000 psi
Tensile Strength:	1,500 psi

D. Pull boxes and extensions shall be furnished in the following nominal sizes (Width X Length X Depth):

Type	Purpose	Dimensions
A	Detector Loops & Hardwire Interconnect	13” x 18” x 24”
B	Standard traffic signal pull box, but also used for detector loops where multiple loops enter the pull box	17” x 30” x 24” 17” x 30” x 12” (Extension)
C	Standard pull box used for most communications applications, or where a larger pull box is needed due to multiple conduits	26” x 38” x 24” 26” x 38” x 12 (Extension)

E. Each enclosure shall be designed and constructed flush to grade with the cover fitting flush to the box.

F. All pull box covers shall be equipped with a minimum of two stainless steel lockdown mechanisms. Multiple piece covers shall be equipped with a means of interlocking with each other, or each section shall be secured with two stainless steel lockdown mechanisms. Tools to unlock the covers shall be furnished. A minimum of one (1) tool shall be furnished with each ten (10) pull boxes supplied. All covers shall have a logo recessed into the cover with the legend, “TRAFFIC SIGNAL” in two-inch minimum height letters, or other as specified by the City of Houston.

G. All covers shall have a recessed access point to allow removal of the cover with a special lifting tool. One lifting tool shall be furnished with each ten (10) pull boxes. The access point shall be located and designed to allow the maximum amount of leverage and safety possible.

H. Pull boxes shall be designed and suitable for installation and use through a temperature range of –40 degrees C to 60 degrees C.

I. All pull boxes and covers shall be rated for a static vertical design load of 15,000 pounds, minimum. All pull boxes must pass a minimum static vertical load test of at least 22,500 pounds. A physical description of the testing methods shall be included with the test reports. Load versus deflection curves shall be provided.

J. All pull boxes shall be capable of supporting a lateral load, design bearing pressure, of 600 pounds per square foot. Lateral load testing shall be applied to the longest dimension. The load shall be transmitted by a flat, rigid plate 24 inches wide by the depth dimension of the enclosure, bearing against any suitable medium which will conform to the shape and angle of the enclosure sidewall to achieve uniform loading.

K. Pull box Vertical Load Testing: The 15,000 pounds design load and 22,500 pounds testing load shall be distributed over a 5 inch by 10 inch area. All covers shall be tested, installed on a typical pull box. The loading pad shall be centered on the part of the cover that will produce the maximum deflection under load. A deflection-measuring device shall be used to measure deflection. Deflection under design load shall not exceed:

1. Cover ½ inch

2. Pull box ¼ inch per foot of pull box length.

L. Permanent deflection of the cover or pull box shall not interfere with the placement or removal of the cover.

M. All covers shall be skid resistant and should have a minimum coefficient of friction of 0.50 on the top surface of the cover.

N. Any point on the cover must be able to withstand a 70 foot-pound impact with a 12-pound weight having a “C” Tup (ASTM D-2444) without puncturing or splitting.

PART 3 EXECUTION

3.01 INSTALLATION

A. General

1. Installations shall be in commercial and residential sidewalks and behind curbs where no deliberate traffic is planned.

2. Each enclosure shall be suitable for installation in either direct or buried native soil, embedded in concrete or embedded in asphalt surfacing. A concrete collar shall be furnished for each installation in asphalt, or where called for on the plans.

3. All enclosures shall withstand shipping and installation practices without chipping, cracking, or structural damage. Any pull box damaged, or cracked, during installation shall be replaced by the Contractor.

4. Installation of the pull boxes shall be in conformance with the details shown on the plans. When shown on the plans, a concrete ring or apron shall be provided.

3.02 CONDUIT ENTRANCE TO PULL BOX

A. Hydraulic conduit entrance punchout tools or equivalent shall be used to provide necessary entrances to pull boxes leaving a clean surface area for the insertion of conduit.

END OF SECTION

SECTION 16711

TRAFFIC SIGNAL CONDUIT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. All traffic signal conduit installed above ground shall be rigid steel, hot-dipped, galvanized conduit. Underground conduit installed in unpaved areas may be either rigid steel, hot- dipped galvanized conduit or Schedule 80 polyvinyl chloride (PVC) conduit, unless specified on the plans. Underground conduit installed under paved roadways and shoulders shall be rigid steel, hot-dipped galvanized conduit.

B. Unless otherwise shown on the drawings, all conductors shall be in conduit except when in metal poles. All conduits and fittings shall be of the sizes and types shown on the drawings. Each section of conduit shall bear evidence of approval of Underwriter's Laboratories.

C. The Contractor may, at the Contractor’s own expense, use conduit of larger size than specified on the drawings providing that the larger size is used for the entire length of the conduit run.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement: This Item will be measured by the linear foot of the various sizes and types of conduit installed based on the type of surface as indicated in the bid item. Conduit shall be measured horizontally along the surface from center of pullbox to center of pullbar or foundation. Risers shall be measured as the amount of conduit extending from the ground surface.

2. Payment: The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Conduit” of the various types and sizes specified. The price shall be full compensation for furnishing and installing conduit; for directional drilling, boring, excavating, furnishing and placing backfill, replacing pavement structure, sod, riprap, curbs or other surfaces; for marking location of conduit (when required); for furnishing and installing all fittings, junction boxes, special radius sweeps, and expansion joints, conduit straps; and for all labor, tools, equipment and incidentals necessary to complete the work.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ANSI C80.1-2020 – American National Standard for Electrical Rigid Steel Conduit

B. National Board of Fire Underwriters - Rules and Regulations

C. NFPA 70 - National Electrical Code

D. NPFC - WW-C-581 - Conduit, Metal, Rigid, and Intermediate; and Coupling, Elbow, and Nipple, Electrical Conduit: Steel, Zinc Coated

E. UL-6 – Electrical Rigid Metal Conduit - Steel

F. UL-1242 – Electrical Intermediate Metal Conduit - Steel

G. Underwriters' Laboratories - Specifications

PART 2 PRODUCTS

2.01 MATERIALS

A. Electrical PVC Conduit - The use of Electrical PVC conduit will be allowed as long as all guidelines set forth in the NEC (National Electrical Code) book are followed. Schedule 80 Electrical PVC will only be used in pertinent applications. In locations above the ground, rigid metal conduit will be used. All grounding procedures set forth in the NEC shall be followed.

1. PVC conduit shall be joined by solvent-weld method in accordance with the conduit manufacturers recommendation. No reducer couplings shall be used unless specifically indicated on the drawings.

B. Rigid Steel, Hot-Dipped, Galvanized Conduit

1. All conduit shall be of mild steel piping, galvanized inside and outside, and shall conform in all respects to UL-6 and UL-1242.

2. Trade Names - Conduit manufactured by Clifton, Pittsburg-Standard, Triangle or Youngstown conforms to the provisions of this specification. Other brands of rigid steel, hot dipped, galvanized electrical conduit may be approved by the engineer provided samples and engineering data submitted by the bidder equal the provisions of this specification.

3. Protective Coating - The galvanized coat of zinc shall be of uniform thickness, not less than 0.0008 inch, applied by the hot-dipped process to not only the inside and outside surfaces of the conduit, but also to the threads of the conduit.

4. Threading and Reaming - Each piece of conduit shall be straight, free from blisters and other defects, cut square and taper reamed, and furnished with coupling in 10 ft. lengths threaded each end. The interior threaded surface of each coupling shall be galvanized to insure 100% galvanic protection when coupled together with lengths of hot-dipped rigid conduit with hot-dipped galvanized threads.

5. Rigid Elbows - Rigid standard and special radius elbows shall be made from the same grade of mild steel piping as rigid steel conduit. They shall be galvanized so that not only the exterior and interior surfaces shall have a galvanized coating but also the threaded area, thereby insuring 100% galvanic protection on all surfaces.

6. Chemical Test for Coating - The hot galvanized coating shall be of such quality and uniformity that a sample of hot-galvanized conduit will not show a fixed deposit of copper after four (4) immersions or dips in a standard copper sulfate solution.

7. Bending Test - The hot-galvanized coating on the inside and outside surfaces shall be sufficiently elastic to prevent cracking or flaking when a sample of finished conduit is bent 90 degrees, at a minimum bend of 60 degrees inner edge of the bend of six (6) times the inside diameter of the conduit. For conduits two (2) inches in diameter, or smaller, special eighteen (18) inch minimum radius sweeps shall be furnished and installed by the contractor.

PART 3 EXECUTION

3.01 CONSTRUCTION METHODS

A. General

1. 1. The contractor shall familiarize himself with the provisions of the General and Special Conditions in regard to permits, codes, laws and ordinances, and these provisions shall be controlling factors, except as specifically noted otherwise or supplemented herein.

2. All work shall be done in accordance with the latest rules and regulations of the National Board of Fire Underwriters, the National Electrical Safety Code and all local ordinances.

B. Coordination

1. The work shall be carefully coordinated with work of other trades. Wherever work covered under this item, the order of work shall be carefully scheduled and coordinated to secure the completion of the various portions in the best possible manner. The rights of the various interests and the sequence when in dispute, shall be established by the Engineer and the Engineer’s instructions as to priority and scheduling shall be final and binding.

C. Placement

1. All joints in conduit shall be cut square, reamed smooth and drawn up tight. Concealed conduit shall run in as direct a manner as practicable, with maximum radius bends. All bends shall be free from dents or flattening. Not more than the equivalent of three quarter bends (two hundred seventy degrees) shall be used in any run between terminals, outlets and junction or pull boxes. Conduit joints shall be made with approved couplings and unions; where conduit cross expansion joints, expansion fittings shall be installed. Conduit runs underground shall be installed a minimum of 24 inches below finished grade, except where it is impossible or impractical. The Engineer or approved designer shall be the sole judge of the permissible depth of conduit installation. The conduit shall be installed as shown on the plans or as directed by the Engineer. Each conduit run shall be swabbed after installation, and a No. 9 galvanized steel pull wire shall be inserted in each conduit and folded in a manner making it easy to retrieve from each end. The conduit ends shall be capped or plugged until cabling and wiring operations commence.

2. Upon request of the Engineer, the contractor shall draw a full-time metal brush, attached by swivel joint to a pull tape through "metal conduit" and a special template having a diameter not less than 75 percent of the inside diameter through PVC conduits to insure that the conduit is clean and free from obstructions. A nylon or non-metal pull tape shall be used in pulling cable and conductors through PVC conduit. Metal tapes will not be permitted in PVC conduit. The conduits shall be placed as shown on the drawings or as directed by the Engineer.

3. Conduit placed for concrete encasement shall be secured and supported in such a manner that the alignment will not be disturbed during placement of the concrete. No concrete shall be placed until all of the conduit ends have been capped and all box openings closed.

4. PVC conduit which is placed under existing pavement, sidewalks, and driveways shall be placed by first providing a void through which the PVC conduit shall be inserted. Boring is required for placing conduit under pavements. Metal conduit which is to be placed under existing pavement, sidewalks, and driveways shall be placed by boring.

5. Existing conduit which has been placed in position on the job site by others for this installation shall be checked to see that there are no obstructions in the conduit prior to threading the wire through. Any such obstructions shall be cleared without damage to the conduit, prior to installing cable.

6. Conduit runs shall be installed in such a manner as to minimize the accumulation of moisture at low points and pockets.

7. The components parts of conduits systems shall, in general, be of like material. Where dissimilar metals are used together, suitable provisions shall be made to prevent galvanic action.

8. The ends of all conduit runs shall be closed immediately after installation to prevent the accumulation of water, dirt and other foreign material. Conduit shall be swabbed out where necessary before conductors are pulled in. Bends may be either factory or field made. All 2 inch conduits shall be placed with special radius sweeps with a minimum radius of 18 inches. Standard bends shall not be allowed with 2 inch conduits.

D. Bonding

1. A No. 8 solid soft bare copper bond wire shall be installed in each conduit. This bond wire shall be firmly attached to the grounding rod installed in each pull box and cabinet. The bond wire shall create a continuous grounding system for the entire conduit system. All conduits, including rigid metal, shall be bonded together with a No. 8 solid bare copper wire and have continuity to every ground rod installed at each signal installation.

E. Pull Rope

1. A 5/16 inch nylon pull rope shall be installed in each conduit installed. A minimum of three feet of pull rope shall be coiled in each pullbox and cabinet.

F. Sealing

1. After installation of cables and wires the conduits shall be sealed with a suitable compound so as to prevent the entrance of moisture or gases.

END OF SECTION

SECTION 16712

SOLAR POWERED SCHOOL ZONE FIELD EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. The purpose of this specification is to provide details of Solar School Zone Flashing Beacon Field Equipment for new installations and replacement parts for existing installations.

B. Field Equipment Includes: cabinets, battery chargers, batteries, solar panels, flashers, and other incidentals required for Solar Powered School Zone Field Equipment.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 16715 - Vehicle Signal Heads (Polycarbonate) (Adjustable, Expandable Type)

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Solar Flashing Beacon Assembly, Complete, in Place – This Item will be measured on the basis of EACH assembly complete in place, tested, and accepted. This item shall include one pole with cap and base, one cabinet assembly, two beacons, solar panel, battery, battery charger, flasher, time switch* and terminal strips, and all conductors, and incidentals necessary to provide a complete functional Solar Flashing Beacon assembly. * Time switch optional to be supplied as single unit or integrated with communications component as part of the RSBMS.

2. Solar Flashing Beacon, Assembly, Complete, Parts – This item shall include one pole with cap and base, one cabinet assembly, two beacons, solar panel, two batteries, battery charger, flasher, and terminal strips. This item will be measured on the basis of EACH complete assembly furnished and accepted.

3. Flashing Beacon Cabinet Assembly – will be measured as EACH unit furnished and accepted.

4. Automatic Battery Charger – will be measured as EACH unit furnished and accepted.

5. Batteries, 12 VDC, Furnished – will be measured as EACH unit furnished and accepted.

6. Solar Panel Array, Furnished – will be measured as EACH unit furnished and accepted.

7. Signal Beacons, Furnished – will be measured as each PAIR of beacons furnished.

8. Solar Flashing Beacon Assembly, With Time Switch*, Complete, in Place – This Item will be measured on the basis of EACH assembly complete in place, tested, and accepted. This item shall include one pole with cap and base, one cabinet assembly, one programmable flashing beacon time-switch, two beacons, solar panel, battery, battery charger, flasher, and terminal strips, and all conductors, and incidentals necessary to provide a complete functional Solar Flashing Beacon assembly.

   * Time switch optional to be supplied as single unit or integrated with as part of the RSBMS.

9. Remote School Beacon Monitoring System (RSBMS) – will be measured as EACH unit furnished, tested, and accepted. This item shall include a Remote School Beacon Management System Field Device (RSBMSFD) consisting of a school beacon timer and a cellular modem, either as individual components or an integrated unit, software subscription and configuration, 10-year connectivity and support plan, school zone flasher back panel, and incidentals necessary to provide a complete functional Remote School Beacon Monitoring System.

10. The work performed, and materials furnished shall be measured as indicated in this Section and will be paid for at the unit price bid for each item, as specified in the bid form. This price shall be full compensation for excavating, backfilling, for constructing, furnishing, installing, and testing Solar Powered School Zone Equipment. This price shall also be full compensation for; concrete and reinforcing steel; electrical conductors, connections, grounding rods, galvanized pipe, fittings, pole caps, pole bases, straps, foundations (concrete or screw-in, as specified), anchor bolts, anchor plates (when required) and any other incidentals necessary to complete the work.

11. Refer to Section 01270 – Measurement and Payment for unit price procedure.

1.04 REFERENCES

A. ASTM A 153 – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

B. TxDOT Special Specification Item 4004 – Screw-In Type Anchor Foundations

1.05 WARRANTY

A. All equipment, except batteries, shall be warranted free from defects in Material and workmanship for minimum three (3) years from date delivered to the City of Houston warehouse. Batteries shall be warranted as specified in the Battery for Solar Powered Flashing Beacons section of this specification.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cabinet Components

1. General: The cabinet door shall be constructed from 5052H32-sheet alloy and shall have a thickness of .125 inch. There shall be no vertical seams in the cabinet shell. All External welds shall be made using the Heliarc method, whereas the wire welding method shall make internal welds. All welds shall be neatly formed and free from cracks, blowholes and other irregularities. The nominal outside dimensions shall be 26-inch (h) x 15.25-inch (w) x 15.75-inch (d). There shall also, be a lip over-hang cross the top of the cabinet covering the top of the door to help in preventing moisture from getting into the cabinet. The cabinet will be designed to protect internal equipment from rain, dust, vandalism and other conditions found in harsh environments.

2. The cabinet door opening shall be double flanged around all sides to form a uniform surface. This is to assure maximum contact with the door gasketing material.

3. All inside and outside edges of the cabinet shall be free of burrs.

4. All single position door restraint shall be provided to hold the door open at a maximum 90-degree angle. This is to prevent door movement in wind conditions.

5. Eight (8) louvered vents (4 per side) shall be provided for adequate ventilation of internal components.

6. Door and Hardware:

   a. The Door will be a minimum of 80% of the front surface area and shall be hinged on the right side when facing the cabinet.

   b. The door shall be furnished with a gasket ½” x 2” closed celled neoprene that shall form a weather tight seal between the cabinet flange and the door. A 3/8” x 5/8” retainer shall be used to hold gasket in place.

   c. The door gasketing shall be sprayed with silicone lubricant so that it does not adhere to the cabinet body-sealing surface.

d. The hinge shall be continuous and shall fasten to the cabinet and door by ¼-20 carriage bolts, washers and nylok nuts. The hinge will be made of .90-inch-thick stainless steel and shall have a .25-inch diameter stainless steel hinge pin.

7. The Latching Mechanism shall be a three-point draw type and shall have the following characteristics:

   a. The center catch and cam shall be fabricated from .1875-inch-thick steel and zinc plated.

   b. The latching rods shall not make direct contact with the inside of the cabinet surface, rather this mechanical interface shall be made by a nylon roller on each of the latching rod ends.

   c. The lock shall be a Corbin #2 lock. Two keys will be furnished with each lock.

   d. On the front side of the door a cover shall be provided over the key slot to prevent debris from getting into the lock. This device shall be attached so that it can provide easy access for unlocking the cabinet.

   e. The latching handle shall have a provision for padlocking in the closed position. The padlocking position shall be at the extreme end of the latching handle to preclude the use of pipe by vandals to force the locking mechanism open.

8. An Operating Handle shall be furnished and shall have the following characteristics:

   a. The handle will be stainless steel with a .750-inch diameter shank.

   b. The latching handle shall have a provision for padlocking in the closed position. The padlocking position shall be in the bottom middle of the latching handle to preclude the use of pipe by vandals to force the locking mechanism open.

   c. There shall be no exposed hardware of any type mounting the latching handle to the door.

   d. The handle shall have a lock hasp to allow the securing of the cabinet with a padlock.

9. Cabinet Layout

a. Top Shelf: Top Shelf shall be removable for easy access to battery on the bottom. The shelf shall have predrilled holes to attach the control panel these holes will be ¼ inch in diameter and shall be centered 7 inches apart 3 inches from the front of the shelf. The top shelf shall have a minimum depth of 9 inches and shall span the entire width of the cabinet. In the back center of the top shelf a half moon shape hole with a diameter of 2 inches shall be in place for ease of bringing cables up to the controller panel. The front lip of the shelf shall be turned up a minimum of ¼ inch and shall be free from sharp edges and burrs. In addition, ¼ x ¾ inch bolts with wing nut shall be supplied for attaching control panel to shelf. The top shelf shall be removable but made rigidly mounted with the use of simple tools.

b. The cabinet shall be provided with a battery shelf fabricated from 5052H32 aluminum having a thickness of .125 inch. The shelf shall be welded into the cabinet for maximum rigidity. A ½ inch of Styrofoam shall be supplied to cover the bottom, sides and back of the cabinet where the battery will sit.

10. Cabinet Finish: Unless otherwise specified, the outside surface of the cabinet shall have a smooth, uniform, polish aluminum finish.

B. Solar Panel

1. The Photovoltaic Module shall provide 12 VDC and be capable of recharging the system to full capacity, after 6 hours of continuous operation, in three (3) hours +/- .5 hours during optimum sun conditions in December. The minimum acceptable wattage output of the solar panel will be 100 watts. Solar Array sizing calculations and the parameters used shall be required. Each solar cell shall be bypass diode protected to prevent power loss if a module is temporarily shaded. The crystalline silicon solar module shall consist of cells that are permanently encapsulated between a tempered glass cover and layers of ethylene vinyl acetate (EVA) pottant with a polyvinyl fluoride (PVF) and aluminum foil back sheet to provide a moisture free environment. Units without foil back sheets must have Underwriter Laboratory (UL) approval. The module frame shall be made from extruded aluminum alloy and adequately sized to attach the desired number and size of solar panels. The mounting bracket shall use tamper proof hardware to secure the PV module to the frame. An ultraviolet (UV) resistant, weatherproof junction box providing wire termination for up to #8 AWG wiring shall be provided with the PV module.

C. Battery for Solar Powered Flashing Beacons

1. The Battery shall have a nominal voltage of 12 VDC. The battery shall be sized to allow four (4) days of autonomy and provide sufficient power to support remote support remote communications at an increased power consumption rate of 1 ampere hour per day. The battery shall conform to the following criteria:

    a. Operating temperature range:

        (1) Discharge: -26 degrees F to + 140 degrees F.

        (2) Charge: -4 degrees F to +122 degrees F.

    b. Vents: Pressure relief vents permanently attached Sealed Construction: Will not spill or leak.

    c. Flag Terminals: Hold clearances for ¼" bolt.

2. Battery shall be housed in the cabinet specified in the above specification. The battery shall carry two (2) year replacement warranty from date of delivery to the City of Houston, and a prorated warranty up to five (5) years.

3. Programmable Control Unit – Programmable time-based control units, when required shall be as listed in the bid items.

D. Battery Charger

1. The Charging Unit shall be 100% solid state and be designed for use as a battery charger in photovoltaic (solar) energy systems. The charger shall be mounted on the control panel.

    a. The charger shall supply maximum solar panel current to the battery until battery is fully charged (trickle charge will not be accepted). Battery voltage will be used to determine when charging is to resume. The resumption threshold shall compensate for temperature. The charge current must be tested at least one (1) time per hour.

    b. The charger shall supply a charging current of up to 10 Amps DC to the batteries.

    c. The charger shall be a modular design and shall be easily replaced with the use of simple tools. There shall be no terminal strip connections on the charging unit it must be a plug-in design. Any meters being used shall be housed in the charging unit.

    d. Metering devices used shall be for checking the battery voltage and solar panel input voltage. One meter built into the charging unit will be used for both operations, an external switching device shall be used to check both measurements.

e. No terminal strip connections are to be on the front of the control panel, all connections will be made on the back of the control panel.

f. Charger shall incorporate a low voltage disconnect that shall prevent battery damage due to extreme discharge.

E. Flashing Unit

1. The Flashing Unit shall be a modular design with a plug being utilized for connecting to the external flashing outputs. The external outputs shall be made on the back of the control panel. The flasher shall be easily replaced with the use of simple tools.

a. The flasher shall be a 12-volt DC charger and shall operate in a range +/ -volts.

b. The flasher shall have a minimum 2 circuits and shall be rated for a minimum of 50 watts per circuit.

c. The operating temperature range shall be from -20 C to + 75 C.

d. The flasher shall be capable of working both Halogen or LED lamp units.

e. The physical size of the flasher unit shall be no larger than 5.50” (L) x 3” (W) x 2” (D).

f. The housing shall be a minimum 18 Ga. Steel.

g. The flasher shall have a programmable flash rate from 50-70 flashes per minute.

F. Signal Beacons

1. The School Zone Beacon Assembly shall operate with two (2) signal beacons. The beacons shall flash alternately (bouncing ball type). The beacons (signal heads, visors and LED lamp units) and mounting hardware shall be supplied as part of this bid.

2. All Flashing Beacons shall be 12” polycarbonate yellow housings with tunnel visor hood and use band on mounting or approved equal. The housing, door and visor shall meet the applicable portions of City of Houston Specification Section 16715 – Vehicle Signal Heads (Polycarbonate) (Adjustable, Expandable Type).

3. Lamp Unit Modules shall be LED (yellow) - 12VDC. All lamp unit modules shall meet the ITE VTCSH-LED Circular Signal Supplement over the full temperature range of -40 degrees C to +74 degrees C and shall meet or exceed the latest ITE uniformity specifications.

4. Signal Beacon Mounting Hardware shall consist of supports for side-of-pole mounting of the signal head in a vertical position shall be 1-1/2" standard pipe bracket arm, attached to the top of the signal head with pipe nipple, threaded cross fitting with adequate closure caps and collared / cast nipples and band-on pole plate. Pole plate shall be provided with a cable guide. The mounting assembly shall consist of one standard pipe sections extending 12-3/4" from and at right angles to the axis of rotational adjustment of the signal head. The supports shall have running threads at least 1-1/4" long at the pole connection end. The signal head shall be adjustable, by rotation of the various signal faces about their vertical axis, throughout a radial angle of 360 degrees and shall be capable of being rigidly clamped in any position through the range of adjustment. The wiring from the signal head shall be able to be enclosed in the top support. A closure cap shall be provided for the bottom opening of the signal head housing.

G. Two-Way Network Programmable Time Switch

1. A time switch shall be provided as an individual component or integrated with the Remote School Beacon Monitoring System. The time switch unit shall have the following general characteristics as defined in detail under the Remote School Beacon Monitoring System Field Device Requirements:

   a. The time switch shall support Ethernet and cellular communications.

   b. The time switch unit shall have a two-way network transceiver able to receive programs and commands generated by a central computer and transmit its programming data back to the central computer upon demand.

   c. The time switch shall be capable of receiving and running the following programs via the two-way network: override plan, time set, setup time switch, day plan programming, default week plan and annual plan programming as described in the Remote School Beacon Monitoring System Interface Requirements.

   d. The time switch shall be housed in an aluminum or stainless-steel enclosure with a means for mounting to a suitable back plane.

   e. The time switch shall be capable of operating on either 12 VDC +/- 2VDC or an AC power source between 95 and 135 VAC.

   f. The AC and DC power supply must be an integral part of the time switch circuit board due to the fact that many flasher cabinets do not have AC power outlets.

   g. A separate power supply module, similar to those used for calculators and battery chargers, is not acceptable.

h. Battery backup memory shall be provided to maintain timekeeping and all programming when the line power source is lost. This backup memory shall maintain timekeeping and all programming for not less than 60 days and shall go online automatically upon failure of the power source. Upon resumption of power source, the unit shall automatically resume normal operation.

i. When the time switch is operating on the backup system, the indicators and relay output shall be off to conserve backup power.

j. The time switch shall have a minimum of four (4) LED indicators to display the following:

(1) When the time switch has power and is operating.

(2) When the time switch is receiving two-way network signal.

(3) When the time switch is receiving GPS signal.

(4) When the output relay is energized or de-energized.

(5) Other may include setting error, program running, etc.

k. The time switch shall have the option of receiving Global Positioning Satellites (GPS) signals from a receiver designed for this function. The GPS receiver may be provided as a separate unit or integrated as part of the RSBMS. The GPS receiver shall reset the time-of-day in the time switch continuously when locked onto at least 3 satellites and shall automatically adjust for time zones and daylight savings time. The time switch must provide the capability of automatically resetting time switch time-a-day from the GPS receiver in the absence of two-way communications.

l. The timer switch shall be capable of operating with AC and DC environments. The relay outputs should be rated at 15-16A.

m. The unit shall consume no more than .250 W at rest and .600 W with relays energized.

H. Remote School Beacon Monitoring System

1. Overview

The Remote School Beacon Monitoring System (RSBMS) must allow for the following requirements:

a. Display of the real-time fault status of the school beacons, including loss of AC power, beacon failure, battery failures and solar charge status.

b. Issue real time alerts via SMS and email to the appropriate response personnel immediately after a fault occurs.

c. Setting up the schedules and holidays of school beacon operation remotely and downloading the schedules to the school beacons.

d. Having manual override of individual or groups of school beacons to be able to turn them immediately on or off to meet early school release, and other unexpected school events.

e. The timer switch shall not require any peripheral attachments.

f. The timer switch shall be capable of being programmed locally via a mobile device interface.

g. Key performance indicators must be maintained by the system and available for report at any predefined frequency. Reports must illustrate the operational availability of school beacons. The report shall include details of the beacon health condition of the battery's, solar chargers and lamps.

h. The timer switch shall be capable of monitoring rapid flashing beacons, this includes battery voltage, solar panel, AC and the number of button presses.

i. The timer switch shall be capable of operating with AC and DC environments.

j. The overall system must be capable of integration to a Smart City Management platform.

k. The hardware shall be under warranty for as long as the devices have a connectivity and support license and connected to the Remote Beacon Monitoring System.

2. Remote School Beacon Monitoring System Client User Interface Requirements

The RSBMS software user interface shall provide, as a minimum, features to meet the following requirements:

a. General:

(1) The user interface shall be web based and be able to be viewed using a browser. Internet Explorer, Chrome and Firefox browsers shall be supported, as well as Safari on an iPad. Systems that use remote desktop or similar to view a thick-client user interface will not be acceptable.

(2) The RSBMS shall require a user name and password to log on.

(3) The RSBMS systems shall be mobile friendly and operators shall be able to open the system on a mobile phone to access the data and control the school beacons. The web-based system shall be viewable on any modern web browser on a mobile phone and automatically sized for the screen.

(4) The RSBMS shall provide user "permissions" that can be assigned to each user by an administrator. Permissions should include at a minimum, a "read-only" level, administrator level, and the ability to give access to any or all of the following: Read/Write Locations, Manual ON/OFF locations, override group scheduling, change/create group scheduling, edit users, and create/edit groups and locations.

b. Map Display:

(1) The RSBMS shall include a scrollable, zoomable map display, with the school beacons shown as representative icons on the map. The map display must have option to select either satellite view or normal street map view, as well as a street view option.

(2) The alarm status of the school beacon shall be clearly indicated on the icon on the map, so that the user can see at a glance which school beacons are in alarm. There should be unique icons to identify different type of beacon statuses.

(3) The status of all beacons shall include if the beacon is currently on and if the beacon has a schedule mismatch.

(4) The map display shall also include a list of school beacons, with the number and priority of alarms indicated on the list. School beacons in high priority alarm shall be moved to the top of the list, followed by medium priority, low priority and then finally by school beacons not in alarm.

(5) The icons shall change to be able to clearly indicate if a school beacon is offline.

(6) Clicking on the icon on the map shall expose a box with the current parameters of the school beacon shown.

(7) The default map display position and zoom shall be configurable by user, so that the user's view will default to show the school beacons that the user is responsible for managing.

(8) The map display shall allow for multiple preset zoom layers, so users can select preset zoom layers to zoom into different areas of the map.

(9) The map display shall allow operators to turn on and off layers. Layers shall include the ability to display the device names of every beacon on the map and include the option to automatically zoom into any selected device.

(10) The map should display a list of recent communication issues, sorted by the most recent failure to communicate.

c. Regional School Beacon Grouping:

(1) The RSBMS shall provide for school beacons to be logically and regionally grouped with no less than two levels of grouping for convenient managing, sorting and selecting.

(2) The RSBMS user logon shall be configurable in such way that users can customize their default view and have visible only the school beacons that belong to the group they are authorized to view.

(3) Users shall also be able to save the map zoom level for their individual log in.

(4) Users shall be able to select multiple preset zoom options to zoom into different areas of the maps.

d. School Beacon Detail Display:

(1) It shall be possible to access detailed device information for the school beacon from the map icon or the device list including as a minimum the following parameters:

(a) The alarm status, if any alarm present, with priority indicated and a text description of the alarm.

(b) The time since the last communication with the device

(c) The following parameters (real time now values, minimum for the day values, maximum for the day values, and average for the day values)

I. The AC mains voltage (value)

II. The battery voltage (value)

III. The battery back-up voltage (value)

IV. The solar charge voltage (value)

V. The presence of AC power (OK or Fail)

VI. The status of the school beacon (On or off, and whether under manual or schedule control)

VII. Beacon failure state (One beacon failure or both beacon failure)

VIII. The cabinet door status (Open or Closed)

IX. Whether the school beacon is in local or remote manual override control

(d) It shall be possible to view real time graphs of each of the value parameters in graphical form, over the recent one-to-two-week period including real time graphs of:

I. The AC mains voltage

II. The battery voltage

III. The battery back-up voltage

IV. The solar charge voltage

V. The beacon failure state (one beacon failure or both beacon failure or okay

VI. The status of the school beacon state (schedule on, schedule off, manual on, manual off, local override on, local override off).

e. School Beacon Individual Remote Override:

(1) From the browser user interface, it shall be possible to remotely override the state of the beacon and place the beacon into state “manual on” or “manual off”.

(2) The beacons shall change state within 30 seconds of the command being issued.

(3) The user interface shall update within 60 seconds to show the actual state of the beacon, so that the user can readily confirm that the remote manual override was successfully executed by the beacon.

(4) The graphical display of the beacon state shall be updated to "manual on" or "manual off", as applicable, to acknowledge when the remote manual override command was issued.

(5) The remote manual override command shall be recorded in the user log.

f. School Beacon Scenario Remote Override:

(1) It shall be possible to create Remote Scenarios in preparation for unexpected events that typically occur for school beacons. This includes being able to group school beacons, and then turn the grouped beacons on or off; or back to schedule using a single click on the user interface.

(2) Setting up and then using these scenarios shall facilitate to change the school beacons for weather events, early release and other short-term changes to the scheduled operation of the beacons.

g. School Beacon Remote Scheduling:

(1) It shall be possible to create scheduled events for the school beacons and publish these schedules to the field controller. The field controller will then store locally in non-volatile memory and use the schedule to operate the school beacon at the correct time.

(2) The field controller will update its internal time clock from the server and/or GPS to ensure that the field controller's clock remains accurate to within 1 minute of the actual time.

(3) It shall be possible to schedule the school beacon plans to turn the beacon on or off by time of day; by day of week and by month of year.

(4) It shall be possible to include holidays and exception schedules. These holidays should automatically turn the school beacon off during holidays. It shall also be possible to create exception days that switch to a different schedule on that specific day. Holidays and exception days shall have a calendar pop out to select the specific date.

(5) It shall be possible to publish the schedule to one beacon or a group of beacons simultaneously.

(6) The schedule shall display in summarized form the time, day(s) of week and month(s) of the year that the schedule is to operate in a summary form, so that it is easy to read the list of schedules.

(7) On the detailed display, the user interface shall display the date, time, and operation for the next seven scheduled events, to allow understanding of the planned operation of the schedule that is currently published to the device.

(8) The next scheduled event information should consider holiday and exception days as well as schedule delays due to weather events.

(9) Scheduling shall include the option to delay, advance or cancel the schedule due to weather events. This schedule delay will only affect the selected days schedule and the following day the schedule will revert back to normal. Users shall have the option to select today, tomorrow or any selected date. User shall also be able to select to only delay the morning schedule or the afternoon schedule or both.

(10) Only users with access rights will be able to change beacon schedules and holiday.

(11) The system must have the ability to determine if there is a "schedule mismatch". This means the schedule that is stored in the central is different to the schedule in the devices. The system must indicate which devices have a schedule mismatch and users can see what caused this. Once an operator downloads the correct schedule these mismatches must clear.

(12) The system shall prohibit the scheduling of multiple/incompatible calendar programming data to a single group of flashers.

(13) Scheduling shall also do error checking to determine if the operator has made any errors while making the schedule. This includes overlapping holidays and exception days as well as consecutive on or off commands.

h. Diagnostics and Log Display:

(1) From the device level detail, it shall be possible to obtain the raw data, error logs, and the communications logs to allow a technician to fault-find problems on the RSBMS.

(2) It shall be possible to filter the logs by device, by device type and/or by group as well as date ranges.

(3) It shall be possible to print these selected logs to a local printer or a PDF file.

(4) It shall be possible to export these logs to Excel on the local computer.

i. Alarms:

(1) The RSBMS shall have a comprehensive alarm generation capability to view/troubleshoot within the software and to enable the response personnel to be notified when an abnormal situation has occurred.

(2) It shall be possible to configure alarms to be generated on any parameter becoming out of tolerance, including analog values, digital values and enumerated values.

(3) Alarm capabilities should monitor the following components with these parameters:

(a) Solar Voltage – Solar voltage levels shall be continuously monitored and updated regularly on the RSBMS. Data should be displayed graphically in 15-minute intervals, illustrating anomalies in the solar charging cycle and providing valuable information about the solar power and surrounding solar environment.

(b) Load Status – continuously monitors load terminals and issues an alert the RSBMS and selected users via text/e-mail if the solar regulator disconnects the load voltage to the system.

(c) Up to 3 LEDs/DC lamps – continuously monitors LED/lamp terminals and sends an alert if an LED or DC lamp burns out or vandalized in certain ways.

(d) Battery – battery voltage levels are continuously monitored and updated regularly in the RSBMS. The data is displayed graphically in 15-minute intervals, illustrating the relationship between the solar and battery voltages. An alert is issued to the RSBMS and selected users via text/e-mail if the monitored battery voltage falls below a user-set level. An alert is also issued in the case of battery theft.

(e) AC Power – continuously monitors for interruptions or loss in AC power and sends an alert in such circumstances.

(f) AC Lamps – continuously monitors AC lamps and sends an alert if an AC lamp burns out or is vandalized in certain ways.

(g) Time Switch – continuously monitors the internal time switch voltages and issues an alert if the time switch loses power.

(h) Door – when a door switch is present, continuously monitors the status of the cabinet door and issues an alert indicated when the door is open.

(4) Alarms shall be configurable to be of different priority levels and distinguish each level by color and/or code.

(5) The current active alarms shall be accessible for view via an expandable window, to see which alarms are active and when the alarm occurred. The highest priority alarms shall rise to the top of the list.

j. Alerts:

(1) The RSBMS shall have comprehensive alerting capability to enable the response personnel to be notified when an abnormal situation has occurred.

(2) When alerts are received via RSBMS, e-mail, or text, the specific type of alert should be described along with the time the alert was detected.

(3) It shall be possible to configure alerts to one or more personnel for each alarm. This will cause, as selected, a text message and/or an email to be sent to the person when an alarm occurs.

(4) User recipients of text/e-mail alerts should be able to configure time periods of the day in which they would or would not like to receive alerts, such as evenings or periods in which they may be on call.

(5) The alert shall be configurable to send via email and/or via text message a message when an alarm clears.

(6) The current active alarms shall be accessible for view to see which alarms are active and when the alarm occurred.

(7) The RSBMS shall communicate the alerts to the user in near real time. The text message and email shall be issued within 30 seconds of the occurrence of an event.

k. Reports:

(1) It shall be possible to view reports on the screen, in the browser of the RSBMS, and if desired, download CSV files for importing into Excel, print the report to a printer or save as a PDF file.

(2) Alarm Activity Report

(a) The RSBMS shall include a report which shows the alarms activity for a defined period and specific location(s).

(b) The Alarm Report shall indicate the time the alarm occurred, priority/type of the alarm; whether it is still active; and if not active then the time when the alarm stopped being active.

(c) It shall be possible to filter the alarms by device type, by device and/or by device group, and by date time to be able to access a large alarm list to view the alarm activity for a school beacon over a pre-defined period.

(3) User Activity Report

(a) The RSBMS shall include a report which shows user activity for a given period, to enable an audit of a user's response to an alarm to be made.

(b) The report shall log access and changes by a user and show which actions the user initiated.

(4) Response Time for Fault Repair Report

(a) The RSBMS shall include a report which shows the response time to clear faults, for a given time frame.

(b) This report will allow the user to determine the number of faults, and the total and average time to clear the fault.

(c) This report will allow the response times by region to be compared.

l. Field Device Requirements

(1) The Remote School Beacon Management System Field Device (RSBMS) shall consist of a School Beacon Timer and a Cellular Modem, either supplied as individual components or an integrated unit, to operate into existing school beacon cabinet assemblies:

(2) The Remote School Beacon Management System Field Device (RSBMSFD) / School Beacon Timer and Cellular Modem shall include:

(a) A small field controller capable of working in conjunction with or have integrated a cell modem. All other inputs and outputs required for the correct operation of the system.

(b) Local Scheduling via a laptop using an internet browser.

(c) The same unit should be able to operate with either AC or DC power.

(d) Monitoring signals such as AC, battery voltage, solar charge voltage and integrated battery backup voltage.

(e) A local override switch to place the beacon in on, off, or schedule control.

(f) Monitor the lamp current to determine if both lamps are working or if only one lamp is working.

(g) Capable of monitoring the door status of the cabinet.

(h) The unit shall include 2 relay outputs so that it can control 2 flasher controller units.

(i) The RSBMSFD unit shall include an extended warrantee for the entire time it is connected to the Remote School Beacon Management System.

(j) The RSBMSFD warrantee shall also include replacing the cellular modem if the cellular technology changes. Such as 2G-3G, 4G-5G or future higher levels.

(3) The RSBMS Field Device (RSBMSFD) shall conform to the following requirements:

(a) The RSBMSFD shall function correctly between -37 degrees C and +74 degrees C.

(b) The RSBMSFD shall be designed to assure the field controller's clock remains accurate to within 1 minute of the actual time and be capable of working in conjunction with or have integrated a cell modem.

(c) The RSBMSFD shall be capable of operating with a replaceable SIM card.

(d) The configuration of the RSBMSFD shall be accomplished by accessing the internal web server with a browser. It shall be possible to configure the RSBMSFD without any special software.

(e) The RSBMSFD shall utilize field-initiated communications. This allows for low cost cellular data plans to be used, with infrequent polling. However, when an abnormal event occurs and is detected by the RSBMSFD, then the RSBMSFD will immediately initiate the transfer of a data packet to the RSBMS to enable real-time alerting of response personnel to take place.

(f) The timer switch shall be capable of operating with AC and DC environments. The relay outputs should be rated at 15-16A.

(g) In the event that the cell service is interrupted or is not available, the RSBMSFD shall store any events that occur in internal memory and forward these events automatically to the RSBMS when the cell service is restored. In this way, a complete record of events at the device can be maintained even if cell service is interrupted for a period. This backup memory shall maintain timekeeping and all programming for not less than 60 days.

(h) The RSBMSFD shall utilize HTTP and HTTPS protocols, and XML data structures, for communications with the RSBMS. In this way the data will be open for future expansion and competition. The use of secret proprietary protocols is not permitted.

(i) The RSBMSFD shall support Ethernet and cellular communications.

I. Pole Assembly

1. The pedestal pole assembly is required for support of the Solar Powered School Zone Field Equipment. Refer to Standard Detail 02582-04 for details of assembly items.

2. Pole shaft shall be one-piece galvanized steel pipe.

3. Screw-in type anchor assembly shall meet the requirements of TxDOT Special Specification Item 4004, and details shown in Standard Detail 02582-04.

4. Breakaway pole base shall be the type as shown in Standard Detail 02582-04.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. Cabinet Mounting

1. The cabinet shall be arranged for side of pole mounting. Two sets of holes shall be predrilled to accommodate two Pelco SE 1100, or equal, mounting brackets. The top set shall accommodate the wire inlet to the cabinet. These mounting brackets shall be supplied as part of the complete cabinet package.

B. Back Panel

1. The control panel shall be 12 inches high by 14 inches wide and have a 4-inch lip at the bottom for the purpose of fastening to the upper shelf. The panel will set up for the charging unit and flashing unit to mount on the panel, also mounted on the panel will be the time switch.

C. Solar Panel Mounting Hardware

1. The photovoltaic (PV) module mounting assembly shall be constructed of galvanized steel (ASTM A-153 Class A) or aluminum, of adequate design and strength to provide a means of securely attaching the PV module frame to a pole at a permanent angle of 45 to 50 degrees. The pole mounting hardware shall accommodate a steel 4.5-inch O.D. pole. The bracket at an inscribed angular position about the pole. Mounting Hardware may mount on the side of the pole or on the top of the pole as long as the bracket is of adequate strength to withstand the weight and wind stresses.

D. Physical and Electrical Interface

1. A Physical and Electrical Interface needs to be maintained for the connection of the controller unit. This interface will need to be a terminal strip on the rear of the control panel. This terminal strip will be where the harness will hook up for the controller unit. The terminal Strip will need to be clearly labeled DC+,DC-, Earth Ground, Relay N/O, Relay Common.

2. A Physical and Electrical Interface will have to be maintained between the solar panel, batteries, and signals; both can be utilized on (1) terminal block to save space. All labeling shall be silk-screened.

E. Hosting And Connectivity Service – The RSBMS shall include a 10-year connectivity and support plan. Option to extend the operation for a further 5 years of the Connectivity and Service agreement of the RSBMS shall be provided. The Connectivity and Service agreement shall include at a minimum:

1. Cellular Connectivity

2. Upgrade the cellular modem if the technology is not supported by the cellular networks.

3. Telephone and email support

4. No cellular overage charges

5. Extended warranty on the hardware for the period of the Connectivity and Service Agreement

6. Over-the-air software updates

7. Over-the-air security updates

8. Future Connected Vehicles Service

3.02 Testing

A. Solar Powered School Zone Beacons Assemblies shall meet or exceed all applicable Texas Manual on Uniform Traffic Control Devices and /or Institute Transportation Engineers standards and these specifications. In addition to testing of pre-shipment samples, complete testing of school zone beacon assemblies may be required at any time prior to acceptance ITE specified signal lamp intensity shall be maintained.

B. Remote School Beacon Monitoring System – The apparent low bidder shall be required to supply a complete working system to the agency for testing and evaluation. This working system shall include a workstation or laptop preloaded with the remote interface, six-field time switch units (RSBMSFD), and any other equipment or supplies necessary for the agency to adequately test and evaluate the system. The bidder shall setup the RSBMSFD at a location identified by the City of Houston. The bidder will successfully demonstrate the CRC error-checking feature to the City of Houston personnel by simulating a time switch receiving a normal message and a corrupted message. The bidder will train City of Houston personnel on how to program and operate the Remote School Beacon Monitoring System. The test and evaluation will take up to 60 days at which time the equipment may be picked up by the bidder or shipped to the bidder freight collect. Upon telephone or written notification, the bidder must deliver this equipment to the agency within 14 calendar days. Failure to comply with the above requirement will render the bid non-responsive.

3.03 Training

A. Training requirements are listed below. The City shall furnish the training classroom and the Project Manager shall schedule the training sessions.

B. Assembly. One (8) hour training class on field assembly training shall be provided as requested by the city Project Manager, for the City's installation contractors and City of Houston's, Houston Public Works - Transportation and Drainage personnel. The instructional training shall be for up to twenty (20) persons at the request of the Project Manager.

C. Maintenance. One training class consisting of eight (8) hours of Maintenance training shall be provided for up to twenty (20) persons, as requested by the city Project Manager.

3.04 Certification

A. Certification. A Vendor Representative shall provide to the City's Project Manager in writing that the City's Installation Contractors have been trained to successfully assemble, program, and operate the beacon assemblies in accordance with manufacturer's specifications and operating manual.

3.05 Documentation

A. Each Solar Powered School Zone Assembly both complete and as parts, shall be provided with the following documentation:

1. Complete accurate schematic diagrams

2. Complete parts list including names and part numbers for vendors, for parts not identified by universal numbers.

3. Operating and Maintenance Manual including simple programming instructions and a programming guide.

END OF SECTION

SECTION 16713

PRE-FORMED LOOPS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Materials and installation of Pre-Formed Loops.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 SUBMTTALS

A. Contractor shall submit a list of intended suppliers and products to be used for loop and lead-in assembly and splice enclosure. City reserves the right to request actual product samples prior to approval.

1.04 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement: This item will be measured as each loop installed, per size specified in the drawings and made fully functional and tested in accordance with this Section or as directed by the Engineer.

2. Payment: Payment for installation of pre-formed loop will be on the basis of each loop installed.

3. The price is full compensation for furnishing and installing the pre-formed loops. Cost of associated lead-in assembly and splice enclosure will not be paid for directly but is to be included in the unit price bid for installation of each pre-formed loop.

4. Refer to Section 01270 – Measurement and Payment for unit price procedures.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide a loop, lead-in cable and splice enclosure that meets the following requirements.

B. General Requirements.

1. The loop / lead-in assembly shall be suitable for applications in which the loop / lead-in assembly will be overlaid with hot asphalt or embedded in concrete.

C. Loop Cable: Provide a loop cable that has the following features:

1. The loop Cable shall be a four-conductor, double-jacketed cable with a nominal outer diameter of 0.360".

2. The individual conductors shall be #18 AWG wire (formed from seven strands of #26 AWG copper wire) with a 0.020" thick layer of cross-linked polyethylene (XLPE) insulation.

3. The inner jacket shall be 0.040" thick cross-linked polyethylene (XLPE).

4. The void between the conductors and the inner jacket shall be spiral wrapped with a clear, moisture resistant binder tape and filled with anamorphous water-block compound.

5. The outer jacket shall be 0.035" thick cross-linked polyethylene (XLPE).

D. Lead-in Cable: Provide a lead-in cable that has the following features:

1. The lead-in cable shall be a two-conductor, double-jacketed cable with a nominal outer diameter of 0.360".

2. The individual conductors shall be #16 AWG wire (formed from nineteen strands of #28 AWG copper wire) with a 0.020" thick layer of cross-linked polyethylene (XLPE) insulation.

3. The inner jacket shall be 0.040" thick cross-linked polyethylene (XLPE).

4. The void between the conductors and the inner jacket shall be spiral wrapped with a clear, moisture resistant binder tape and filled with an amorphous water-block compound.

5. The outer jacket shall be 0.042' thick cross-linked polyethylene (XLPE).

E. Cross-linked Polyethylene (XLPE) Insulation

1. The cross-linked polyethylene (XLPE) insulation used for wire insulation and cable jacketing shall be capable of withstanding temperature up to 426° Fahrenheit.

F. Splices and Enclosure: Splices and enclosure that encapsulates the spliced connections shall have the following additional features:

1. Splices between the individual loop cable conductors and the splices between the loop cable conductors, and the lead-in cable conductors shall be soldered, sealed, and waterproofed.

2. The enclosure that encapsulates the spliced connections shall be fabricated from a high impact glass impregnated plastic with a minimum thickness of 0.240".

3. The two halves of the splice enclosure shall be sealed with a water resistant gasket material.

4. The interior cavity of the splice enclosure shall be completely filled with an amorphous water block compound.

5. The splice enclosure shall be submerged in a saltwater solution for three (3) days.

6. At the end of this three days period, the electrical integrity of these splices shall be verified by using a 500 Volt DC MegOhm meter to ensure that the resistance between either lead-in conductor and the saltwater solution is 200 Mega Ohms or greater.

PART 3 EXECUTION

3.01 LOOP INSTALLATION

A. General.

1. Provide equipment that utilizes the latest available techniques for design and construction with a minimum number of parts to maximize standardization.

B. Loop Installation – Asphalt Overlay

1. Place the Pre-formed loop in the proper position and orientation on the asphalt base lift.

2. Route the lead-in cable to the desired termination point.

3. Cut the fiberglass backed mastic tape into 2"x4" or 3'x4" strips. Use the mastic tape (and optional corner brackets) to hold the loop and lead-in cable in place.

4. Apply the top lift, make certain that the loop cable does not get pulled into the augers in the paving machine.

C. Loop Installation – Poured Concrete

1. Place the Preformed Loop in the proper position and orientation on top of the concrete reinforcing steel.

2. Route the lead-in cable to the desired termination point.

3. Cut an appropriate number of ½" poly tees. Cut an equal number of lengths of 3/8" rebar.

4. Use the tees, rebar and nylon cable ties to hold the loop cable in place at least 2" above the concrete reinforcing steel. The lid-in cable can be tied directly to the concrete reinforcing steel.

5. Poor the concrete making certain not to disturb the loop cable.

END OF SECTION

SECTION 16715

VEHICLE SIGNAL HEADS (POLYCARBONATE) (ADJUSTABLE, EXPANDABLE TYPE)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Polycarbonate Vehicle Signal Heads with mounting attachments and light emitting diode (LED) lamp indications, louvered back plates, and Geometrically Programmed Louvers (GPL).

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 16718 - Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for Vehicle Signal Heads will be measured by each vehicle signal head assembly required with specified mounting hardware. Vehicle Signal Heads shall consist of one (1) or more sections with visor(s), mounting hardware, LED indication color(s) specified and louvered back plates. The Vehicle Signal Head housings, doors and visors shall be Federal Highway Yellow.

2. Payment for Geometrically Programmed Louver (GPL) and adjustable full-circle visor will be measured as each unit required.

3. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for “Vehicle Signal Head”, of the various configurations complete with LED indication(s) and mounting hardware and louvered back plates as specified.

4. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ITE Specification for Traffic Control Signal Heads: LED Circular Signals

B. ITE Specification for Traffic Signal Heads: LED Arrow Signals

C. ITE Specification for Pedestrian Traffic Control Signals: LED Pedestrian Signals

PART 2 PRODUCTS

2.01 MATERIALS

A. The traffic control signal heads shall be in accordance with the latest revision of ITE Specifications for Traffic Control Signal Heads: LED Circular Signals, Traffic Control Signal Heads: LED Arrow Signals and Pedestrian Traffic Control Signals: LED Pedestrian Signals.

B. Each traffic signal face shall consist of one or more signal sections rigidly fastened together as per manufacturer's recommendations in such a manner as to present a continuous pleasing appearance.

C. The electric and optical system of the signal head shall, unless otherwise specified, be designed for operation from a power supply of 115 volt, single phase, 60 Hz alternating current and LED displays.

D. Polycarbonate shall be used in fabricating the vehicle signal heads described herein. Structural requirements for polycarbonate materials are described in Paragraphs. 2.02 and 2.03.

E. All material for the mounting attachments shall be metal.

2.02 HOUSINGS

A. The polycarbonate vehicle signal head housing cases shall be a one-piece polycarbonate resin material with sides, top, and bottom integrally molded. The housing shall be injection molded from ultraviolet and heat stabilized flame retardant, permanently colored polycarbonate resins. The housing shall be a minimum of 0.125 inches (3.18 mm) thick measured anywhere on the housing and shall be internally ribbed so as to produce the strongest possible assembly consistent with lightweight. The terminal block shall either be securely mounted or integrally molded into the housing.

B. Provision shall be made for accommodation of the particular type of mounting specified and attachment of doors, optical units, and other such accessories as may be specified for the particular installation. All traffic signal housing cases, together with doors, lenses, and mounting attachments, shall comprise a dust and moisture proof housing for the optical units, connecting wiring, and terminal block. The housing cases shall be of such construction as to assure permanent alignment of the lens in the traffic signal face. Design of door, housing, and visor shall be such that no light is visible in the profile view of the traffic signal face.

C. Vehicle Signal Head housing cases shall be of the sectional, adjustable, expandable type. The assembled housings for each signal face shall consist of three or more individual dual sections, each designed for housing a single complete optical unit. Individual signal sections shall be rigidly attached to form a single head either with at least four machine screws between each section or by the bolt-and-washer conduit method. Complete signal heads shall provide positive locked positioning when used with serrated brackets, mast arm, or span wire fittings.

D. Portions of cases providing for attachment to supporting arms shall be molded with large bosses for the supporting arms. Each housing case shall be so attached to its supporting arm that it will be adjustable by rotation about its vertical axis in such a manner that any pair of adjacent cases may be adjusted individually to give indications in two directions as close as 15 degrees apart and may be rigidly clamped in any position throughout the range of adjustment. Provision shall be made for carrying the traffic signal leads enclosed in the mounting attachment.

E. Both the top and bottom of each traffic signal housing case shall be provided with an opening of two inches (50 mm) in diameter to accommodate 1-1/2" (38 mm) pipe brackets. A locking ring shall be integrally cast or molded around the bottom opening. Around the top opening shall be either an integrally cast or molded locking ring or a separate splined locking ring designed to fit into notches. The locking rings shall have a minimum of 72 evenly spaced teeth and shall be so designed that the top and bottom rings will mate to provide a perfectly aligned signal head with flush connection between the outer circumference of the sections.

F. Any open end of an assembled signal housing shall be plugged with an ornamental cap and gasket of an approved type.

2.03 HOUSING DOOR

A. The housing door of each traffic signal housing shall be a one one-piece polycarbonate resin material with an approximate 12-inch (300 mm) diameter circular opening for the lens as specified. The housing door shall be a minimum of 0.125 inches (3.18mm) thick measured anywhere on the housing door. The door shall be attached to the housing by means of two stainless steel hinge pins.

B. Two stainless steel wing screws shall be installed on the side of the door to provide for opening and closing the door without the use of special tools. Wing screws shall have a flat-bearing surface or stainless steel flat washer to prevent gouging of the housing door by the wing screws. Wing screws shall remain captive in the housing door when the door is open.

2.04 VISORS

A. Each traffic signal housing door shall be equipped with an easily detachable standard tunnel visor (unless requested otherwise). The visor shall be a polycarbonate resin to match the housing and door. The visor shall be rigidly attached to the door with rust-resistant connections in a manner that will prevent the leakage of light and moisture throughout the periphery of attachment.

B. Unless requested otherwise, the visor on the front of each door shall:

1. Be circular in section

2. Have a downward tilt of 2 to 8 degrees

3. Encompass approximately 300 degrees of the lens

4. Extend outward from the face of the lens a minimum of 9-1/2" (240 mm) for 12inch (300 mm) diameter lens, (measured at its outer visible circumference)

5. Be of such design that the encircled portion of the lens will not be visible in the profile view of the traffic signal face

6. Be open at the bottom so as to prevent the accumulation of snow, dirt, and rain.

C. Visors shall be easily removed and replaced without damage to visor or signal head.

D. The four (4) tabs used to mount the visor to the signal shall be slotted. It shall not be necessary to completely remove the mounting screws to remove or replace the visor.

2.05 OPTICAL SYSTEM

A. The Vehicular Light Emitting Diode (LED) Indications to be furnished with the Vehicle Signal Head shall meet the requirements of Specification Section 16718 - Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement.

2.06 TERMINAL BLOCKS AND ELECTRICAL

A. Terminal blocks shall be either two or seven position and be double row, with each section consisting of two 8-32 x 5/16-in. binding screws and a conducting metal strip between the screws.

B. The terminal blocks shall be a one-piece molded construction using phenolic materials, rated for a minimum 20 amps, 250 volt service

C. Each LED module shall be wired to a two position terminal block located in that signal section. A seven position terminal block shall be furnished in the outermost signal section of any 3 or more section vehicle signal head assembly. All sections of the vehicle signal head assembly shall be wired to the seven position terminal block. All terminal blocks shall be securely mounted in an accessible position and shall be of weatherproof-molded construction, equipped with identified terminals. Binding screws shall be provided for the field and interior wires.

D. Maintain throughout the vehicle signal head the color coding for wires from the LED Module to the main terminal block as shown below:

Indication	Color Code
Red Ball / Arrow	Red
Yellow Ball	Yellow
Green Ball	Green
Yellow Arrow	Yellow with Blue or White Tracer Green
Arrow	Green with Blue or White Tracer Neutral White

2.07 MOUNTING ATTACHMENTS

A. All mounting attachments shall be aluminum. Provision shall be made for carrying the signal leads enclosed in the mounting attachment. The mounting attachment, together with supporting arms and assembled housings, shall comprise a dust-and-moisture-proof enclosure for optical units and lead wiring. Mounting attachments shall be of one of the following types as specified for the particular vehicle signal head required.

1. Span-Wire Mounting. The span-wire mounting attachment shall consist of a cable clamp to receive a suspension cable of 3/8" (10 mm) diameter together with a suitable connection to the signal head. The mounting shall provide a "balance adjuster" between the signal head and span wire capable of permitting freedom of movement with reference to the point of suspension. The signal head shall be adjustable by rotation about its vertical axis in a horizontal plane and the mounting attachment shall be so constructed that the head may be firmly clamped in any position throughout the range of adjustment. The mounting shall provide a suitable outlet for wiring from the signal head tilted downward and so constructed as to effectively seal the interior of the head from dust and moisture and prevent undue abrasion of signal wiring. Mountings for signal head units not balanced at the point of support shall be provided with a suitable compensating device to insure that the signal head will assume a normally vertical position. The mast-arm vehicle signal head mounting hardware shall be Astro-Brac Atlas Large Capacity Cable Mount assembly, or approved equal.

2. Mast-Arm Mounting. The mast-arm vehicle signal head mounting hardware shall be Astro-Brac Atlas Large Capacity Tenon Mount assembly, or approved equal.

3. Side-of-Pole Mounting. Supports for side-of-pole mounting of the signal head in a vertical position shall be 1-1/2" standard pipe bracket arms, attached to the top and bottom of the signal head with pipe nipples, serrated elbows and collared / cast nipples and band-on pole plates. Pole plates shall be provided with a cable guide. The mounting assembly shall consist of two standard pipe sections extending 12- 3/4" from and at right angles to the axis of rotational adjustment of the signal head. Both supports shall have running threads at least 1-1/4" long at the pole connection end. The signal head shall be adjustable, by rotation of the various signal faces about their vertical axis, throughout a radial angle of 360 degrees and shall be capable of being rigidly clamped in any position through the range of adjustment. The wiring from the signal head shall be able to be enclosed in the top or bottom support.

2.08 LOUVERED VEHICLE SIGNAL HEAD BACK PLATE

A. The back plate shall be attached to all new vehicle signals. Back plate shall be continuously louvered around its perimeter.

B. Back plates shall be vacuum formed ABS plastic or aluminum.

C. Vacuum formed ABS plastic back plates shall contain ultraviolet inhibitors and stabilizers for protection against UV degradation

D. The back plate shall extend around the periphery of the signal face a distance of five (5) inches for faces with twelve (12) inch lenses, and shall have a 3” corner radius.

E. ABS vacuum formed back plates shall be black and color consistent throughout the entire piece without varying shades and tones.

F. The louvers shall be evenly spaced around the back plate, including the top and bottom. The number of louvers adjacent to the vehicle signal head shall be nine (9) per signal section per side. Both the top and bottom back plate sections shall have nine (9) louvers each. The louvers shall be at least 3-1/2” long by 5/8” wide with an opening of at least ¼”. The back plate shall be pre-drilled to fit the vehicle signal head for which it is designed.

G. ABS vacuum formed back plates shall have a minimum thickness of .125”. All outside edges shall be formed with a ½” to 5/8” flange (inside dimension) turned away from the front surface. The back plate shall have a haircell finish on the front side and smooth finish on the back side.

H. Aluminum back plates shall be fabricated from anodized sheet aluminum and be painted dull black.

I. Stainless steel hardware for attaching the back plate to the vehicle signal head shall be provided.

2.09 GEOMETRICALLY PROGRAMMED LOUVER (GPL)

A. The louver shall have the following capabilities:

1. Fit all manufacturers' 12" vehicle signal heads.

2. Retrofit into existing 12" vehicle signal heads.

3. Provide a full round ball display, with minimum slat effect, throughout the selected view range.

4. Provide an absolute exact visual cut-off.

5. Allow the view angle within each signal section to be adjusted to a designated area.

6. Have minimum glow outside the view range.

7. Allow for controlling either the horizontal or vertical view range within the signal visor.

B. The louver housing shall consist of a two-piece assembly injection molded from black UV inhibited ABS plastic. Two (2) brass inserts shall be molded into the bottom half allowing the assembly to be fastened together with two (2) stainless steel screws.

C. The louver housing O.D. shall be 11-1/2" and have spherical contour which allows the light beam from the signal section to be directed up to 10-degrees in all directions from the centerline of the visor/lens system.

D. The inside surface shall have a multiplicity of grooves for positioning light directing baffles. The remaining inside surface shall be grooved to prevent surface reflections of light.

E. Two (2) sponge neoprene O-rings shall be positioned in grooves on the outside surface to prevent light leakage between the housing and the visor.

F. The louver housing design shall allow the baffle positions to be changed in order to adjust the view angle.

G. The baffles shall be molded from flat black, 10% glass filled UV inhibited virgin polycarbonate.

H. Each baffle shall be thin opaque disc with a multiple of parallel evenly spaced apertures (openings). Each structural member forming the aperture shall have a cross section which allows for good stiffness and structural integrity, but shall have a thin edge to prevent reflection (glow) outside the desired viewing range.

I. All baffles shall be identical in design and interchangeable within the housing. The plane of each baffle shall be 90-degrees to the centerline axis of the housing.

J. The louver shall be supplied with the necessary self-threading screw hardware to attach the louver to the vehicle signal head visor.

K. The louver shall include an installation kit that includes installation instructions, adjustment tool, visor marking template, and all incidentals necessary for attachment and positioning of the louver.

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 16716

PEDESTRIAN SIGNAL HEADS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Pedestrian Signal Heads with mounting attachments, and countdown pedestrian signal module with light emitting diode (LED) lamp indications.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 16719 – Countdown Pedestrian Signal Module

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

B. Pedestrian Signal Heads will be measured by each pedestrian signal head assembly required with specified mounting hardware. Pedestrian Signal Heads shall consist of each pedestrian signal housing assembly with mounting hardware, and countdown pedestrian signal module with LED indications. The Pedestrian Signal Head housing shall be Federal Highway Yellow.

C. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Pedestrian Signal Head Including Countdown Module". This price shall be full compensation for furnishing, assembling, and installing the pedestrian signal head and countdown pedestrian signal module complete with LED indications; and for all mounting hardware, labor, tools, equipment, and incidentals necessary to complete the Work as specified.

D. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ITE - Adjustable Face Pedestrian Head Standard

B. TxDOT - Texas Manual on Uniform Traffic Control Devices (TMUTCD)

PART 2 PRODUCTS

2.01 MATERIALS

A. Manufacturers/suppliers furnishing these items shall be experienced in design and construction of such items and shall furnish evidence of having supplied similar items, which have been in successful operation for not less than three (3) years.

B. The lamp units shall be a single, self-contained device, not requiring on-site assembly for installation into an existing traffic signal housing. If proper orientation of the lamp units is required for optimum performance, prominent and permanent directional markings, i.e., UP ARROW or the word UP or TOP, for correct indexing shall be clearly marked on each unit as to configuration and mounting orientation.

2.02 GRID TYPE PEDESTRIAN SIGNAL – LED

It is the intent of this specification to describe minimum acceptable design and operating requirements for an LED illuminated grid type pedestrian signal.

A. General Design Requirements

1. Design, material and construction of LED pedestrian signal heads shall be in accordance with requirements set forth in "Adjustable Face Pedestrian Head Standard", of the Institute of Transportation Engineers and the "Texas Manual on Uniform Traffic Control Devices", latest revision.

2. The general construction shall include a single-piece cast aluminum housing, a solid state LED indication, message lens, a single-piece cast aluminum swing down door frame, a blank out Z-crate type sun visor, and appropriate other hardware. The design shall optimize performance per unit of energy consumed.

3. Optically, the pedestrian signal shall be capable of displaying brightly and uniformly, while being subject to strong ambient light conditions, the alternate symbol messages "HAND" and countdown numbers in Portland orange, and "WALKING PERSON" in lunar white. Under the same strong ambient light conditions, the messages shall blank out when signal is not energized.

4. The maximum overall dimensions of the signal housing shall be 19 inches wide, 18- 3/4 inches high, and 9-1/2 inches deep including the Z-crate type sun visor and hinges.

B. Mechanical Construction

1. The housing shall be one-piece, corrosion-resistant, die-cast aluminum alloy.

2. The housing shall be designed in such a way that all components and wiring are readily accessible by means of a hinged door and legend cover plate of the full size of housing face.

3. Gasketing material suitable to maintain weather, dust-tight seal about door and cover plates shall be used.

4. The door frame shall be a one-piece, corrosion-resistant aluminum alloy die casting, complete with two-hinged lugs at the bottom and two-latch slots cast at the top of each door. Hinge pins shall be corrosion-resistant material. Two stainless steel wing nuts and washers shall be attached to the top of the cast with the use of stainless steel spring pins. Latching or unlatching of the door shall require no tools.

C. Z-Crate Visor

1. The face of the signal shall be furnished with suitable Z-crate visor baffle designed to prevent false indications, due to sunlight or other reflections, without the use of hoods.

2. The visor baffle shall have a high-grade, flat black finish.

D. Optical System-LED Pedestrian Signals

1. The LED indications to be furnished with the Pedestrian Signal Heads shall meet the requirements of Specification Section 16719 - Countdown Pedestrian Signal Module.

E. Wiring

1. All wiring shall be Underwriters' Laboratories (UL) approved for voltages involved. Terminals for field wiring shall be suitable for #14 AWG wire.

2. Barrier type terminal block, minimum twelve (12) terminal plates with two (2) binding screws each, shall be mounted in each housing.

F. Mounting Attachments

1. Side-of-Pole Mounting: Supports for side-of-pole mounting of the signal head in a vertical position shall be 1-1/2" standard pipe bracket arms, attached to the top and bottom of the signal head with pipe nipples, serrated elbows and collared / cast nipples and band-on pole plates. Pole plates shall be provided with a cable guide. The mounting assembly shall consist of two standard pipe sections extending 12-3/4" from and at right angles to the axis of rotational adjustment of the signal head. Both supports shall have running threads at least 1-1/4" long at the pole connection end. The signal head shall be adjustable, by rotation of the various signal faces about their vertical axis, throughout a radial angle of 360 degrees and shall be capable of being rigidly clamped in any position through the range of adjustment. The wiring from the signal head shall be able to be enclosed in the top or bottom support.

G. Painting

1. Pedestrian signal housing and mounting attachments shall be available in two finishes. If no color is indicated, a yellow coating, as specified below, shall be furnished.

2. Federal Highway Yellow Finish: Signal housing and mounting attachments shall be primed and electrostatically finished with a yellow coating, except for baffle with paint finish. Finish shall be cured for minimum of twenty (20) minutes at 350 degrees F.

3. Flat Black Finish: Signal housing and mounting attachments shall be primed and finished with a flat black paint finish. Finish shall be cured for a minimum of twenty (20) minutes at 350 degrees F.

PART 3 EXECUTION - NOT USED

END OF SECTION

SECTION 16718

VEHICLE TRAFFIC CONTROL SIGNAL HEADS –
Light Emitting Diode (LED) Circular Signal Supplement

PART 1 GENERAL

1.01 SECTION INCLUDES

A. The purpose of this specification is to provide the minimum performance requirements for a 300 mm (12 in) Light Emitting Diode (LED) vehicle traffic signal module while in service. This specification is not intended to impose restrictions upon specific designs and materials that conform to the purpose and the intent of this specification. This specification is not restricted to any specific LED technology.

1.02 DEFINITIONS

A. Catastrophic Failure: The total loss of visible illumination from an LED Light source.

B. Chromaticity: The color of the light emitted by a module, specified by the x, y chromaticity coordinates on the 1931 Commission Internationale d'Eclairage (CIE) chromaticity diagram.

C. Conditioning: Energizing a LED Signal Module at a specified ambient temperature for a specified period of time, to cause any early electronic component mortality failures to occur and to detect any component reliability problems.

D. Duty Cycle: The amount of time during a specified time period that a module is energized, expressed as a percent of the specified time period.

E. Hard Coat: A surface coating or film to provide front surface abrasion resistance.

F. LED Light Source: A single light emitting diode (LED) or an array of LEDs.

G. LED Signal Module (module): A signaling unit comprised of an array of LEDs and related power supply, and any required lenses, which, when connected to appropriate power, provides a circular signal indication.

H. Luminance: The luminous flux emitted or reflected from a surface, in a given direction, per unit solid angle, divided by the area of the surface, expressed as cd/m2.

I. Luminous Intensity: The luminous flux emitted in a given direction from a source, per unit solid angle, expressed in candelas (cd).

J. Minimum Maintained Luminous Intensity: The minimum Luminous Intensity a module is required to provide throughout service as a traffic control signal.

K. Nominal Operating Voltage: The AC RMS voltage, 120 VAC, at which photometric performance and Power Consumption are specified.

L. Power Consumption: The electrical power in Watts consumed by a module when operated at Nominal Operating Voltage and ambient operating temperature range.

M. Power Factor: The Power Factor equals Watts divided by Volt-Ampere or the ratio of Power Consumption in Watts to Volt-Amperes.

N. Total Harmonic Distortion (THD): THD is the ratio of the root-mean-square (RMS) value of the harmonics to the amplitude of the fundamental component of the AC waveform.

O. Translate: To move an object along a linear vector, such that the orientation of the object does not rotate relative to the original frame of reference.

P. Turn OFF Time: The amount of time required after removal of the Nominal Operating Voltage for the LED Signal Module to show no visible illumination.

Q. Turn OFF Voltage: The voltage below which the LED Signal Module emits no visible illumination.

R. Turn ON Time: The amount of time required for the LED Signal Module to reach 90% of full illumination.

S. Volt-Amperes: The product of the root-mean-square (RMS) line voltage and RMS line current, measured with true RMS meters.

T. Diffused: Lens must be designed to diffuse the light form the LED array over the surface of the lens.

1.03 ENVIRONMENTAL REQUIREMENTS

A. All exposed components of a module shall be suitable for prolonged exposure to the environment, without appreciable degradation that would interfere with function or appearance. As a minimum, selected materials shall be rated for service for a period of a minimum of 72 months.

B. A module shall be rated for use throughout an ambient operating temperature range, measured at the exposed rear of the module, of -40°C (-40°F) to +74°C (+165°F).

C. A module shall be protected against dust and moisture intrusion, including rain and blowing rain.

D. The module lens shall not crack, craze or yellow due to solar UV irradiation after a minimum of 72 months in service.

1.04 REFERENCES

A. Federal Communication Commission (FCC) Title 47, Subpart B, Section 15

B. NFPA 70, National Electrical Code

C. Society of Automotive Engineers (SAE) J576 – Plastic Materials for Use in Optical Parts

PART 2 PRODUCTS

2.01 MATERIALS

A. LED SIGNAL MODULE

1. A module shall be capable of replacing the existing optical components or signal module in a signal housing, or shall provide a complete replacement of the signal head.

2. The module lens shall be Hard Coated or otherwise made to comply with the material exposure and weathering effects requirements of the Society of Automotive Engineers (SAE) J576.

3. The module lens supplied shall be covered by transparent film or materials with similar color and transmissive characteristics.

4. The module lens may be a replaceable part, without the need to replace the complete LED Signal Module. Removal of lens will be with simple hand tools and such that no inclusion of additional adhesive, sealants, etc., will be required to provide replacement of lens.

5. Materials used for the lens and module construction shall conform to ASTM specifications for the materials, where applicable.

6. Lens must diffuse the LED array over the entire surface of the lens.

7. LED Modules used for arrows must meet same photometric and Chromaticity requirements as circular modules. (optional)

8. Enclosures containing either the power supply or electronic components of the signal module shall be made of UL94 flame retardant materials. The module lens is excluded from this requirement.

2.02 MODULE IDENTIFICATION

A. Each module shall be identified on the backside with the manufacturer’s name, model, operating characteristics and serial number. The operating characteristics identified shall include the Nominal Operating Voltage and stabilized Power Consumption, in watts and Volt-Amperes.

B. Modules and removable lenses shall have a prominent and permanent vertical indexing indicator, i.e., UP Arrow, or the word UP or TOP, for correct indexing and orientation in the signal housing.

C. Modules conforming to all non-optional requirements of this specification may have the following statement on an attached label: "Manufactured in Conformance with the COH LED Circular Signal Supplement."

2.03 PHOTOMETRIC REQUIREMENTS

A. Luminous Intensity, Uniformity & Distribution.

1. Minimum Maintained Luminous Intensity: When operated under the conditions defined in Sections 1.03.B and 2.04.B.1, the Luminous Intensity values for modules shall not be less than the values calculated using the method described below for a minimum period of 72 months.

2. Calculate the vertical intensity factor ($f(I_{Vert})$) for the range from 12.5 degrees up (+12.5) to 27.5 degrees down (-27.5), using the appropriate equation:

For $\theta_{Vert} > -2.5$ degrees:

$$f(I_{Vert}) = 0.05 + 0.9434 * e^{-\left(\frac{\theta_{Vert}+2.5}{5.3}\right)}$$

For θ_{Vert} :S -2.5 degrees:

$$f(I_{Vert}) = 0.26 + \left(\frac{\theta Vert}{143}\right) + 0.76 * \left[e^{-0.02(\theta_{Vert}+2.5)^2}\right]^{(-0.07*\theta_{Vert})}$$

where: θ_{Vert} is the angle measured above or below a horizontal plane perpendicular to the face of the module lens. (Note: angles above the horizontal plane are positive, while angles below the horizontal plane are negative.)

3. Calculate the horizontal intensity factor ($f(I_{Horiz})$) for the range from 27.5 degrees left to 27.5 degrees right:

$$f(I_{Horiz}) = 0.05 + \left(0.95 * e^{\left(-\frac{1}{2}*\left(\frac{\theta_{Horiz}}{11}\right)^2\right)}\right)$$

where: θ_{Horiz} is the angle measured from a vertical plane to the left or right,

perpendicular to the face of the module lens.

4. Select the appropriate peak Minimum Maintained Luminous Intensity value for the specified module size and color:

   Peak Minimum Maintained Luminous Intensity values, at $\theta_{Vert} = -2.5$ deg and $\theta_{Horiz} = 0$ deg $[I_{(-2.5,0)}]$, by size and color of the module are:

Color	I (-2.5, 0) 200m	I (-2.5, 0) 300m
Red	165 cd	365cd
Yellow	410 cd	910 cd
Green	215 cd	475 cd

5. Multiply the vertical intensity factor times the horizontal intensity factor (for the selected pair of angles). Round the result to two significant figures, and multiply the combined angular intensity factor times the peak Minimum Maintained Luminous Intensity value for the appropriate signal size and color:

   $I_{(\theta vert, \theta horiz, size, color)} = [f(I_{Vert})*f(I_{Horiz})]*I_{(-2.5,0)}$

   The resultant value of the Luminous Intensity shall be rounded to the nearest whole number.

   Example: What is the Minimum Maintained Luminous Intensity value for a green, 300 mm LED signal light at 5 degrees down and 10 degrees left?

   $I_{(-5, 10, 300, Green)} = [f(I_{Vert}=-5)*f(I_{Horiz}=10)]*475$ cd
   $I_{(-5, 10, 300, Green)} = [0.953*0.678]*475$ cd
   $I_{(-5, 10, 300, Green)} = 0.65*475 = 309$ cd

6. Table 1 located at end of spec., provides the Minimum Maintained Luminous Intensity values, over the required angular range, at 5-degree increments. Note that the horizontal limitations vary for various vertical angles (e.g.: at θ_{Vert} = +12.5 degrees, requirements are only specified from 7.5 degrees right to 7.5 degrees left, while at θ_{Vert} = -12.5 degrees, the horizontal limitations are from 27.5 degrees right to 27.5 degrees left). Table 2 located at end of specification, provides the Minimum Maintained Luminous Intensity values, over the required angular range, at 2.5-degree increments. Tables 1 and 2 are provided to illustrate the minimum required values at certain specific angles within the required angular range of performance (i.e. while testing for light output compliance of a module in a laboratory, an agency may use Table 1, and/or other specific pairs of vertical and horizontal angles of its choosing within the required angular range.) One must use the procedure outlined above for determining the Minimum Maintained Luminous Intensity values at any specific pairs of vertical and horizontal angles within the required angular range.

7. Maximum permissible Luminous Intensity: When operated within the temperature range specified in Section 1.03.B, the actual Luminous Intensity for a module shall not exceed three times the required peak value of the Minimum Maintained Luminous Intensity for the selected signal size, and color.

8. Luminance uniformity: The uniformity of the signal output across the entire module lens shall not exceed a ratio of 10 to 1 between the maximum and minimum Luminance values (cd/m2).

B. Chromaticity

1. Color regions: The measured Chromaticity coordinates of modules shall conform to the following color regions, based on the 1931 CIE Chromaticity diagram (see Figure 1):

Red: y = 0.308; y = 0.953 – 0.947x; y = 0.290:

Point	Red	
	X	Y
1	0.692	0.308
2	0.681	0.308
3	0.700	0.290
4	0.710	0.290

Yellow: y = 0.151 + 0.556x; y = 0.972 – 0.976x; y = 0.235 + 0.300x:

Point	Yellow	
	X	Y
1	0.545	0.454
2	0.536	0.449
3	0.578	0.408
4	0.588	0.411

Green: y = 0.655 - 0.831xx = 0.150; y = 0.422 - 0.278x:

Point	Green	
	X	Y
1	0.005	0.651
2	0.150	0.531
3	0.150	0.380
4	0.022	0.416

2. Color uniformity: The dominant wavelength for any individual color measurement of a portion of the emitting surface of a module shall be within ±3nm of the dominant wavelength for the average color measurement of the emitting surface as a whole.

2.04 ELECTRIC

A. All wiring and terminal blocks shall meet the requirements. Two secured, color coded, 600V, jacketed wires, a minimum of 20 AWG and at least 1 meter (39 in) in length, conforming to the NFPA 70, National Electrical Code, and rated for service at +105°C, shall be provided.

B. Voltage Range

1. LED Signal Modules shall operate from a 60±3 Hz AC line power over a voltage range from 80 to 135 VAC RMS.

2. Fluctuations in line voltage over the range of 80 to 135 VAC shall not affect Luminous Intensity by more than ±10 percent.

3. The module circuitry shall prevent flicker of the LED output at frequencies less than 100 Hz over the voltage range specified in Section 2.04B.1.

4. Low Voltage Turn OFF: There shall be no visible illumination from the LED Signal Module when the applied voltage is less than 35 VAC.

5. Turn-ON and Turn-OFF Time: A module shall reach 90% of full illumination (turn-ON) within 75 msec of the application of the Nominal Operating Voltage. The signal shall cease emitting visible illumination (turn-OFF) within 75 msec of the removal of the Nominal Operating Voltage.

C. Transient Voltage Protection

1. The on-board circuitry of a module shall include voltage surge protection, to withstand high-repetition noise transients and low-repetition high-energy transients.

D. Input Protection (optional)

1. At the point of entry to the module for each input provide two 0.5-Ohm, 10-watt wire- wound power resistors with 0.2 micro Henries inductance (one on the AC+ Line & on the AC- Line). Provide one 20 Joule surge arrestor between AC+ to AC-. A 0.68 microfarad capacitor must be placed between AC+ & AC – (between the resistor & arrestor).

E. Electronic Noise

1. The LED signal and associated on-board circuitry shall meet the requirements of the Federal Communication Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise by Class A digital devices.

F. Power Factor and AC Harmonies

1. Modules shall provide a Power Factor of 0.90 or greater when operated at Nominal Operating Voltage, and 25ºC (77ºF).

2. Total Harmonic Distortion induced into an AC power line by a module at Nominal Operating Voltage, and at 25ºC (77ºF), shall not exceed 20%.

G. Controller Assembly Compatibility

1. The current draw shall be sufficient to ensure compatibility and proper triggering and operation of load current switches and conflict monitors in signal controller units.

2. Off State Voltage Decay: When the module is switched from the On state to the Off state the terminal voltage shall decay to a value less than 10 VAC RMS in less than 100 milliseconds when driven by a maximum allowed load switch leakage current of 10 milliamps peak (7.1 milliamps AC).

H. Failed State Impedance

1. The module shall be designed to detect catastrophic loss of the LED load. Upon sensing the loss of the LED load, the module shall present a resistance of at least 250 kn across the input power leads within 300 msec. The LED Light source will be said to have failed catastrophically if it fails to show any visible illumination when energized according to Section 2.04B.1 after 75 msec.

PART 3 EXECUTION

3.01 PHYSICAL & MECHANICAL REQUIREMENTS

A. General

1. Modules shall fit into existing traffic signal housings built to the VTCSH Standard without modification to the housing, or shall be stand-alone units that incorporate a housing meeting the performance and design requirements of the VTCSH Standard.

2. Installation of a module into an existing signal housing shall not require the use of special tools. The module shall connect directly to existing electrical wiring system.

3.02 CONSTRUCTION

A. A module shall be a self-contained device, not requiring on-site assembly for installation into an existing traffic signal housing. The power supply for the module may be either integral or packaged as a separate component. The power supply may be designed to fit and mount inside the traffic signal housing adjacent to the LED Signal Module.

B. Assembly and manufacturing processes for a module shall be designed to assure all internal LED and electronic components are adequately supported to withstand mechanical shock and vibration due to high winds and other sources.

Table 1

Table 1 provides the Minimum Maintained Luminous Intensity values for the Section 16718 COH SPEC. LED Circular Signal, for the range from 12.5 degrees above to 22.5 degrees below the horizontal plane, and from 27.5 degrees left to 27.5 degrees right of the vertical plane, at 5 degree increments.

Minimum Maintained Luminous Intensity Values—Section 16718 COH SPEC LED Circular Signal

Vertical Angle	Horizontal Angle	Luminous Intensity (candela)					
		200m (8-inch)			300 mm (12-inch)		
		Red	Yellow	Green	Red	Yellow	Green
+12.5	2.5	17	41	22	37	91	48
	7.5	13	33	17	29	73	38
+7.5	2.5	31	78	41	69	173	90
	7.5	25	62	32	55	137	71
	12.5	18	45	24	40	100	52
+2.5	2.5	68	168	88	150	373	195
	7.5	56	139	73	124	309	162

Vertical Angle	Horizontal Angle	Luminous Intensity (candela)					
		200m (8-inch)			300 mm (12-inch)		
		Red	Yellow	Green	Red	Yellow	Green
	12.5	38	94	49	84	209	109
	17.5	21	53	28	47	118	62
	22.5	12	29	15	26	64	33
-2.5	2.5	162	402	211	358	892	466
	7.5	132	328	172	292	728	380
	12.5	91	226	118	201	501	261
	17.5	53	131	69	117	291	152
	22.5	28	70	37	62	155	81
	27.5	15	37	19	33	82	43
-7.5	2.5	127	316	166	281	701	366
	7.5	106	262	138	234	582	304
	12.5	71	176	92	157	391	204
	17.5	41	103	54	91	228	119
	22.5	21	53	28	47	118	62
	27.5	12	29	15	26	64	33
-12.5	2.5	50	123	65	110	273	143
	7.5	40	98	52	88	218	114
	12.5	28	70	37	62	155	81
	17.5	17	41	22	37	91	48
	22.5	8	21	11	18	46	24
	27.5	5	12	6	11	27	14
-17.5	2.5	23	57	30	51	127	67
	7.5	18	45	24	40	100	52
	12.5	13	33	17	29	73	38
	17.5	7	16	9	15	36	19
	22.5	3	8	4	7	18	10
-22.5	2.5	17	41	22	37	91	48
	7.5	13	33	17	29	73	38
	12.5	10	25	13	22	55	29
	17.5	5	12	6	11	27	14
-27.5	2.5	12	29	15	26	64	33
	7.5	8	21	11	18	46	24

Note 1: Luminous Intensity values for equivalent left and right horizontal angles are the same. Note 2: Tabulated values of Luminous Intensity are rounded to the nearest whole value.

Table 2

Table 2 provides the Minimum Maintained Luminous Intensity values for the Section 16718 COH SPEC LED Circular Signal, for the range from 12.5 degrees above to 22.5 degrees below the horizontal plane, and from 27.5 degrees left to 27.5 degrees right of the vertical plane, at 2.5 degree increments.

Minimum Maintained Luminous Intensity Values—Section 16718 COH SPEC LED Circular Signal

Vertical Angle	Horizontal Angle	Luminous Intensity (candela)					
		200m (8-inch)			300 mm (12-inch)		
		Red	Yellow	Green	Red	Yellow	Green
+12.5	0.0	18	45	24	40	100	52
	2.5	17	41	22	37	91	48
	5.0	17	41	22	37	91	48
	7.5	13	33	17	29	73	38
+10.0	0.0	23	57	30	51	127	67
	2.5	23	57	30	51	127	67
	5.0	21	53	28	47	118	62
	7.5	18	45	24	40	100	52
+7.5	0.0	31	78	41	69	173	90
	2.5	31	78	41	69	173	90
	5.0	28	70	37	62	155	81
	7.5	25	62	32	55	137	71
	10.0	21	53	28	47	118	62
	12.5	18	45	24	40	100	52
+5.0	0.0	46	115	60	102	255	133
	2.5	45	111	58	99	246	128
	5.0	41	103	54	91	228	119
	7.5	36	90	47	80	200	105
	10.0	31	78	41	69	173	90
	12.5	25	62	32	55	137	71
+2.5	0.0	69	172	90	153	382	200
	2.5	68	168	88	150	373	195
	5.0	63	156	82	139	346	181
	7.5	56	139	73	124	309	162
	10.0	46	115	60	102	255	133
	12.5	38	94	49	84	209	109
	15.0	30	74	39	66	164	86
	17.5	21	53	28	47	118	62
	20.0	17	41	22	37	91	48
	22.5	12	29	15	26	64	33
0.0	0.0	106	262	138	234	582	304
	2.5	102	254	133	226	564	295
	5.0	96	238	125	212	528	276
	7.5	84	209	110	186	464	242
	10.0	71	176	92	157	391	204
	12.5	58	144	75	128	319	166
	15.0	45	111	58	99	246	128
	17.5	33	82	43	73	182	95
	20.0	25	62	32	55	137	71
	22.5	18	45	24	40	100	52

Vertical Angle	Horizontal Angle	Luminous Intensity (candela)					
		200m (8-inch)			300 mm (12-inch)		
		Red	Yellow	Green	Red	Yellow	Green
-2.5	0.0	165	410	215	365	910	475
	2.5	162	402	211	358	892	466
	5.0	150	373	196	332	828	432
	7.5	132	328	172	292	728	380
	10.0	112	279	146	248	619	323
	12.5	91	226	118	201	501	261
	15.0	71	176	92	157	391	204
	17.5	53	131	69	117	291	152
	20.0	38	94	49	84	209	109
	22.5	28	70	37	62	155	81
	25.0	20	49	26	44	109	57
	27.5	15	37	19	33	82	43
-5.0	0.0	157	390	204	347	865	451
	2.5	153	381	200	339	846	442
	5.0	142	353	185	314	783	409
	7.5	125	312	163	277	692	361
	10.0	107	267	140	237	592	309
	12.5	86	213	112	190	473	247
	15.0	66	164	86	146	364	190
	17.5	50	123	65	110	273	143
	20.0	36	90	47	80	200	105
	22.5	26	66	34	58	146	76
	25.0	20	49	26	44	109	57
	27.5	15	37	19	33	82	43
-7.5	0.0	130	324	170	288	719	375
	2.5	127	316	166	281	701	366
	5.0	119	295	155	263	655	342
	7.5	106	262	138	234	582	304
	10.0	89	221	116	197	491	257
	12.5	71	176	92	157	391	204
	15.0	56	139	73	124	309	162
	17.5	41	103	54	91	228	119
	20.0	30	74	39	66	164	86
	22.5	21	53	28	47	118	62
	25.0	17	41	22	37	91	48
	27.5	12	29	15	26	64	33
-10.0	0.0	89	221	116	197	491	257
	2.5	86	213	112	190	473	247
	5.0	81	201	105	179	446	233
	7.5	71	176	92	157	391	204
	10.0	59	148	77	131	328	171
	12.5	48	119	62	106	264	138

Vertical Angle	Horizontal Angle	Luminous Intensity (candela)					
		200m (8-inch)			300 mm (12-inch)		
		Red	Yellow	Green	Red	Yellow	Green
	15.0	38	94	49	84	209	109
	17.5	28	70	37	62	155	81
	20.0	20	49	26	44	109	57
	22.5	15	37	19	33	82	43
	25.0	12	29	15	26	64	33
	27.5	8	21	11	18	46	24
-12.5	0.0	50	123	65	110	273	143
	2.5	50	123	65	110	273	143
	5.0	46	115	60	102	255	133
	7.5	40	98	52	88	218	114
	10.0	35	86	45	77	191	100
	12.5	28	70	37	62	155	81
	15.0	21	53	28	47	118	62
	17.5	17	41	22	37	91	48
	20.0	12	29	15	26	64	33
	22.5	8	21	11	18	46	24
	25.0	7	16	9	15	36	19
	27.5	5	12	6	11	27	14
-15.0	0.0	30	74	39	66	164	86
	2.5	30	74	39	66	164	86
	5.0	28	70	37	62	155	81
	7.5	25	62	32	55	137	71
	10.0	20	49	26	44	109	57
	12.5	17	41	22	37	91	48
	15.0	13	33	17	29	73	38
	17.5	10	25	13	22	55	29
	20.0	7	16	9	15	36	19
	22.5	5	12	6	11	27	14
-17.5	0.0	23	57	30	51	127	67
	2.5	23	57	30	51	127	67
	5.0	21	53	28	47	118	62
	7.5	18	45	24	40	100	52
	10.0	17	41	22	37	91	48
	12.5	13	33	17	29	73	38
	15.0	10	25	13	22	55	29
	17.5	7	16	9	15	36	19
	20.0	5	12	6	11	27	14
	22.5	3	8	4	7	18	10
-20.0	0.0	20	49	26	44	109	57
	2.5	20	49	26	44	109	57
	5.0	18	45	24	40	100	52
	7.5	17	41	22	37	91	48

Vertical Angle	Horizontal Angle	Luminous Intensity (candela)					
		200m (8-inch)			300 mm (12-inch)		
		Red	Yellow	Green	Red	Yellow	Green
	10.0	13	33	17	29	73	38
	12.5	12	29	15	26	64	33
	15.0	8	21	11	18	46	24
	17.5	7	16	9	15	36	19
-22.5	0.0	17	41	22	37	91	48
	2.5	17	41	22	37	91	48
	5.0	15	37	19	33	82	43
	7.5	13	33	17	29	73	38
	10.0	12	29	15	26	64	33
	12.5	10	25	13	22	55	29
	15.0	7	16	9	15	36	19
	17.5	5	12	6	11	27	14
-25.0	0.0	15	37	19	33	82	43
	2.5	13	33	17	29	73	38
	5.0	13	33	17	29	73	38
	7.5	12	29	15	26	64	33
-27.5	0.0	12	29	15	26	64	33
	2.5	12	29	15	26	64	33
	5.0	10	25	13	22	55	29
	7.5	8	21	11	18	46	24

Note 1: Luminous Intensity values for equivalent left and right horizontal angles are the same.
Note 2: Tabulated values of Luminous Intensity are rounded to the nearest whole value.

Figure 1

Color Regions for LED Traffic Control Signal Lights:

Figure 1 illustrates the acceptable color regions for traffic control signal lights using LED emitters as the light source.

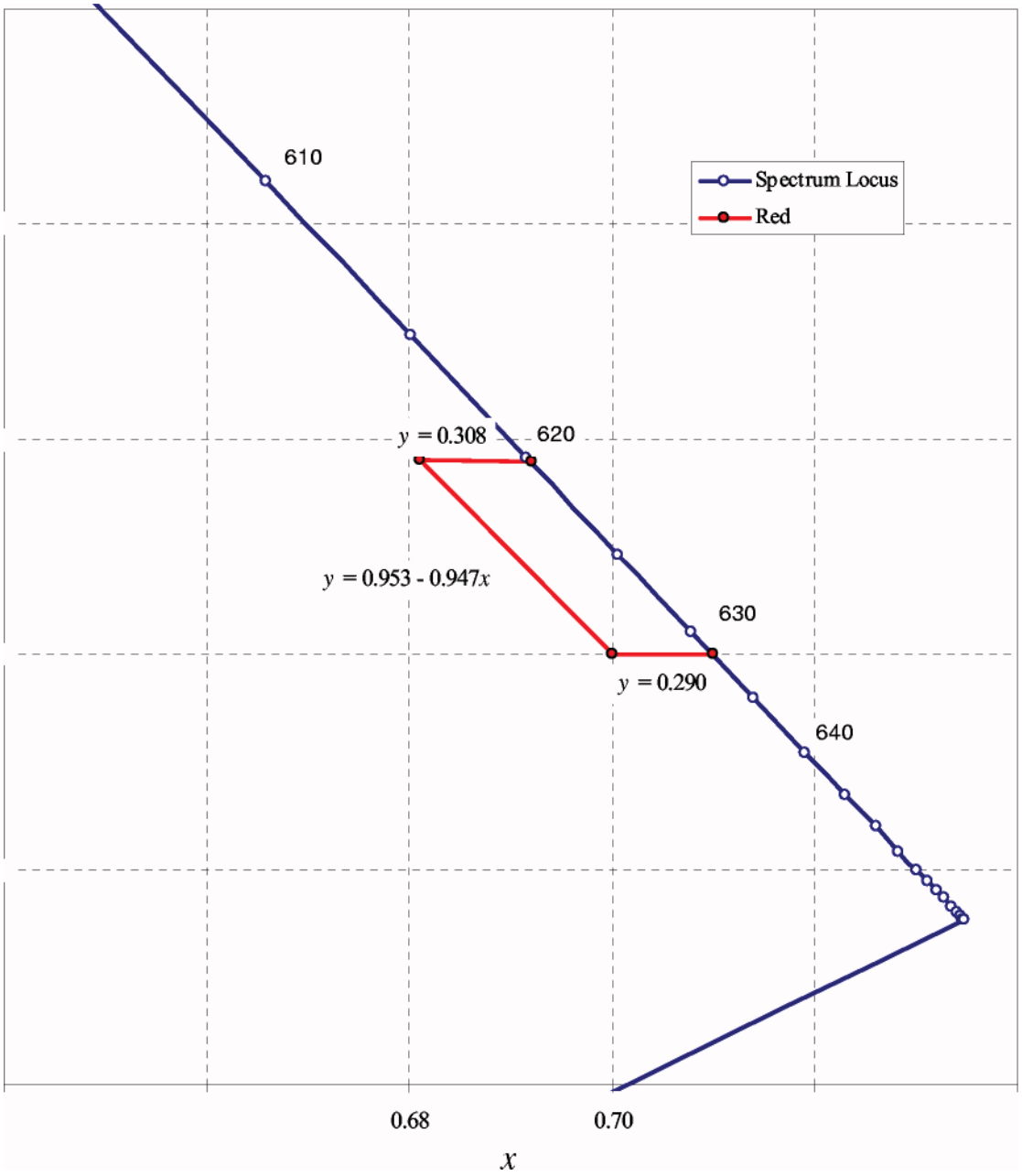


Figure 1a: Color Region for Red Traffic Control Signal Lights
Figure 1 (cont'd)
Color Regions for LED Traffic Control Signal Lights:

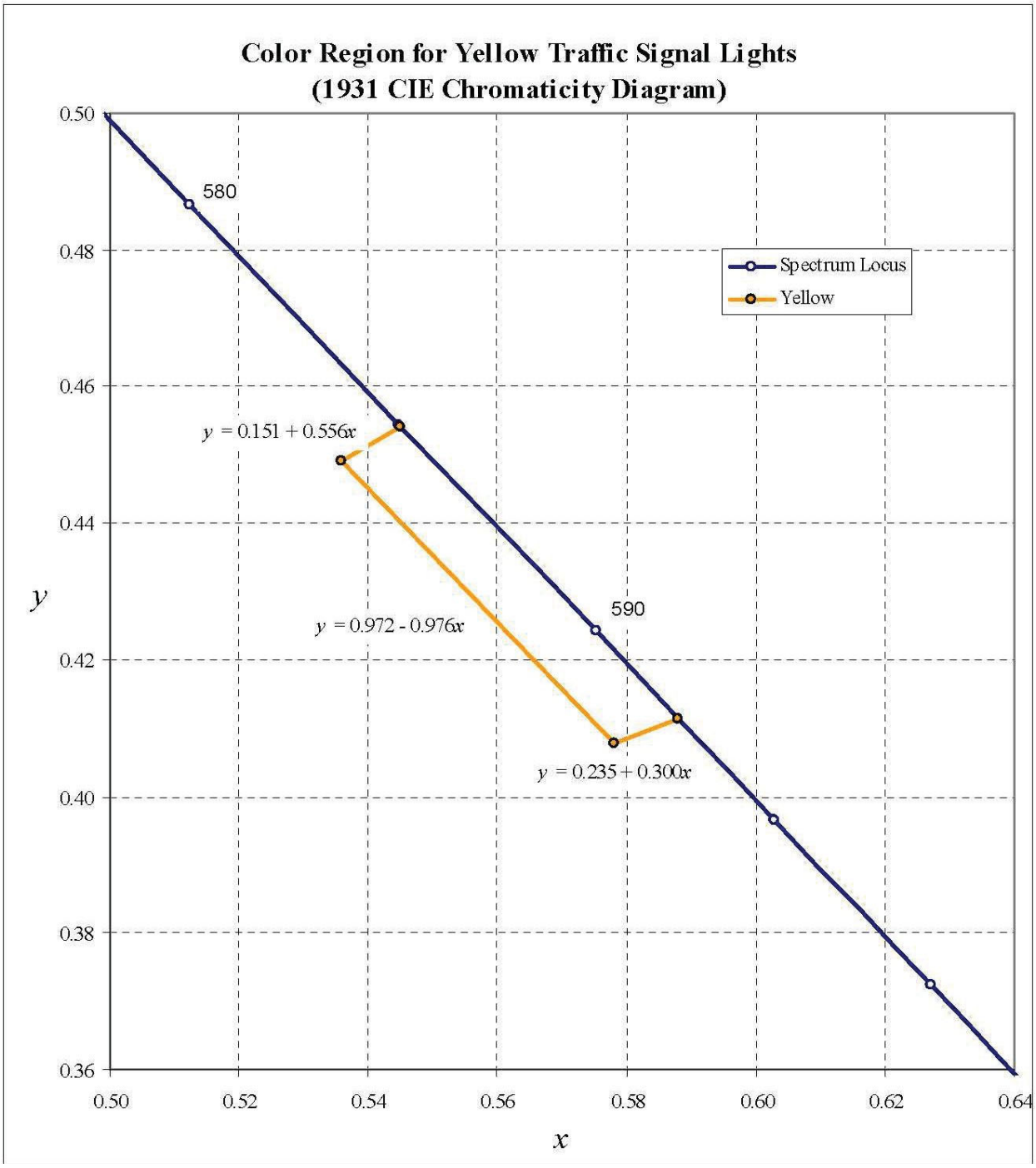


Figure 1b: Color Region for Yellow Traffic Control Signal Lights

Figure 1 (cont'd)

Color Regions for LED Traffic Control Signal Lights:

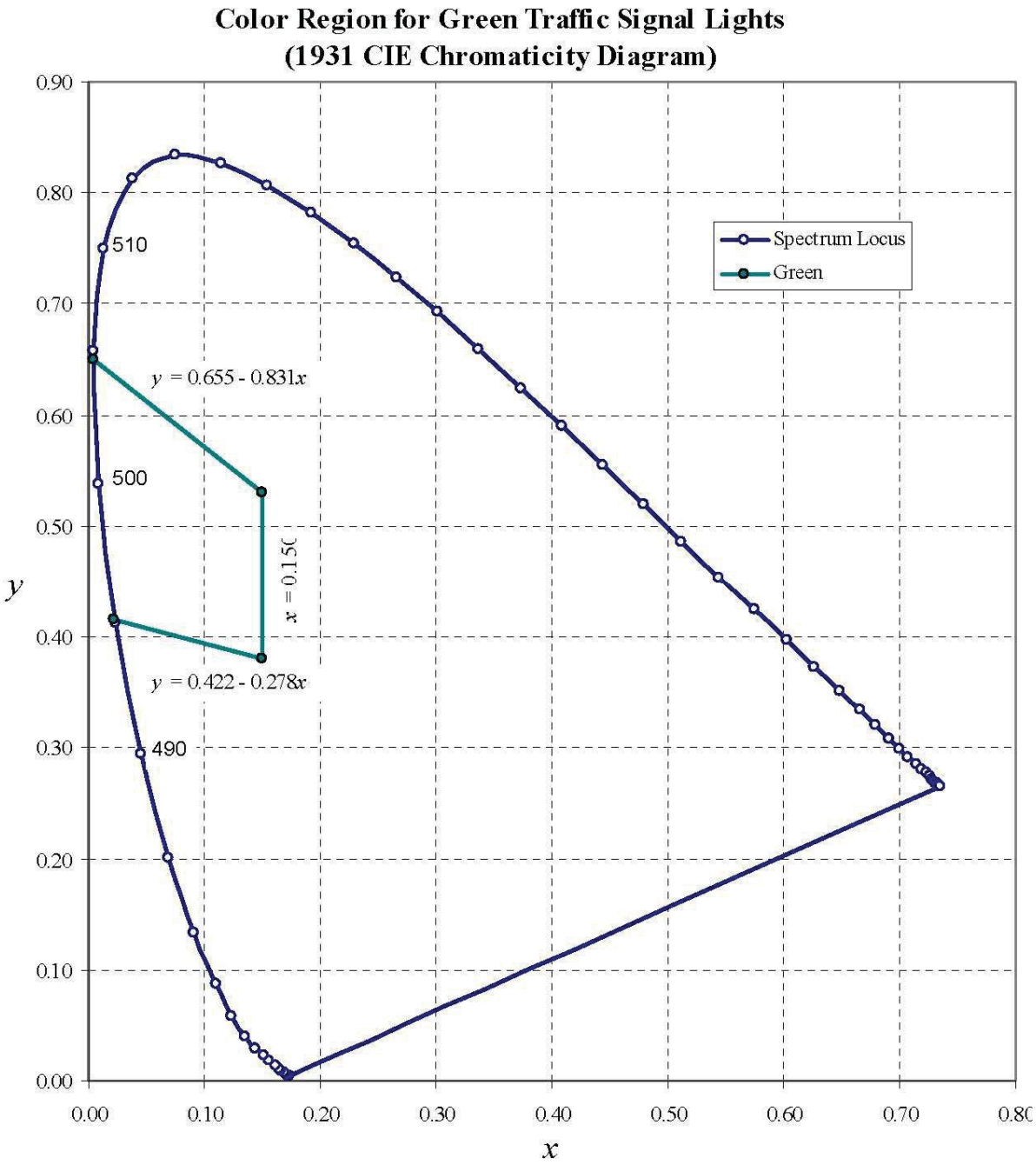


Table 1 a. – Minimum Maintained Luminous Intensity

Vertical Angle	Horizontal Angle	Red 8"		Yellow 8"		Green 8"		RED 12"		Yellow 12"		Green 12"	
		Min.	160%	Min.	110%	Min.	135%	Min.	160%	Min.	110%	Min.	135%
12.5	2.5	17	27	41	45	22	30	37	59	91	100	48	65
	7.5	13	21	33	36	17	23	29	46	73	80	38	51
7.5	2.5	31	50	78	86	41	55	69	110	173	190	90	122
	7.5	25	40	62	68	32	43	55	88	137	151	71	96
	12.5	18	29	45	50	24	32	40	64	100	110	52	70
2.5	2.5	68	109	168	185	88	119	150	240	373	410	195	263
	7.5	56	90	139	153	73	99	124	198	309	340	162	219
	12.5	38	61	94	103	49	66	84	134	209	230	109	147
	17.5	21	34	53	58	28	38	47	75	118	130	62	84
	22.5	12	19	29	32	15	20	26	42	64	70	33	45
-2.5	2.5	162	259	402	442	211	285	358	573	892	981	466	629
	7.5	132	211	328	361	172	232	292	467	728	801	380	513
	12.5	91	146	226	249	118	159	201	322	501	551	261	352
	17.5	53	85	131	144	69	93	117	187	291	320	152	205
	22.5	28	45	70	77	37	50	62	99	155	171	81	109
	27.5	15	24	37	41	19	26	33	53	82	90	43	58
-7.5	2.5	127	203	316	348	166	224	281	450	701	771	366	494
	7.5	106	170	262	288	138	186	234	374	582	640	304	410
	12.5	71	114	176	194	92	124	157	251	391	430	204	275
	17.5	41	66	103	113	54	73	91	146	228	251	119	161
	22.5	21	34	53	58	28	38	47	75	118	130	62	84
	27.5	12	19	29	32	15	20	26	42	64	70	33	45
-12.5	2.5	50	80	123	135	65	88	110	176	273	300	143	193
	7.5	40	64	98	108	52	70	88	141	218	240	114	154
	12.5	28	45	70	77	37	50	62	99	155	171	81	109
	17.5	17	27	41	45	22	30	37	59	91	100	48	65
	22.5	8	13	21	23	11	15	18	29	46	51	24	32
	27.5	5	8	12	13	6	8	11	18	27	30	14	19
-17.5	2.5	23	37	57	63	30	41	51	82	127	140	67	90
	7.5	18	29	45	50	24	32	40	64	100	110	52	70
	12.5	13	21	33	36	17	23	29	46	73	80	38	51
	17.5	7	11	16	18	9	12	15	24	36	40	19	26
	22.5	3	5	8	9	4	5	7	11	18	20	10	14
-22.5	2.5	17	27	41	45	22	30	37	59	91	100	48	65
	7.5	13	21	33	36	17	23	29	46	73	80	38	51
	12.5	10	16	25	28	13	18	22	35	55	61	29	39
	17.5	5	8	12	13	6	8	11	18	27	30	14	19
-27.5	2.5	12	19	29	32	15	20	26	42	64	70	33	45
	7.5	8	13	21	23	11	15	18	29	46	51	24	32

END OF SECTION

SECTION 16719

COUNTDOWN PEDESTRIAN SIGNAL MODULE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Countdown Pedestrian Signal Module and appurtenances.

1.02 RELATED SECTIONS

A. Section 01270 - Measurement and Payment

B. Section 16716 – Pedestrian Signal Heads

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for countdown pedestrian signal modules under this section. Include cost in unit price Work as specified in Section 16716 – Pedestrian Signal Heads.

2. Refer to Section 01270 - Measurements and Payments for unit price procedures.

1.04 QUALITY ASSURANCE

A. Furnish LED countdown pedestrian signal modules that conform to the following:

1. TxDOT - Texas Manual on Uniform Traffic Control Devices (TMUTCD)

2. ITE – Pedestrian Traffic Control Signal Indicators – Light Emitting Diode (LED) Signal Modules (PTCSI)

3. Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 on the Emission of Electronic Noise

B. The items furnished and installed under this contract shall be new, unused of the latest product in production to commercial trade, and shall be of the highest quality as to materials used and workmanship. Manufacturers furnishing these items shall be experienced in design and construction of such items and shall furnish evidence of having supplied similar items which have been in successful operation. The bidder shall be an established supplier of the items bid.

1.05 REFERENCES

A. ANSI/NEMA 250-2020 – Enclosures for Electrical Equipment (1,000 Volts Maximum)

B. ANSI/ASQ Z1.4 – Sampling Procedures and Tables for Inspection by Attributes

C. Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 on the Emission of Electronic Noise.

D. ITE – Pedestrian Traffic Control Signal Indicators – Light Emitting Diode (LED) Signal Modules (PTCSI)

E. NEMA TS 2-2021 - Traffic Controller Assemblies with NTCIP Requirements

F. NFPA 70, National Electric Code

G. TxDOT – Texas Manual on Uniform Traffic Control Devices (TMUTCD)

1.06 SILENCE OF SPECIFICATIONS

A. The apparent silence of these specifications as to any detail, or the apparent omission from them of a detailed description concerning any point, shall be regarded as meaning that only the best commercial practice is to prevail and that only material and workmanship of the finest quality are to be used. All interpretations of these specifications shall be made on the basis of this statement. The bidder shall be an established supplier of the items bid.

1.07 TEST EQUIPMENT

A. Suppliers/manufacturers shall furnish with their bid a complete description and cost of any special test equipment that is necessary to install, operate, or maintain its equipment.

1.08 SUBMITTALS

A. Upon request, one schematic wiring diagram and installation manual shall be provided with each LED module.

1.09 WARRANTY

A. A minimum guarantee for both materials and workmanship shall be provided by the Contractor for the products bid as specified. The guarantee (warranty) period shall begin the day the City officially accepts the item. Any guarantee work is to be completed within 15 days after receipt of notice of material deficiencies.

B. Warranties and Guarantees

1. All material, workmanship and labor furnished shall be covered by Supplier(s)/Manufacturer(s) guarantee and/or warranty for a minimum period of sixty (60) months. Warranty period shall begin the day the LED signal module is received by the City of Houston, either as new order or warranty repair. Bidder shall also be required to have resources to complete any required warranty work within fifteen (15) days after receipt of found defective LED signal module. The City of Houston's preference is for all non-warranty service to be charged a singular flat-rate. Successful bidder will include flat rate repair cost, if available in bid document for all non-warranty covered repairs. If flat rate repair charge is not available, then Supplier(s)/Manufacturer(s) will provide current hourly labor rate, along with any associated minimum charges that may apply.

2. Successful bidder shall bear all expenses connected with return of any material which the City deems necessary to return for adjustments during guarantee period. Any work done by the City will be at a rate of $40 per labor unit.

3. Modules which exhibit luminous intensities less than the minimum values specified within the first 36 months, of the date of delivery, shall be replaced or repaired.

4. The City of Houston reserves the right to withhold payments which may be due, should it be discovered that material does not meet specifications and/or claims of bidder.

5. Supplier(s)/Manufacturer(s) shall make all engineering data, diagrams, software changes or improvements, which increases performance of equipment purchased under this bid, available to the City of Houston at no additional cost.

PART 2 PRODUCTS

2.01 MATERIALS

A. Countdown Pedestrian Signal Module

1. The message-bearing surface of the module shall be supplied with a fully populated "HAND" and "MAN" symbol, overlapping, that comply with PTCSI Standard for these symbols for a message-bearing surface of the size specified.

2. The LED module shall display a solid Portland orange hand and lunar white man and two Portland orange countdown numbers.

3. The numbers 00 to 99 on the numerical display shall have 2 rows of LEDs, that are side by side, not offset, and a minimum height of 9 inches.

4. The LED countdown pedestrian signal module shall be a single, self-contained device.

5. Portland Orange (amber hand and countdown numbers) LEDs shall be "AlInGaP" (Aluminum Indium Gallium Phosphorus) technology or equal, and rated for 100,000 hours or more of continuous usage at 25ºC and 20 mA. White LEDs shall be InGaN (Indium Gallium Nitride) technology.

6. The assembly and manufacturing process for all internal LED and electronic components shall be adequately supported to withstand mechanical shock and vibration from high winds and other sources.

7. The signal module shall be made of UL94VO flame-retardant materials. The lens is excluded from this requirement.

8. The lens of the LED pedestrian and countdown signal modules shall be polycarbonate UV stabilized.

9. The exterior of the lens of the LED countdown pedestrian signal module shall be uniform and frosted to reduce sun phantom effect.

10. Each individual LED traffic module shall be identified for warranty purposes with the manufacturer's trade name, serial number and operating characteristics, i.e., rated voltage, power consumption, and volt-ampere.

11. LED countdown pedestrian signal modules shall fit into traffic housings built to the VTCSH Standard without any modification to the housing.

12. Lens must diffuse the LED array over the entire surface of the lens.

B. ENVIRONMENTAL REQUIREMENTS

1. The LED pedestrian and countdown signal modules shall be rated for use in the ambient operating temperature range of -40ºC to +60ºC (-40ºF to +140ºF).

2. The LED pedestrian and countdown signal modules, when properly installed with gasket, shall be protected against dust and moisture intrusion per requirements of ANSI/NEMA Standard 250-2020 for type 4 enclosures to protect all internal LED, electronic, and electrical components.

C. ELECTRICAL REQUIREMENTS

1. The secured, color coded, 914 mm (36 in) long, 600V, 20 AWG minimum, jacketed wires, conforming to the National Electrical Code, rated for service at +105ºC, are to be provided for electrical connection.

2. The LED pedestrian and countdown signal module shall operate from a 60 ±3 Hz AC line over a voltage range of 80 to 135 volts rms. Variations in the voltage range shall have a minimal impact, less than 10%, on the luminous output of the module. Rated voltage for all measurements shall be 120 ±3 volts rms.

3. The LED circuitry shall prevent perceptible flicker over the voltage range specified above.

4. Transient Voltage Immunity: The modules shall be tested for transient immunity, at minimum amplitude of 2000 volts, using the procedure described in, NEMA Standard TS 2-2021.

5. Catastrophic failure of one LED light source in Man & Hand Symbol shall not result in the loss of more than the light from the one display segment.

6. The LED pedestrian and countdown module shall be operationally compatible with the currently used controller assemblies. The LED pedestrian and countdown module shall be operationally compatible with conflict monitors.

7. The LED pedestrian and countdown module including its circuitry must meet Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise.

8. The LED pedestrian and countdown module shall provide a power factor of .90 or greater when operated at the nominal operating voltages, and 25 degrees C (77 degrees F).

9. Total harmonic distortion (current and voltage) induced into an AC power line by an LED pedestrian and countdown module operated at the nominal operating voltages, and 25 degrees C (77 degrees F), shall not exceed 20 percent.

D. INPUT PROTECTION (optional)

1. At the point of entry to the module for each input provide two 0.5-Ohm, 10-watt wire- wound power resistors with 0.2 micro Henries inductance (one on the AC+ Line & on the AC- Line). Provide one 20 Joule surge arrestor between AC+ to AC-. A 0.68 microfarad capacitor must be placed between AC+ & AC – (between the resistor & arrestor).

E. PHOTOMETRIC REQUIREMENTS

1. Luminance

a. For a minimum period of 60 months, the maintained minimum luminance values for the modules under the operating conditions defined in Article 2.01.B.1, when measured normal to the plane of the icon surface, shall not be less than:

Walking person: 2,200 cd/m2
Hand: 1,400 cd/m2

b. The luminance of the emitting surface, measured at angles from the normal of the surface, may decrease linearly to a value of 50% of the values listed above at an angle of 15 degrees.

c. The light output requirements in this specification apply to pedestrian signal heads without any visors, hooded or louvered (egg-crate). Addition of such visors may affect the light output of the signal head, and the purchasing agency may wish to consult the issue with the manufacturer.

2. Uniformity and Distribution

a. The uniformity of the walking person and hand icons' luminance shall meet a ratio of not more than 1 to 5 between the minimum and maximum luminance values, as measured in 12mm (0.5 in) diameter spots.

b. When operating within the temperature range specified in Article 2.01.B.1, the average luminance of the module shall not exceed three times the maintained minimum luminance of the modules, as defined in Article 2.01.E.1.

3. Chromaticity

a. The standard colors for the LED Pedestrian Signal Module shall be White for the walking person and Portland Orange for the hand icon. The colors for these icons shall conform to the following color regions, based on the 1931 CIE chromaticity diagram:

(1) Walking Person—White:

Blue boundary: $x = 0.280$
1st Green boundary: $0.280 \leq x < 0.400$
$y = 0.7917 \cdot x + 0.0983$
2nd Green boundary: $0.400 \leq x < 0.450$
$y = 0.4600 \cdot x + 0.2310$
Yellow boundary: $x = 0.450$
1st Purple boundary: $0.450 \leq x < 0.400$
$y = 0.4600 \cdot x + 0.1810$
2nd Purple boundary: $0.400 \leq x < 0.280$
$y = 0.7917 \cdot x + 0.0483$

White		
Point	x	y
1	0.280	0.320
2	0.400	0.415
3	0.450	0.438
4	0.450	0.388
5	0.400	0.365
6	0.280	0.270

(2) Hand—Portland Orange:

Yellow boundary: $y = 0.390$
White boundary: $0.600 \leq x \leq 0.659$
$y = 0.990 – x$
Red boundary: $y = 0.331$

Portland Orange		
Point	x	y
1	0.6095	0.390
2	0.600	0.390
3	0.659	0.331
4	0.669	0.331

4. Color Uniformity

a. The uniformity of the emitted colors shall be such that any color measurement within a 12mm (0.5 in) spot on the emitting surface shall fall within the following regions around the average measured color of the entire emitting surface:

(1) Walking Person—White:

(a) Where Δx and Δy are the differences in the chromaticity coordinates of the measured colors to the coordinates of the average color, using the CIE 1931 Chromaticity Diagram and a 2 degree Standard Observer.

(2) Hand—Portland Orange:

(a) The dominant wavelength for all individual color measurements shall be within ±3 nm of the dominant wavelength for the average of all the individual color measurements.

F. FUNCTIONAL REQUIREMENTS

1. Basic Operation

   a. The control and regulation module shall allow for the countdown displays to be automatically adjusted with the programmed intervals of the traffic controller.

2. Operating Modes: The module shall operate in one mode:

   a. Clearance Cycle Countdown Mode – The module will start counting when the flashing clearance signal turns on and will countdown to "0" and turn off when the steady "Don't Walk" signal turns on.

3. Power Failures

   a. The equipment must maintain a consistent countdown during short power failures (<1 second). A longer failure or an absence of signal superior to one (1) second must turn off display and trigger a restart system remembering the last sequence, as it is done for the NEMA traffic controller.

2.02 UNIT IDENTIFICATION

A. Units shall be clearly marked on the back surface of the unit in a permanent manner showing information required for warranty and long term performance. Information to be shown shall include manufacturer name, date of manufacture, electric power requirements, model type, and serial number.

PART 3 EXECUTION

3.01 PRODUCT TEST AND INSPECTION

A. Upon final delivery The City of Houston will randomly select two modules of each type and deliver City of Houston approved testing laboratory. Said modules shall be subjected to testing according to Article 2.01.C.4 with all associated costs including shipping to be born by supplier. Any quality issues resulting from these tests will result in rejection of whole shipment.

3.02 FIELD QUALITY CONTROL

A. The City of Houston may perform random sample testing on all shipments. Random sample testing will be completed within 45 days after delivery. Optical testing shall be performed with the LED module mounted in a standard pedestrian signal unit. The number of modules tested shall be determined by the quantity of each shipment. The Traffic Operations Division shall determine the sampling parameters to be used for the random testing. Acceptance or rejection of the shipment shall conform to ANSI/ASQ Z1.4 for random sampled shipments.

B. Supplier(s)/Manufacturer(s) shall have field engineers or technicians available on request to assure satisfactory initial operation, and to consult with City Traffic Engineer, or City Traffic Engineer's representative, on any special circuitry that may be required in certain applications.

END OF SECTION

SECTION 16720

TRAFFIC SIGNAL CABLE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This specification describes minimum requirements for traffic signal control cable and/or wire used in City of Houston traffic signal installations. A digital copy of IMSA specifications can be obtained by contacting the City of Houston - Traffic Operation and Maintenance at 2200 Patterson Street, Houston, Texas 77007.

1.02 SILENCE OF SPECIFICATIONS

A. The apparent silence of these specifications as to any detail, or the apparent omission from it of a detailed description concerning any point, shall be regarded as meaning that only the best commercial practice is to prevail and that only material and workmanship of the finest quality are to be used. All interpretations of these specifications shall be made on the basis of this statement. The bidder shall be an established supplier of the items bid.

1.03 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.04 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement: This item will be measured by the linear foot of traffic signal cables, as per the various sizes and types shown on the drawings. Measurement will not be made for cable inside signal heads and controllers and cable coiled pull boxes, in pole bases and coiled on span wires.

2. Payment: The work performed and materials furnished in accordance with this item and measured as provided under “Measurement” will be paid for at the unit price bid for “Traffic Signal Cables” of the various types and sized specified. This price shall be full compensation for furnishing and installing all materials, and for all, tools, equipment and incidentals necessary to complete the work.

3. Refer to Section 01270 – Measurement and Payment for unit price procedure.

1.05 REFERENCES

A. International Municipal Signal Association (IMSA) Specifications

1.06 QUALITY ASSURANCE

A. Manufacturer furnishing these items shall be experienced in design and construction of such items and shall furnish evidence of having supplied similar items which have been in successful operation. The bidder shall be an established supplier of the items bid.

PART 2 PRODUCTS

2.01 MATERIALS

A. The items furnished shall be new, unused of the latest product in production to commercial trade, and shall be of the highest quality as to materials used and workmanship.

B. The cables shall conform to specification requirements of the International Municipal Signal Association (IMSA) for the specific type cables included in the bid form, and THW wire shall conform to industry standards. These specifications and standards are included in this specification by reference.

2.02 INSULATION

A. Insulation compound and thickness for each conductor shall conform to the specification requirements as specified for each item of the bid form.

2.03 JACKET

A. Jacket compound and thickness for multi-conductor cable shall conform to the specification requirements as specified for each item of the bid form.

2.04 VOLTAGE RATING

A. All cables and/or wire furnished shall be rated at 600 Volts.

2.05 CONDUCTORS

A. Copper used to form the conductors shall be soft or annealed copper and shall be formed as solid or stranded conductor(s) as specified for each item of the bid form.

2.06 CONDUCTOR IDENTIFICATION AND CABLE MARKER

A. Each conductor shall be identified by color-coding conforming with specification requirements specified for each item of the bid form. Each cable shall be identified at maximum 2-foot intervals with manufacturers name and year of manufacture.

2.07 SOURCE QUALITY CONTROL

A. Test and Test Methods: All cables and/or wires shall be sampled and tested at the factory to determine their compliance with specification requirements as specified for each item of the bid form.

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 16724

EMERGENCY VEHICLE PREEMPTION (EVP)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. The system employs optical communication to identify the presence of designated emergency vehicles and causes the traffic signal controller to advance to and/or hold a desired traffic signal display selected from phases normally available. The matched set of components which make up the system will cause the existing traffic controller to be manipulated upon recognition of the signal from the vehicle. This communication is effective to the optical detectors at or near the intersection over a line-of-sight path of up to 1800 feet.

B. The system requires no attention of the vehicle operator other than a simple emitter "ON" switch located in the vehicle which is to remain "ON" until the end of the emergency run. The system shall operate on a first-come, first-served basis. The system is capable of overriding lower priority systems of similar nature while yielding priority to activity such as railroad, drawbridge, etc. The system shall interface with existing traffic signal controllers without compromising normal operation or existing safety provisions.

C. The Emergency Vehicle Preemption (EVP) consists of optical emitter assemblies, optical detectors, optical detector cable, phase selectors, preempt module and card rack. The EVP Intersection Components are the optical detectors, optical detector cable, phase selectors, preempt module and card rack. Emitter assemblies will be supplied by the Contractor only when specifically called out on the plans.

1.02 SILENCE OF SPECIFICATIONS

A. The apparent silence of these specifications as to any detail, or the apparent omission from them of a detailed description concerning any point, shall be regarded as meaning that only the best commercial practice is to prevail and that only material and workmanship of the finest quality are to be used. All interpretations of these specifications shall be made on the basis of this statement. The bidder shall be an established supplier of the items bid.

1.03 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.04 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. This item will be measured by each intersection of the required optical detectors, optical detector cable, phase selectors, preempt module and card rack complete in place.

2. The work performed and materials furnished in accordance with this item and measured as provided under "Measurement" will be paid for at the unit price bid for "Emergency Vehicle Preemption". This price shall be full compensation for furnishing, installing and testing the system; and for all labor, tools, equipment and incidentals necessary to complete the work.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.05 QUALITY ASSURANCE

A. Manufacturer(s) furnishing these items shall be experienced in design and construction of such items and shall furnish evidence of having supplied similar items which have been in successful operation.

B. The bidder shall be an established supplier of the items bid.

1.06 WARRANTY

A. A minimum guarantee for both materials and workmanship shall be provided by the Contractor for the products bid as specified. The guarantee (warranty) period shall begin the day the City officially accepts the item. Any guarantee work is to be completed within 15 days after receipt of notice of material deficiencies.

1. Warranties and Guarantees

a. Any and all equipment furnished shall be covered by manufacturer's guarantee or warranty for a period of twelve (12) months commencing on final acceptance date with respect to parts, workmanship, and performance of the product.

b. The Contractor shall bear all expenses connected with the return of any equipment which the City deems necessary to return to the Contractor for proper adjustment or repairs during the guarantee period.

PART 2 PRODUCTS

2.01 MATERIALS

A. The items furnished and installed under this contract shall be new, unused of the latest product in production to commercial trade, and shall be of the highest quality as to materials used and workmanship.

2.02 MATCHED SYSTEM COMPONENTS

A. The City of Houston EVP is comprised of four basic matched components. To ensure system integrity, operation and compatibility, the four basic components (optical emitter, optical detector, detector cable, phase selector) shall be from the same manufacturer. The bidder shall supply and install the optical detector(s), detector cable, and phase selector for each intersection called for on the plans.

B. The bidder of the Emergency Vehicle Preemption equipment shall provide with the bid written certification from the manufacturer that the system components were designed, manufactured and tested as a system of matched components and will meet or exceed the requirements of this specification and work with the existing City of Houston optical emitters.

2.03 SYSTEM OPERATION

A. Priority control phase selection shall be activated by an optically transmitted signal of 14.035 HZ or 9.639 HZ, or upon the activation of a test switch.

B. The traffic controller shall receive inputs from the preempt module upon activation of the appropriate signal from the phase selector.

C. The system shall provide power for up to three optical detectors for each priority channel. The system shall maintain continuous communication between the optical emitter equipped vehicle and the traffic controller.

D. The system shall allow the traffic signal controller to resume normal timing operation after the optical signals cease for an appropriate period.

E. The system shall not attempt controller manipulation nor retain priority vehicle calls during periods of "intersection flash" or "railroad preempt" operations.

2.04 SYSTEM COMPONENT SPECIFICATIONS

A. Optical Emitter Assembly

1. The assembly shall include an optical energy emitting unit for mounting to the exterior of the vehicle, an emitter control switch for mounting to the interior dash or instrument panel, and all necessary wiring and hardware for a typical installation.

2. The optical emitter assembly shall operate over an ambient temperature range of -30 degrees F (-34 degrees C) to up to 140 degrees F (+60 degrees C).

3. The optical energy emitting unit shall contain an internal regulated power supply to convert 12 VDC (positive or negative ground) vehicle battery power to high voltage required for the flashtube and meet the following electrical requirements:

a. Operational at 10 volts DC to 15 volts DC,

b. Have internal protection for a sustained input voltage of up to 25 volts DC,

c. Deliver sufficient optical energy to activate the optical detector from a distance of 1800 feet, and

d. Consume no more than 40 watts.

4. The optical energy emitting unit shall weigh not more than 4.5 pounds.

5. The optical energy emitting unit shall not exceed the following physical dimensions:

a. Length - 5.25 inches,

b. Width - 7.0 inches, and

c. Height - 6.63 inches.

6. The optical energy emitting unit shall be capable of producing precisely-timed pulses of high intensity light in response to a low voltage trigger signal from the crystal controlled emitter control switch.

7. The optical energy emitting unit shall be controlled by a single ON/OFF switch which requires no warm-up, setting, or adjustments by the vehicle operator. An indicator located adjacent to the ON/OFF switch shall identify that the crystal controlled timing circuitry is energized.

8. The emitter control switch shall produce crystal controlled low voltage trigger pulses to the optical energy emitting unit. For high priority/Class II applications, the frequency of the trigger pulses shall be 14.035 +/-0.255 HZ. For low priority/Class I applications, the frequency of the trigger pulses shall be 9.639 +/-0.119 HZ.

B. Optical Detector

1. The optical detector shall be a lightweight, weatherproof device capable of sensing and transforming pulsed optical energy into electrical signals for use by the phase selection equipment.

2. The unit shall be high impact polycarbonate construction with stainless steel and/or brass hardware.

3. The unit shall be designed for mounting at or near an intersection on a mast arm, pedestal, pipe, or span wire.

4. The unit shall accept optical signals from two directions and provide a single electrical output signal.

5. The unit shall include a design feature to allow aiming of the two optical sensing inputs for skewed approaches or slight curves.

6. The unit shall have a built-in terminal strip to simplify wiring connections.

7. The unit shall receive power from the phase selector and have internal voltage regulation to be operational from 16 to 40 volts.

8. The unit must be responsive to the optical emitter at a distance of 1800 feet.

9. The unit must deliver the necessary electrical signal to the phase selector via up to 1000 feet.

10. The unit shall employ a replaceable circuit board assembly and photocells to facilitate repair.

C. Optical Detector Cable

1. The cable must guarantee delivery of the necessary quality signal from the optical detector to the phase selector over a non-spliced distance of 1000 feet.

2. The cable must guarantee sufficient power to the optical detector over a non-spliced distance of 1000 feet.

3. The cable must be of durable construction to satisfy the following installation methods:

   a. Direct burial,

   b. Conduit and mast arm pull, and

   c. Exposed overhead, supported by messenger wire.

4. The weight shall not exceed .04 lbs/ft.

5. The outside diameter shall not exceed 0.3 inches.

6. The insulation rating shall be 600 volts minimum.

7. The temperature rating shall be 80 degrees C minimum.

8. The cable shall have three conductors of AWG #20 (7x28) stranded, individually tinned copper, color coded insulation as follows:

   a. Orange for delivery of optical detector power,

   b. Blue for optical detector power return, and

   c. Yellow for optical detector signal.

9. The conductors shall be shielded with aluminized polyester and have an AWG #20 (7x28) stranded and individually tinned drain wire to provide signal integrity and transient protection.

10. The shield wrapping shall have a 20% overlap to ensure integrity following conduit and mast arm pulls.

D. Phase Selector

1. All phase selectors shall be digitally controlled and be capable of providing high and low priority operations.

2. The unit shall be a plug-in, two-channel, dual priority device intended to be installed directly into a card rack wired into the traffic signal cabinet.

3. The unit shall be powered from 115 volts, 60 HZ mains and contain an internal, regulated power supply to support optical detectors.

4. The unit shall be capable of recognizing the following pulse rates as delivered by the optical detectors:

   a. 9.639 HZ +/-.119 HZ as low priority (Class I), and

   b. 14.035 HZ +/-.255 HZ as high priority (Class II).

5. The primary optical detector inputs and power outputs shall be on the card edge. Two additional detector inputs, per channel, shall be provided via a front panel connector.

6. One opto-isolated NPN output per channel shall be delivered to the appropriate channel pin on the card edge connector as follows:

   a. HZ +/-.02 HZ 50% on duty square wave in response to a Class I call, and

   b. A "Steady On" in response to a Class II call.

7. The unit shall utilize crystal control timing and optical pulse rate recognition circuitry to assure:

   a. Accurate optical signal recognition for dual priority,

   b. Synchronous logic,

   c. Precise output pulse, and

   d. Accurate call dropout time.

8. The unit shall have six recessed range controls per channel, three for low priority and three for high priority, to adjust optical sensitivity (emitter range).

9. The unit shall have a solid state "Power On" indicator.

10. The unit shall have a "Class I" and "Class II" solid state indicator for each channel which performs as follows:

    a. Flash during call validation, and

    b. Be steady-on during valid call and test switch operations.

11. The unit shall have a test switch for each channel to deliver Class I or Class II signal pulse rates to verify proper function at both optical emitter flash rates, first-come, first-served operation, and Class II override capability.

12. The unit shall have a selectable call dropout time of 5 seconds or 10 seconds.

13. The unit shall properly identify a high priority (Class II) demand with any combination of up to 10 high and low priority emitter signals being received simultaneously and asynchronously on either channel.

14. The unit shall not exceed the following physical dimensions:

    a. Length (including handle) - 7.91 inches,

    b. Width - 1.11 inches, and

    c. Height - 4.50 inches.

E. Traffic Controller Preemption Module

1. A traffic controller preemption module shall be supplied in addition to the four basic matched components. This module shall interface between the phase selector(s) and the traffic signal controller to provide dual priority preempt operation.

2. The preempt module shall be a plug-in, microprocessor controlled, 4 input, 13 output, dual priority device.

3. The preempt module shall recognize steady-on (high priority) over-pulsing (low priority) inputs from the phase selector and assign control on first-come, first-serve and, high priority over low priority basis.

4. The preempt module shall recognize input signals from one or two dual priority phase selectors for up to four separate channels of emergency vehicle preemption.

5. The preempt module shall have a delay timer adjustable from 0 to 15 seconds in one second increments. The delay timer, when properly set, will guarantee a minimum green time for the phase or phases being served prior to initiating the preempt operation.

6. The preempt module shall use the standard input functions available on any NEMA type traffic signal controller and shall not cause the controller to abbreviate its programmed yellow or all red clearance times.

7. When the phase selector deactivates its output, the preempt module shall place vehicle calls on all phases of the traffic signal controller and then allow the controller to resume its regular phase sequence.

8. The preempt module shall provide a separate output for "coordination free" to release the traffic signal controller from coordination control during the operation of the Emergency Vehicle Preemption.

9. The preempt module shall have a separate input that when active shall cause the preempt module to turn off all outputs to allow for railroad or drawbridge operation.

F. Card Rack

1. The card rack shall be a shelf-mounted device designed to accommodate two phase selectors and a preempt module.

2. The rack shall be constructed of 5052 aluminum of .062" thickness and shall not exceed 7.38" W x 4.71" H x 7.13" L. All of the aluminum components consisting of the sides, top, bottom, and front panel shall be clear anodized.

3. The optical detector cable shall terminate on two terminal strips, 4-position, feed- through solder type. The color code and function of each wire shall be clearly silk screened adjacent to each terminal.

4. The front panel of the card rack shall be hinged to provide easy access to the inside of the rack. Machine screws shall be used to secure the front panel when in the closed position.

5. The card rack shall be equipped with a quick disconnect type connector and 6' harness, wired to accommodate the installation of the card rack in a traffic signal cabinet.

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 16725

DYNAMIC MESSAGE SIGN (DMS)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnish and install amber colored Light Emitting Diode (LED) Dynamic Message Signs (DMS) with a full matrix display capable of displaying 3 rows of nominal 12-38 inch characters, 12 characters per line. Furnish a sign capable of displaying graphics and character fonts approved for DMS use by the Manual on Uniform Traffic Control Devices (MUTCD), latest revision and its accompanying reference documents. The sign shall be of front access design providing serviceability to internal sign components. Furnish, install integrate, and test the equipment including cabinets, operating software, cabling and communications.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Measurement: This Item will be measured by each “Arterial LED DMS Field Equipment” of the size specified, furnished, installed, and tested; and by Lump Sum for “DMS Master Controller and Software” installed, fully functional, and tested.

2. Payment: The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement,” will be paid for at the unit price bid for “Arterial LED DMS Field Equipment,” of the size specified, and “DMS Master Controller and Software” installed, fully functional, and tested. This price is full compensation for furnishing, placing, and testing materials and equipment; for tools, labor, equipment, hardware, operational software packages, supplies, support, personnel training, shop drawings, documentation, and incidentals.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. AASHTO Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, latest edition

B. Federal Communications Commission (FCC) Title 47, Sub Part B, Section 15; Regulations Concerning the Emission of Electronic Noise

C. ISO 9001 - Quality Management Systems Requirements

D. NEMA 250 - Enclosures for Electrical Equipment (1, 000 Volts Maximum), latest edition

E. NEMA TS-2 - Traffic Controller Assemblies with NTCIP Requirements, latest edition

F. NEMA NTCIP 2001:1996 - National Transportation Communications for ITS Protocol (NTCIP) Class B Profile (Formerly TS 3.3-1996)

G. NEMA TS 3.6 - Object Definitions for Dynamic Message Signs (DMS), 1997 edition

H. NEMA TS-4 - Hardware Standards for Dynamic Message Signs (DMS) with NTCIP Requirements, latest edition

I. Texas Manual on Uniform Traffic Control Devices

J. TxDOT Special Specification 6005 - Testing, Training, Documentation, Final Acceptance, and Warranty

K. TxDOT Special Specification 6006 - Electronic Components

L. TxDOT Special Specification 6026 National Transportation Communications for ITS Protocol for Dynamic Message Signs, 2004 edition

1.05 DEFINITIONS

A. Central Controller - Central control computer server and software being run at the TMC or on another computer which communicates with the sign controller to obtain status or manipulate and provide the operation of the DMS.

B. Display - The visible face of the sign.

C. DMS - The display and the housing surrounding the display.

D. DMS Control Software - Software used in the sign controller to control the display.

E. Dynamic Message Signs (DMS) - Enable the display of text, consisting of strings of alphanumeric and other characters, and approved graphics in the LED DMS. Assemble the required components from a common set of modules.

F. Message - The text or graphical information displayed to the motorist. Messages may be more than one page of information.

G. Module - A matrix of equally spaced pixels.

H. Neutral State - When the sign is blank or a predefined message is displayed.

I. Pitch - Distance measured from center to center of adjacent pixels. This distance can be measured both horizontally and vertically.

J. Pixel - A cluster of LED's which form a dot.

K. Sign Controller - A device located in close proximity to the DMS which controls the text messages being displayed. The sign controller receives NTCIP commands via Ethernet port. The sign controller manages the operation of the DMS and will utilize solid state hard drive.

1.06 SUBMITTALS

A. The sign manufacturer must submit 3 references, successfully operating a multi-unit, multi-line State arterial, permanently-mounted, overhead dynamic message sign systems supplied by this manufacturer under the current corporate name, for a minimum period of 5 years.

B. Include current name and address of organization and the current name and telephone number of an individual from the organization who can be contacted to verify system operation for the reference data, as well as date of system installation. Provide this information before documentation submittal. Failure to furnish the above references will be sufficient reason to reject the supplier's equipment.

C. The sign manufacturer must submit at least three references from at least three different State or City transportation agencies showing successful operation of permanent multi-line LED DMS systems as described above. These references must demonstrate the manufacturer's capability of meeting the operational requirements listed above. Include in the reference data the current name and address of organization, and the current name and telephone number of an individual from the organization who can be contacted to verify system operation, as well as date of system installation.

D. All information required in this section must be included in the submittal package. Failure to furnish the above references will be sufficient reason to reject the supplier's equipment.

1.07 QUALITY ASSURANCE

A. Manufacturer Requirements / Qualifications.

1. The manufacture shall meet the following requirements:

a. Have been in the business of manufacturing (and under the same corporate name) outdoor permanently mounted roadway LED DMS, which are used to manage vehicular roadway traffic, for a minimum of ten (10) years prior to contract bid date.

b. Have in operation a minimum of fifty (50) outdoor permanently mounted roadway LED DMS, which are used to manage vehicular roadway traffic. Each of these shall have successfully operated for a minimum of three (3) years prior to contract bid date.

c. Have in operation five (5) State or City transportation owned and operated LED DMS systems. Each shall use NTCIP as their primary communications protocol and be communicating over wireless or fiber optic cable networks.

d. Utilize a documented in-house or certified program (such as the International Organization for Standardization - ISO 9001) quality management system that has been in place for no less than three (3) years prior to the contract bid date.

PART 2 PRODUCTS

2.01 MATERIALS

A. Furnish solid state display elements and modules. No mechanical or electromechanical elements or shutters will be accepted. Ensure the DMS are suitable for operations in exposed outdoor locations.

B. General Requirements. Furnish new, corrosion resistant materials. Furnish, assemble, fabricate, and install materials as shown on the plans, in the requirements of this item, and in the pertinent most recent requirements of the following:

1. TxDOT Special Specification 6026, “National Transportation Communications for ITS Protocol for Dynamic Message Signs”, 2004 Specification.

2. TxDOT Special Specification 6006, “Electronic Components”

3. TxDOT Special Specification 6005, “Testing, Training, Documentation, Final Acceptance, and Warranty”

4. NEMA TS-2 Section 2 (environmental requirements), latest edition

5. NEMA TS-4, latest edition

6. NEMA Enclosure Standard 250 (NEMA Type 3R outdoor enclosures)

C. Furnish and install the vendor diagnostic software to 10 City of Houston maintenance laptops. Furnish and install the following equipment for each DMS field site as shown on the plans.

1. LED DMS sign

2. Sign controller

3. DMS mounting brackets and hardware

4. Cabling

5. Field equipment cabinet

6. Central controller software and diagnostics

D. General Construction. Furnish a completed sign that presents a clean and neat appearance. Poor workmanship is cause for rejection of the sign. Protect equipment until it is accepted. Make the exposed connectors watertight.

1. Design the sign to withstand sustained AASHTO wind loadings without permanent deformation. Calculate maximum wind loadings at 100 mph with gusts up to 120 mph unless otherwise shown on the plans.

2. Utilize the latest available techniques to minimize the number of different parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality. Design equipment for ease of maintenance with a front access to ensure component parts are readily accessible for inspection and maintenance.

3. Provide and label test points for checking essential voltages. Use connectors for external connections. Key and label connectors to preclude improper hookups.

4. Ensure sign performance and clarity is not impaired due to continuous vibration, UV exposure, and other environmental conditions including chemicals associated with the transportation environment, and methods commonly used for cleaning traffic devices (steam, power washing detergents).

E. Sign Housing. Sign housing shall be of all aluminum construction. Construct the back panel display construct the sign back panel and display boarder with 1/8-in. thick 5052-H32 aluminum alloy or approved equivalent. Use aluminum alloy 6061-T6 or 6063-T5 for framing structural members. The housing shall provide front access design for serving internal maintenance items. The front access panels shall utilize vertical hinges with gravity braces to hold the panel open at 90 degrees.

1. The sign housing shall have a forced air ventilation system with filtered air intakes and weatherproof exhaust panels. The ventilation shall be controlled automatically by an internal temperature sensor or by communicated commands. The ventilation system shall be able to keep the sign and housing operating within the specified environmental requirements. Other variations of housing may also be acceptable upon review and approval of the engineer.

F. Electronic Components.

1. Ensure the system and associated circuitry conform to the requirements in Federal Communications Commission (FCC) Title 47, Sub Part B, Section 15; Regulations Concerning the Emission of Electronic Noise.

G. Mechanical Components. Provide stainless steel external screws, nuts, and locking washers. Do not use self tapping screws unless approved. Provide corrosion resistant materials which are resistant to fungus growth and moisture deterioration. When dissimilar metals are used, separate them with an inert dielectric material. For pertinent components submit an independent laboratory certification of compliance with associated sections of NEMA TS 2 and TS 4 standards.

H. Message. Ensure characters displayed adhere to MUTCD and AASHTO DMS standards. Ensure the brightness of the characters displayed on the sign provide optimum legibility during every lighting condition.

I. Pixel Optical Characteristics.

1. Each pixel consists of Aluminum Indium Gallium Phosphide-type (AlInGaP) amber LEDs emitting a wave length of 592 nano-meters (amber). Ensure every pixel has the same pitch (horizontal and vertical) across the display. Ensure pixel size to be 1.75x1.75 inches.

2. Ensure the optical characteristics comply with NEMA TS4 requirements in every aspect including: Contrast ratio, Luminance, Chromaticity, 30o Cone of Vision, etc.

3. Ensure the pixels in this project have equal color and on-axis intensity. Furnish proof through submission of LED bin and batch information.

4. Automatic control pixel brightness to compensate for differences in ambient light level, i.e. daytime, night.

J. Pixel Status Monitoring

1. Pixel Test. Test the full operational status of each pixel and report the status to the local sign controller. Upon request from central, identify a list of modules with defective pixels. The pixel test may briefly disturb the displayed message for less than 0.5 sec.

2. Pixel Read. Report back to the local controller which pixels are on/off. Upon request from central, provide a list of which pixels are on/off. Ensure pixel read does not interfere with the displayed message.

K. Display Modules (Full-Matrix): Assemble display modules to form a continuous full matrix message display. Provide each display module with a connector for power and a connector for controls and data.

1. Each display module at a minimum must include an LED display circuit board containing LED pixels arranged into a 27X48 matrix and displaying minimum 12 in. high character. Each pixel should consist of 1.75x1.75 inches. All display modules provided by one manufacturer must be interchangeable throughout that manufacturer's sign system and not require any address switches or adjustment when interchanged or placed in service. Module addressing, where required, must be accomplished in the connector. Ensure the LED DMS consists of sufficient modules to provide the number of lines and rows of characters as shown on plans. Ensure the replacement of a complete display module is possible without the use of any tools. Interconnect modules through keyed connectors only to preclude improper hookups. The maximum horizontal and vertical pixel pitch spacing on each module shall be 1.70 inches (+/- 0.10 in.).

L. Photoelectric Sensor Devices. Provide photocells that cause automatic light intensity adjustment. Install 3 photocells on the sign. Install 1 photocell to measure the "DAY" and "NIGHT" threshold. Install the other 2 on the front of the sign to measure the "OVERBRIGHT" threshold.

1. Enable the brightness to be manually adjustable from the local sign controller in 1% increments. Enable the brightness control to be returned to automatic from the sign controller, laptop, or the central controller.

M. Sign Display Dimensions. Sign display panel size is not to be larger than 144" wide and 72" high. Display dimension may vary only by approval of the engineer.

1. For distance between characters and line, follow NEMA TS4 requirements for full matrix as appropriate.

N. Display Border. Provide the DMS with an 8 in. minimum matte black border. Position the border such that the front surface is flush with the display and the display edge does not interfere with installation or removal of the display modules.

O. Surface Finish. Finish the other traffic facing surfaces with a matte black, licensed factory applied KYNAR 500 Resin, fluoropolymer based coating system. Submit the certification from the licensed factory KYNAR 500 coater. Alternatives to KYNAR 500 will not be accepted. Provide a natural aluminum mill finish on the other exterior metal surfaces. No painted surfaces will be permitted.

P. Environmental Behavior. Furnish signs and associated field electronics that operate without any decrease in performance over the NEMA TS2 temperature range of –40°F to + 165°F with a relative humidity of up to 95%. Need ventilation system temperature controls, fan, etc.

Q. Main Power Supply and Energy Distribution.

1. Design the sign and its controller for use on the following:

a. Power Line Voltage - 120/240 (±10%) VAC Nominal, single-phase power, protected by one 40 A circuit breaker(s)

b. Frequency – 60 Hz ±3 Hz

2. Sign Power. Furnish a power supply with a minimum efficiency of 80% when operated at 50% to 100 % of maximum load. Furnish a power supply with a power factor of 0.95 or greater at operating voltage from 50% to 100% of maximum load.

3. Including voltage surge protection to withstand the following:

a. Primary Input Power Interruption. Use material that meets the requirements of "Power Interruption" section of the NEMA Standard TS2, latest revision.

b. Power Service Transients. Use material that meets the requirements of "High Repetition, Low-Energy Transients" section of NEMA Standard TS2, latest revision.

c. Power Service Transients. Use material that meets the requirements of "Low Repetition, High-Energy Transients" section of NEMA Standard TS2, latest revision.

d. Provide Ground Fault Circuit Interrupter (GFI) devices to protect each service outlet.

e. Ensure exposed cables are Type XHHW and sized as required by the NEC.

R. Field Equipment Cabinet. Mount a NEMA 3R single-door enclosure, of sufficient size to house the electronic equipment, to the support structure unless otherwise shown in the plans. Provide a minimum of one empty fold down 10 in. X 10 in. shelf. Provide a shelf capable of supporting a 20 lb. load.

1. Provide the following items in the field equipment cabinet:

a. Power-on indicator

b. Room for communication devices called out in the plans.

c. Remote communications port – Ethernet plug-in connector for remote communications with sign controller

d. Local communications port – Ethernet plug-in connection for the laptop computer to communicate locally with sign controller

e. One Ethernet cable, a minimum of 4 ft. long, to connect the laptop computer to the local communications port

f. Waterproof local/remote switch and LED indicator

g. A minimum of one GFI protected duplex outlet

h. Power protection/distribution panel

2. Construct the field equipment cabinet using 0.125 in. thick unpainted sheet aluminum. Continuously weld the exterior seams for cabinets and doors. Smooth the exterior welds.

3. Furnish the cabinet with one full size door to provide access to the cabinet. Provide the door with 3 hinges, or a full length stainless steel piano hinge, with stainless steel pins spot welded at the top. Mount the hinges so that it is not possible to remove them from the door or cabinet without first opening the door. Brace the door and hinges to withstand a 100 lb. per vertical ft. of door height load applied vertically to the outer edge of the door when standing open. There must be no permanent deformation or impairment of any part of the door or cabinet body when the load is removed.

4. Fit the cabinet door with a number 2 Corbin lock. Provide 2 keys for each cabinet. Provide cabinet doors that are also pad lockable.

5. Double flange the door opening on all four sides.

6. Provide a gasket to seal the cabinet door facing, use a closed-cell neoprene gasket material that maintains its resiliency after exposure to the outdoor environment. Ensure the gasket does not show sign of rolling or sagging.

7. Submit shop drawings of the cabinet for approval by the Engineer before installation.

8. Silk-screen the markings and identification on the power protection panel and seal with a clear sealer, acrylic, or as approved.

S. Main Power Supply and Energy Distribution.

1. Design the sign and its controller for use on the following:

a. Power Line Voltage - 120/240 VAC Nominal, single-phase power, protected by one 40 A. two-pole (common trip) main circuit breaker. The system must operate within a voltage range of 95 VAC to 135 VAC.

b. Frequency – 60 Hz. ±3 Hz.

2. Under normal operation, the drop in voltage between no load and full load of the sign and its controller must not exceed 10% of the nominal voltage.

3. Protect the system by two stages of transient voltage with solid state surge protection suppression devices on the incoming power line. If enabled by the central controller, tripping of both stages of surge protection must prevent power from reaching any components of the sign. Tripping of each stage of the surge protection must cause the sign controller to call central and report the error condition (for dialup operation) or report the error condition to central on the next poll (for multi-drop operation). Also low voltage surge protection suppression for copper cables for signal distribution entering or exiting the cabinet shall be provided.

4. Provide power protection by a thermal magnetic circuit breaker associated with a 5 mA ground fault circuit interruption (GFI) device. A GFI device must protect all service outlets.

5. The sign must have a 100 A. 240/120 VAC, two-pole load center with 6-circuit capability. Power each circuit in the sign from a separate circuit breaker.

6. The power cables must be type XHHW and sized as required by the NEC for acceptable voltage drop to supply AC power to the sign.

7. Uninterruptible Power. Provide an uninterruptible power supply to maintain the controller and communications for 2 hr. The batteries must be sealed and contained to protect the sign from damage should there be a leak.

T. Sign Controller. Provide a sign controller with resident software. Perform the communication, control, and feedback functions for the DMS through the local sign controller. Sign controller shall use solid state hard drive (no moving parts).

1. Send and receive messages from the sign controller through the communication demarcation shown in the plans, via the remote communications port housed in the field equipment cabinet.

2. Ensure the communications ports and the sign act in accordance with the commands defined in the latest version of TxDOT's Special Specification, "National Transportation Communications for ITS Protocol for Dynamic Message Signs."

3. Modes of Operation. The mode of operation determines which level of control governs the DMS message selection. Provide the following modes of operation:

   a. Master- the DMS master [central controller] or attached local laptop determines the appropriate message or test pattern.

   b. Local - the sign controller is used to determine the appropriate message, test pattern, sign configuration, and diagnostics.

c. Neutral - the rest/restore state for the display. Provide a neutral state that is user programmable and set as blank as a factory default.

d. Test – the test patterns provided by the manufacturer to determine the functional and non-functional pixels.

4. Use a hardware watchdog circuit to provide automatic reset of sign controller in the event of failure.

5. Ensure the sign controller prevents improper information from being displayed in the event of a system malfunction.

6. Operate the sign controllers such that malfunction of any sign controller results in a rest in neutral state and does not affect the operation of any other sign in the DMS system.

7. In the event of a communications failure with the DMS central controller, ensure the local sign controller sets the sign to neutral after a defined number of minutes, as shown on the plans, unless communications are restored within this period.

U. DMS Master Controller and Software.

1. Software Requirements. Build the DMS Master Controller software as a 32-bit Windows application to be run under the latest Microsoft Windows version or the version as directed.

2. The DMS shall be compatible with current legacy TranStar operating software and hardware and the 2004 (or latest) NTCIP for DMS.

3. Furnish software that is a graphical user interface based program designed for DMS system integration, control, and automation.

4. Provide the server version of this software along with a Microsoft Windows Server. Install the client version of this software must be installed on the operator workstations as shown on the plans.

5. Design the DMS Master Controller software to be user friendly, have full mouse support, and utilize window-driven color screens.

6. Furnish software capable of controlling a minimum of 250 dynamic message signs. Furnish a DMS Master Controller capable of controlling at least 8 dynamic message signs per channel. Reference the signs by 19 character minimum text names. Sign numbers or cryptic abbreviations will not be allowed.

7. Provide asynchronous communication with the signs compatible with NTCIP 1203(DMS) over Ethernet.

8. Provide a user selectable communications data rate.

9. Furnish DMS Master Controller software that drives signs of different sizes up to 4 lines of characters, with a maximum of 30 characters per line.

10. Furnish DMS Master Controller software that checks each message entered against the size of the sign. If the message size exceeds the limit for the sign, ensure the DMS Master Controller rejects the message for storage or display. In this case, ensure an error message displays on the DMS Master Controller CRT and is logged in the log file for permanent record. If the operator has font access privileges, ensure the software offers the option of compressed fonts or reduced character spacing before canceling the request and recording an error.

11. Furnish DMS Master Controller software that polls each connected sign for status retrieval at user specified time intervals, or once every 60 seconds by default.

12. Furnish DMS Master Controller software that polls the sign controllers for the status of the LED power supply voltages. When a low voltage message is received, ensure the sign is be blanked by the sign controller and that this error message is displayed on the DMS Master Controller CRT and logged in the log file for permanent record.

13. Furnish DMS Master Controller software that includes a function to view the status and current display of the connected signs as retrieved at the last polling, in both system and sign-by-sign modes. Include in the DMS Master Controller software a pixel test to view the operational status of each pixel and display the status as a function of the pixel's location for each individual sign. The operational pixel status will specify 5 different states for each pixel - fully operational, half out, fully out, half stuck on, or fully stuck on. On the DMS Master Controller CRT, ensure the operational pixel status is displayed in a graphical, pixelated, "WYSIWYG" format of the sign face showing each and every pixel and its associated status by showing each pixel state in a different color. Initiate the pixel test once a day and on command.

14. Ensure a list of defective pixels is logged in the log file for permanent record and printed on command, listing pixel status, sign number, module number, column number, and pixel number.

15. Furnish DMS Master Controller software that includes a function to view the operational status of the fans and displays each individual fan number and the corresponding fan status for each sign in the system. Initiate a fan test on command and once a day. Ensure that failure of a sign fan generates an error message displayed on the DMS Master Controller CRT and logged in the log file for permanent record.

16. Furnish DMS Master Controller software that polls the sign controllers for the temperature readings from the temperature sensors in each individual sign. Ensure that a temperature reading greater than a programmable level causes a blanking message to be sent to the sign and an error message to be displayed on the DMS Master Controller CRT and logged in the log file for permanent record. Furnish DMS Master Controller software that polls the sign controller for errors and failures, including:

    a. Data channel availability and Data transmission error

    b. Communications failure recovery

    c. Power recovery

    d. Pixel status

    e. Fan status

    f. Temperature status

    g. Power supply status

17. Furnish DMS Master Controller software that polls the sign controller for the following information:

    a. Actual message that is visibly displayed on the sign on an individual pixel basis

    b. Current sign illumination level

    c. Local Control Panel switch position (Master or local)

    d. Error and failure reports

    e. Temperature readings

    f. Power supply voltage levels

    g. Heater status

    h. Uninterruptible power supply status if available

18. Furnish DMS Master Controller that receives calls from sign controllers for any of the following conditions at each sign:

    a. AC power failure

    b. AC power recovery

19. Ensure any malfunction of a connected sign is recorded in the log file and a printout is made.

20. Provide a DMS Master Controller software system that is easily programmable to support any type of printer.

21. Furnish DMS Master Controller software that permits access by a minimum of 16 users, with each user identified by a name, password, and access rights.

22. To gain access to the system, require each user to enter a name and password which is recorded in the log file.

23. Make access rights fully programmable by levels for each user, enabling the user to access only those functions which the user is cleared to access.

24. Ensure that each event, including log on attempts by non-authorized users, is recorded in a log file and, if a printer is connected, printed. Include in the record: The event number, date/time, sign name/user name, and event description. Store status logs in a database.

25. Furnish DMS Master Controller software that displays and prints any log file on the system sorted by user's login, sign event, date/time, sign name, or any combination of the above.

26. Furnish DMS Master Controller that creates, modifies, and stores sign libraries consisting of up to 640 messages on hard disk. Store the messages by 12 character (minimum) text names. Message numbers or cryptic abbreviations are not allowed.

27. Logically group the messages into libraries, allowing the software to control signs of different sizes and types. Furnish a DMS Master Controller capable of assigning messages to multiple libraries to minimize program set-up time and repetitive data entry.

28. Furnish a DMS Master Controller that displays on a sign an existing message, a modified message, a new message, or an immediate message.

29. Furnish a DMS Master Controller that shows messages in a graphical, pixelated, "WYSIWYG" format of what will actually be displayed on the sign face before a message is manually downloaded to the sign controller. Enable new messages and editing of messages to also be performed in this graphical "WYSIWYG" format.

30. Include in the central software a display window which accurately reflects the message, in graphical, pixelated "WYSIWYG" format, as it is visibly displayed on the sign, including different colors for pixels which are on, half-on and off. Also include in this graphical, pixelated, "WYSIWYG" format, flashing and alternating displays.

31. Furnish a DMS Master Controller that normally displays single stroke (5 x 7) characters with double-column spacing between characters on the signs. Furnish a DMS Master Controller that is also able to display compressed (4 x 7), expanded (6 x 7), or double-stroke (7 x 7) character fonts or is able to change the default spacing between characters on the signs. Provide spacing options that are one, two, or three pixel columns. Ensure each font is fully customizable, and that the DMS Master Controller is capable of downloading any modifications to the sign controller at any time without any software or hardware modifications.

32. Furnish a DMS Master Controller capable of displaying a self-updating time, temperature, and date display on the signs.

33. Furnish a DMS Master Controller that includes a window which can modify any character of any font by using the mouse to turn on and off pixels of a graphical, pixelated, "WYSIWYG" character. Ensure the DMS Master Controller then downloads the revised font to the sign controllers.

34. Furnish a DMS Master Controller that includes a window which shows the characters of any font in a graphical, pixelated, "WYSIWYG" format.

35. Furnish a DMS Master Controller that has time of day schedules for any or all signs in the system.

36. Furnish a DMS Master Controller that creates or modifies 32 scenarios. A scenario consists of display definitions attached to signs. Start the displays on the respective signs either manually from the keyboard or as part of the time of day schedule. The display definitions may include messages, blanks, static, alternating, or flashing messages.

37. Furnish DMS Master Controller software that provides a function to automatically change the time on the DMS Master Controller and in each local sign controller due to changes for daylight savings time. Ensure the software then automatically advances the clock 1 hour, and sets back the clock 1 hour when the exact time to start and end daylight savings time is reached, respectively. Also, ensure the function automatically adjusts for leap years.

38. Furnish a DMS Master Controller that includes a window to easily customize the brightness table of any sign controller and downloads this new table into the non- volatile memory of the sign controller.

39. Furnish DMS Master Controller software that allows remote terminals to communicate with the DMS system. Provide communication with the DMS Master Controller through dedicated, Ethernet, or dial-up lines.

40. Furnish DMS Master Controller software that checks each message entered for spelling errors and prompts to the attention of the user any misspelled words for editing and confirmation. In addition to spelling, ensure the software checks the message against an approved/disapproved words list. Ensure the operator is notified of any disapproved words found and the disapproved message is recorded in the log. Ensure messages containing disapproved words are not displayed on the signs.

41. Furnish DMS Master Controller software that automatically logs off any operator after a user specified time of keyboard inactivity.

42. Provide each function of the DMS Master Controller with a context sensitive help screen.

43. Furnish a DMS Master Controller able to utilize any Ethernet port for any function, including remote terminal communications, and that supports simultaneous communication with at least 3 remote terminals on dial-up or dedicated lines.

44. Message Display Time. For each message, enable the operator to define either a display time in hours and minutes (maximum 99 hours and 59 minutes), or an unlimited display time.

45. Furnish a DMS Master Controller capable of performing the following functions:

    a. Display a message on the signs, including:

        (1) Static messages

        (2) Flashing messages

        (3) Alternating messages

46. Ensure it is possible to separately vary the flashing and alternating frequencies.

47. Provide flashing messages with the following adjustable timing:

    a. Message time on, 0.5 to 5.0 seconds in 0.1 second increments

    b. Message time off, 0.5 to 5.0 seconds in 0.1 second increments. Ensure it is possible to flash any character or set of characters in a static message

48. Provide alternating messages with the following adjustable timing:

    a. Primary message time on, 0.5 to 5.0 seconds in 0.1 second increments

b. Primary message time off, 0 to 5.0 seconds in 0.1 second increments

c. Alternate message time on, 0.5 to 5.0 seconds in 0.1second increments

d. Alternate message time off, 0 to 5.0 seconds in 0.1second increments

49. Ensure it is possible to flash any character or set of characters in an alternating message at the adjustable frequencies listed above for flashing messages. In this case, make the flashing period submultiples of the alternating on time it is associated with.

50. Furnish software capable of programming events, enabling the user to select a specific preprogrammed event to display multiple and different types of messages on multiple and different types of DMS. Ensure this software is able to hold a minimum of 956 pre-programmed events.

V. Vendor Diagnostic Software. Install in the City of Houston maintenance laptops Vendor Diagnostic Software that provides the following capabilities as a minimum:

1. DMS startup

2. Onsite maintenance which includes complete diagnostic of the sign, with screens and commands similar to the DMS master controller software

3. Remote Terminal functions, with screens and commands identical to the DMS master controller software to maintain operator familiarity

4. Display any message stored in the sign controller PROM

5. Create a new message to display on the dynamic message sign

6. Start a "test pattern" display to check and verify each individual pixel of the sign

7. Create a non-volatile activity log, for later transfer to the DMS Master Controller, in order to maintain a complete historical record if the DMS Master Controller is unable to do so.

8. Communications with the DMS Master Controller and provide remote access to the DMS Master functions.

2.02 SOURCE QUALITY CONTROL

A. The equipment covered by this Specification shall be subjected to design approval tests and factory demonstration tests (FDT) at the Contractor-provided facility in the Houston area to determine conformance with all the Specification requirements. The Engineer may accept certification by an independent testing lab in lieu of the design approval tests, to verify that the design approval tests have previously been satisfactorily completed. The Contractor shall arrange for and conduct the tests in accordance with the testing requirements stated herein. Unless otherwise specified, the Contractor is responsible for satisfying all inspection requirements prior to submission for the Engineer's inspection and acceptance.

B. The Engineer reserves the right to have the Engineer's representative witness all design approval tests and factory demonstration tests. The results of each test shall be compared with the requirements specified herein. Failure to conform to the requirements of any test shall be counted as a defect, and the equipment shall be subject to rejection by the Engineer. Rejected equipment may be offered again for a retest, provided that all non-compliance's have been corrected and retested by the Contractor and evidence thereof submitted to the Engineer.

C. The tests on all or one type of equipment must be completed within 5 days. Any delays in performing all these tests will result in the Contractor paying the additional costs of providing the Engineer's representatives for the additional testing.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Perform tests in accordance with TxDOT Special Specification 6005, "Testing, Training, Documentation, Final Acceptance, and Warranty." Additional testing requirements are as follows:

1. Verification of NTCIP Compliance. The City of Houston will verify, through use of the NTCIP Tester (supplied by the vendor or contractor). The shell equipment complies with the requirements of NEMA NTCIP 2001:1996 NTCIP Class B Profile and TS 3.6-1997 NTCIP Object Definitions for DMS.

2. System Tests. Conduct approved DMS system tests on the field equipment with the central equipment. The tests must, as a minimum, exercise all remote control functions and display the return status codes from the controller for a minimum of 72 hr. Complete and submit approved data forms as the basis for review and for rejection or acceptance. If system tests fail because of any components in the subsystem, correct or substitute the particular components with other components and repeat the tests. If a component has been modified as result of the system test failure, prepare a report and delivered it to the Engineer before retesting.

3. If technical data are not considered adequate for approval, samples may be requested for testing by the Engineer. The contract period will be not extended for time lost or delays caused by testing prior to final City of Houston approval of any items.

B. Final inspection and acceptance of equipment shall be made after installation at the designated location as shown on the plans, unless otherwise specified herein.

C. Test Procedures. The Contractor shall provide 5 copies of all design approval, factory demonstration, stand-alone and subsystem test procedures and data forms for the Engineer's approval at least 60 days prior to the day the tests are to begin. The test procedures shall include the sequence in which the tests will be conducted. The test procedures shall have the Engineer's approval prior to submission of equipment for tests.

1. The Contractor shall furnish data forms containing all of the data taken, as well as quantitative results for all tests. The data forms shall be signed by an authorized representative (company official) of the equipment manufacturer. At least one copy of the data forms shall be sent to the Engineer.

2. The Contractor shall be responsible for providing the test fixtures and test instruments for all the tests.

D. Design Approval Tests. Design approval tests shall be conducted by the Contractor on one or more samples of equipment of each type, as approved by the Engineer, to determine if the design of the equipment meets the requirements of this Specification. The test shall be conducted in accordance with the approved test procedures as described in above.

1. The Engineer shall be notified a minimum of 30 calendar days in advance of the time these tests are to be conducted. The design approval tests shall cover the following:

a. Temperature and Condensation. The field equipment described in Articles 2., 4. and 5. specified for the Factory Demonstration Tests (FDT) shall be successfully performed under the following conditions in the order specified below:

(1) The equipment shall be stabilized at –30°F (-25°C). After stabilization at this temperature, the equipment shall be operated without degradation for 2 hours.

(2) Moisture shall be caused to condense on the equipment by allowing it to warm up to room temperature in an atmosphere having relative humidity of at least 40% and the equipment shall be satisfactorily operated for 2 hours while wet.

(3) The equipment shall be stabilized at 165°F (65°C). After stabilization, the equipment shall be satisfactorily operated for 2 hours without degradation or failure.

b. Primary Power Variation. The sign controller equipment shall meet the specified performance requirements when the nominal input voltage is 120 VAC ± 12 VAC. The equipment shall be operated at the extreme limits for at least 15 min. during which the operational test of the FDT shall be successfully performed.

c. Relative Humidity. The equipment shall meet its performance requirements when subjected to a temperature of 165°F (65°C) and a relative humidity of 90%. The equipment shall be maintained at the above condition for 48 hours. At the conclusion of the 48-hour soak, the equipment shall meet the requirements of the operational test of the FDT within 30 minutes of beginning the test.

d. Vibration. The equipment (excluding cabinets) shall show no degradation of mechanical structure, soldered components, or plug-in components and shall operate in accordance with the manufacturer's equipment specifications after being subjected to the vibration tests as described in "Vibration Test" section of the NEMA standard TS2, latest edition.

e. Consequences of Design Approval Test Failure. If the unit fails the design approval test, the design fault shall be corrected and the entire design approval test shall be repeated. All deliverable units shall be modified, without additional costs to the City of Houston, to include design changes required to pass the design approval tests.

E. Demonstration Test. The Contractor shall be responsible for conducting demonstration tests on all units at a Contractor-provided facility within the Houston area. These tests shall be performed on each unit supplied. The Engineer shall be notified a minimum of 30 calendar days before the start of tests.

1. All tests shall be conducted in accordance to requirements of article 2.02. The contractor shall write the test procedure for approval by the engineer. Each equipment shall have passed the following individual tests:

a. Examination of Product. Each equipment shall be examined carefully to verify that the materials, design, construction, markings and workmanship comply with the requirements of the Specification.

b. Continuity Tests. The wiring shall be checked to determine conformance with the requirements of the appropriate paragraphs in the Specifications.

c. Operational Test. Each equipment shall be operated long enough to permit equipment temperature stabilization, and to check and record an adequate number of performance characteristics to ensure compliance with the requirements of this Specification.

2. The status of each sign pixel shall be tested and reported to the local sign controller upon request from central. The test shall identify a list of modules with defective pixels and a list of which pixels are not operating properly.

3. Consequences of Demonstration Test Failure. If any unit fails to pass its demonstration test, the unit shall be corrected, and another unit substituted in its place and the test successfully repeated.

4. If a unit has been modified as a result of a demonstration test failure, a report shall be prepared and delivered to the Engineer prior to shipment of the unit. The report shall describe the nature of the failure and the corrective action taken.

5. If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the City of Houston or extension of the contract period.

F. Stand-Alone Test. The Contractor shall conduct an approved stand-alone test of the equipment installation at the field site. The test shall, as a minimum, exercise all stand-alone (non-network) functional operations of the field equipment with all of the equipment installed as per the plans, or as directed by the Engineer.

1. Approved data forms shall be completed and turned over to the Engineer as the basis for review and rejection or acceptance. At least 30 working days' notice shall be given prior to all tests to permit the Engineer or Engineer’s representative to observe each test.

2. Consequences of Stand-Alone Test Failure. If any unit fails to pass its stand-alone test, the unit shall be corrected, or another unit substituted in its place and the test successfully repeated.

3. If a unit has been modified as a result of a stand-alone test failure, a report shall be prepared and delivered to the Engineer prior to the retesting of the unit. The report shall describe the nature of the failure and the corrective action taken.

4. If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the City of Houston or extension of the contract period.

G. System Integration Test. The Contractor shall conduct approved DMS system tests on the field equipment with the master equipment. The tests shall, as a minimum, exercise all remote control functions and display the return status codes from the controller for a minimum of 72 hours. Approved data forms shall be completed and turned over to the Engineer as the basis for review and for rejection or acceptance.

1. Consequence of System Test Failure. If system tests fail because of any component(s) in the subsystem, the particular component(s) shall be corrected or substituted with other component(s) and the tests shall be repeated. If a component has been modified as a result of the system test failure, a report shall be prepared and delivered to the Engineer prior to retesting.

H. Seventy-two Hour and 90-Day Test Periods. After the installation of the DMS system is completed and the successful completion of the System Test, the Contractor shall conduct one continuous 72-hour full operating test prior to conducting a 90-day test period. The type of test to be conducted shall be approved by the Engineer, and shall consist primarily of exercising all control, monitor and communications functions of the field equipment by the master equipment.

1. The 90 days test period shall commence on the first day after the successful completion of the approved 72-hour continuous full operating test period.

2. During the 90 days test period, downtime, due to mechanical, electrical and/or other malfunctions, shall not exceed 5 working days. The Engineer may extend the 90 days test period by a number of days equal to the downtime in excess of 5 working days.

3. The Engineer will furnish the Contractor with a letter of approval stating the first day of the 90 days test period.

I. Provide documentation, training, final acceptance and warranty in accordance with TxDOT Special Specification 6005, “Testing, Training, Documentation, Final Acceptance, and Warranty.” In addition, provide the following technical assistance and references:

1. Require the manufacturer's representative presence to assist the Contractor's technical personnel at each sign installation site to provide technical assistance in following areas:

a. Sign to structure installation

b. Field equipment cabinet installation

c. Sign to controller cabling

d. Do not execute the initial powering up of the signs without the permission of the manufacturer's representative.

END OF SECTION

SECTION 16727

TRAFFIC SIGNAL SAW-CUT LOOP DETECTOR

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Loop Detectors

1. This specification and detailed drawings describe the materials and installation procedures necessary to install loop detectors in roadways in the City of Houston. Basically, the inductive loop detector consists of a few turns of wire embedded in the roadway pavement which are connected to an electronic component mounted in a roadside cabinet. The detector is designed so that the passage of a vehicle over the loop in the pavement modifies the magnetic flux around the resonantly tuned loops of wire which is sensed by a transistorized unit that transmits the vehicle presence or passage to the traffic signal controller. Since traffic signal timing and sequencing are totally dependent on the quality and placement of the loops, craftsman type skills must be exercised on installation procedures. Loops may be adjusted by the Engineer, as necessary.

B. Card Rack Amplifiers

1. These specifications define the minimum acceptable design, operational and functional performance requirements for high performance, two-channel inductive loop vehicle detector units and data acquisition software that can provide binned traffic data and real- time traffic measurements on a vehicle-by-vehicle basis. The system shall provide current measurements and vehicle detection information on the last vehicle for use in local control, incident detection and advanced traffic management systems.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Measurement: This Item will be measured by the linear foot of sawcut containing loop wire and by each two (2) channel detector amplifier. Deviation of the Contractor from the layout on the drawings will require prior approval of the Engineer.

2. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Loop Detector Sawcut" for the various sizes and types of loop detectors specified on the drawings furnished and installed. This price shall be full compensation for furnishing, installing and testing the loop detectors; and for all labor, tools, equipment and incidentals necessary to complete the work.

3. Loop detector amplifiers as measured under "Measurement" will be paid for at the unit price bid for "Two Channel Detector Amplifiers" furnished and installed. This price shall be full compensation for furnishing, installing, and testing the loop detector amplifiers.

4. The City of Houston shall not be required to pay for software and/or hardware related modifications or changes and/or for associated labor that is required to correct errors.

5. The City of Houston shall be required to pay for any software and/or hardware- related modifications or changes and/or for associated labor that result from requested options, features or enhancements.

6. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. IMSA Spec. No. 51-5-1985 – Loop Detection Wire

B. International Municipal Signal Association, Specification #50-2

C. NEMA TS2-2021 – Traffic Controller Assemblies with NTCIP Requirements

D. Texas Department of Transportation Traffic Signal Work Typical Detail/Traffic Signal Barricade and Signs

E. Texas Manual on Uniform Traffic Control Devices, latest revision

F. UL 510 - Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape

1.05 WARRANTY

A. Detectors shall be warranted against defects in workmanship or materials for five (5) years from date of purchase.

PART 2 PRODUCTS

2.01 LOOP DETECTOR MATERIALS

A. Flexible embedding sealer shall meet the following minimum specifications:

1. The flexible embedding sealer shall be designed to enable vehicular traffic to pass over the properly filled saw cut immediately after installation without tracking or stringing of the material. The flexible embedding sealer shall form a surface skin allowing exposure to vehicular traffic within 30 minutes at 75 degrees F. And completely cure to a tough, rubber-like consistency in two to seven days after installation.

2. Properly installed and cured flexible embedding sealer shall exhibit resistance to effects of weather, vehicular abrasion, motor oils, gasoline, anti-freeze solution, brake fluid, deicing chemicals and salt normally encountered, in such a manner that the performance of the vehicle detector loop wire is not adversely affected.

3. Flexible embedding sealer shall be applicable to both Portland cement concrete and asphalt concrete pavements.

4. The flexible embedding sealer shall exhibit minimal shrinkage during or after its installation, and in no manner affect the performance characteristics of the material.

5. The flexible embedding sealer shall be designed to permit clean-up of material and application equipment with non-flammable solvents such as l.l.l. trichloroethane or Scotch-Grip Brand Solvent No. 4 (Prior to curing of flexible embedding sealer)). Should any flexible embedding sealer material be allowed to cure in the application nozzle, it shall be able to be pulled our as a solid plug.

6. The flexible embedding sealer shall have a minimum 12 month shelf life in undamaged original containers when stored in a cool, dry environment.

7. The flexible embedding sealer shall be designed for roadway installation when the surface temperature is between 40 degrees F and 140 degrees F.

8. The flexible embedding sealer shall have the following physical properties in its uncured and cured states.

   a. Physical Properties of the uncured (wet) flexible embedding sealer:

Property	Requirement	Test Procedures
Weight	10.1 lbs/gal (+/- 0.5 lbs)	Weight/Gallon
Viscosity	10,000-85,000 CPS	Viscosity
Drying Time	24 hrs. (max)	Tack-Free Time
Skinning Time	6 hrs.	

   b. Physical Properties of the cured flexible embedding sealer:

Property	Requirement	Test Procedure
Hardness (Indentation)	65-85	Rex Hardness
Tensile Strength	700 psi (min.)	Tensile & Elongation
Elongation	250%	Tensile & Elongation

B. Loop wire shall be IMSA Spec. No. 51-5-1985, #14 AWG, copper, stranded, single conductor pvc/nylon-with tube jacket. The maximum O.D. of the entire cable shall be 0.260 inches.

2.02 CARD RACK DETECTOR AMPLIFIER

A. General Design Requirements

1. A communication link shall provide remote access to the detector for reading unit configuration settings, for fault identification and verification, for real-time system monitoring and data collection on up to two channels of detection. It shall include password security to the detector to change configuration settings. The communication link shall provide for party line communication on up to eight units using 4-bit hardwired addresses to the card edge connector and/or 127 software programmable addresses in EEPROM memory.

2. The interface and data acquisition software shall be organized by application and facilitate setup, real-time traffic monitoring and collection of binned count and occupancy data. A vehicle log shall provide a means for logging of vehicle speed, vehicle length, loop-to-loop travel time and detection duration. Optional modes of operation shall include a vehicle travel direction detection setup capability using overlapped 6-foot by 6-foot loops, a long-loop count mode to provide turning movement counts and a microloop mode selection when channels are connected to microloop sensors.

3. The successful bidder or contractor shall supply data acquisition and interface software and vehicle detectors that meet all the operational and functional performance requirements in accordance with the terms and conditions of this specification.

4. The bidder or contractor shall be responsible for any testing, rework and/or re-testing of equipment delivered under this contract that may be required to meet these specifications, at no expense to the City of Houston.

5. The bidder’s documentation shall indicate the manufacturer's name, address, model numbers, and include the shipping address for warranty repair work, as required in these specifications.

6. The City of Houston shall have the option to request and provide the communication protocols to a professional engineering consultant or OEM for integrating the data acquisition and interface software into its advanced traffic management system.

7. Serial numbers shall be clearly legible and permanently placed on each inductive loop detector unit.

B. General Hardware - Standards and Performance Requirements

1. The inductive loop detector units shall be fully interchangeable, whether used for system counting, occupancy measurement, speed and length measurement, directional detection, binned data collection, remote data acquisition in advanced traffic management systems or for local intersection control (including long-loop counting).

2. Detector configuration data shall be entered using special interface and data acquisition software. A communication interface shall provide for remote connection and configuration of detectors, real-time activity monitoring and data acquisition via modem to remote devices.

3. Inductive loop detector units shall meet the latest edition of the National Electrical Manufacturers Association (NEMA) Standard TS2-2021 for Type 2 controller and cabinet assemblies plus the functional and performance requirements of this specification. The detectors shall be configured as plug-in devices which meet the requirements for NEMA TS2-2021, actuated Type 2 A2 operation and Type 1 A1 operation in 44-pin input files.

4. Detectors shall comply with NEMA TS2-2021 for four-channel rack mount type units, NEMA designation “D,” except that Delay and Extension Timing shall be provided on two channels in lieu of NEMA TS2- 2021 requirements.

5. Detectors shall also be suitable for use in California/New York TYPE 170/179 and ATC cabinets with 22-pin input files.

6. Detectors shall detect and hold the presence of all licensable motor vehicles (including small motorcycles). This shall be accomplished, without detecting traffic in the adjacent lane (beyond 36 inches from the loops except as noted below), on the following loop configurations with 100 up to 1000 feet of homerun cable.

   a. One to six series connected, 6-foot by 6-foot square loops with three turns of #14 AWG wire.

   b. One to six series connected, 6-foot by 6-foot square loops with four turns of #14 AWG wire.

   c. A 6-foot wide by 30-foot long loop with two or three turns of #14 AWG wire (when set to detect small motorcycles, may detect adjacent lane traffic).

   d. A 6-foot wide by 20-foot to 60-foot long quadrupole loop with a winding two- four-two turns of #14 AWG wire. When sensitivity is set to detect small motorcycles, adjacent lane traffic shall not be detected.

e. Single, double and triple microloop probe sets.

7. The detection performance described above shall be accomplished when using lead-in/homerun cable lengths of from 50 feet to over 1,000 feet of #14 AWG conductor homerun cable, i.e., International Municipal Signal Association, Specification #50-2.

8. A pushwheel switch shall be provided to allow selection of the threshold/sensitivity setting which will detect and hold presence of all licensable motor vehicles (including motorcycles), without detecting vehicles, moving or stopped, in the adjacent lane (36 inches from the loop connected to this channel, except as noted in Article 2.02.B.6.

9. Each channel shall automatically self tune with full sensitivity, to any loop and lead-in combination resulting in a total inductance of 20 to 2500 microhenries, with a Q factor of five or greater, within four seconds after application of power.

10. Detectors shall track changes in inductive loop or lead-in electrical characteristics that take place when environmental changes occur, which affect inductive loops installed in undamaged pavement, to insure that units operate properly without producing a false indication, a loss of detection or a change in sensitivity due to weather changes.

C. Special Features and Functional Performance Requirements

1. Detectors shall be microprocessor controlled and shall be configurable with manual switch settings and via software settings in EEPROM memory.

2. Detectors shall include eight sensitivity settings (thresholds), in 2:1 steps. Threshold settings shall directly relate to nanohenries of inductance change (Delta L). Detection output shall be based on a response to a change in the inductance which exceeds the Delta L threshold selected. For a given loop type, such as a 6- foot by 6-foot, three-turn square loop, it shall not be necessary to readjust the sensitivity setting to detect a specific vehicle type and/or to get consistent occupancy measurements using a range of lead-in or homerun cable lengths that vary from 100 feet up to 3500 feet.

3. Each detector shall have a single, switched oscillator system to sequentially excite and measure each channel to prevent crosstalk between channels within a unit.

4. Each detector shall have a three-position toggle switch to manually select one of three operating frequencies to reduce crosstalk between detector units. These three frequencies shall also be software selectable.

5. Each detector shall have two serial ports, a front panel RS232 port and transmit/receive pins on the card edge connector, to facilitate serial communication.

6. Each serial port shall have a multi-drop mode and be capable of party line communication with up to eight detectors on the party line.

7. The detector unit shall be designed to accommodate the addition of an optional plug-in communication module to allow expansion of the multi-drop capability to 32 devices on a common serial port bus and convert the rear port into an independent port. With the optional module installed, communication with a PC through the front port shall not interfere with system communication on the rear serial port.

8. Baud rates shall be selectable at 1200, 2400, 4800, 9600, or 19200 BPS using the interface software. With the communication module installed, the baud rates shall be independently settable for the front and rear serial ports.

9. The unit shall be designed to accommodate either an optional plug-in communication module or a plug-in memory module to expand the memory used for on-board count and occupancy binning.

10. The front panel serial port shall have EIA-232 electrical characteristics and shall terminate with a front panel 6-pin circular Mini-DIN connector.

11. A communication cable with a DB-9 female connector (for a computer serial port connection) and a 6-pin Mini-DIN male connector (for the front panel serial port connection) shall be provided with the interface and data acquisition software. The communication cable shall enable direct communication with a remote reporting device or a PC running Windows 10 or latest version and shall be compatible with the City's controller and system software..

12. Units shall have software settable addresses from 128 to 254. Address 255 shall be assigned as a "wildcard" to be used only when connected to the front panel port to establish connection and read the correct address from the device.

13. Units shall have 4-bit back panel hardwired addressing capability to allow selection of one of 16 hard-wired addresses. Back panel addressing shall be enabled via the interface software.

14. An external 24VDC Green control input shall be provided to control the output timing. If True (ground level = 0 to +8VDC), the Green input shall disable Delay and enable Extension Timing; and if False (+16 to +30VDC or Open), the Green input shall disable Extension and enable Delay Timing. Software shall provide for an option to disable Green Gating so that Delay or Extension Timing is provided unconditionally.

15. Detector units shall have a Presence or Pulse mode output option. Selection shall be via front panel switches or software settable options.

16. Each channel shall have a pushwheel sensitivity switch to enable manual selection of the output mode and sensitivity (threshold) settings as follows:

    a. The pushwheel switch shall have an OFF mode position indicated by an “X” marking. This position shall disable each channel's output and front panel Detect and Fault indicators.

    b. The pushwheel shall have seven Presence mode sensitivity settings.

    c. The pushwheel shall have eight Pulse mode sensitivity settings. Pulse mode settings shall use a square-wave marking over the channel sensitivity numeral to differentiate from Presence mode settings.

17. Each increase in Presence or Pulse mode settings shall double the sensitivity (reduce the threshold) from the previous setting.

    a. The highest sensitivity (smallest change) setting shall have a Delta L threshold value of eight nanohenries.

    b. The lowest sensitivity setting shall have a Delta L threshold of 1024 nanohenries.

18. Presence output shall hold vehicle detection for at least four minutes minimum for small licensed motor vehicles (100cc. motorcycles) and for at least 60 minutes for automobiles before tuning-out vehicles (dropping recognition of vehicle presence) over a 6-foot by 6-foot square loop with three or four turns of wire.

    a. The presence output shall not tune out when vehicle motion exists (defined as vehicle entry and departures continue every few minutes and vehicles remain present in the sensing zone) for at least 60 minutes.

19. In Fast Recovery mode the channel shall recover to full sensitivity within 750 milliseconds after all vehicles leave the inductive loop sensing zone.

20. Pulse mode shall provide a single, 118±5 millisecond, output pulse in response to an 18-foot long vehicle traveling over a 6-foot by 6-foot loop at eight miles per hour, and for successive vehicles traveling over the same loop at speeds ranging from ten to 100 miles per hour, with a one second headway. Pulse width shall be programmable from interface software.

    a. If a vehicle remains over the loop, further detection shall be inhibited for a 1.9- second re-phase delay. Then full sensitivity shall return immediately regardless of continued presence of the vehicle. Pulse re-phase shall be programmable from interface software.

21. Detector units shall have optically-isolated FET outputs to provide fail-safe solid state operation (loss of power to the detector will provide a constant call to the controller--if it has power).

22. Loop detector channels shall continue to function with a single point to ground on the loop/lead-in system.

23. Each channel shall have loop measurement capability to continuously verify loop system integrity. The loop detector shall be capable of detecting and displaying current and historical faults (a short to ground, an open circuit or an inductance change □□ 25%) in the inductive loop or lead-in system.

24. Each channel shall have two LED indicator lights on the front panel; a green "Detect" LED and a red "Fault" LED.

25. The green "Detect" indicator shall indicate detection output status and output timing in process.

26. It shall indicate an Extend flash while the call output is actuated following a directional detection.

27. The green "Detect" indicator shall flash during Delay and Extension Timing to provide a visual indication of timed output.

    a. Delay and Extension flash rates shall differ by at least four times the other's rate. Delay shall be four flashes per second and Extension shall be 16 flashes per second.

28. The green "Detect" indicator shall be ON continuously during a fault condition unless fail-safe for a particular condition is disabled using the interface software.

    a. During a fault condition on a channel, the channel shall display a continuous call indication on its green “Detect” LED and generate a continuous, fail-safe, output on the primary output, regardless of the Pulse or Presence operating mode selected.

29. A status output shall provide a serial coded message to external devices (controllers) that are capable of using the serial information in accordance with NEMA conventions described in TS2-2021.

30. A red "Fault" LED shall indicate current or historical channel fault condition (status) and type. The Fault indicator shall flash a coded message during an open loop condition, a shorted loop system condition and a □□ 25% change of inductance condition. The associated channel’s red “Fault” LED shall provide visual indication of fault type and status as follows:

    a. OFF state indicates no faults (current or historical).

b. ON for one second and one .25 second short pulse indicates a current open loop fault.

c. A one second ON and two .25 second short pulses indicates a current shorted loop fault.

d. ON for one second and three short pulses indicates a current greater than 25% change in inductance fault.

e. A long pulse (six second) followed by a short pulse (.25 second) indicates a historical open.

f. A long pulse followed by two short pulses indicates a historical shorted loop.

g. A long pulse followed by three short pulses indicates a historical greater than 25% change in system inductance fault.

31. A fault indication shall be enabled for as long as the fault remains, except by turning the channel OFF in software or by selecting the "X" setting on the sensitivity switch.

32. If the fault heals or is corrected, the affected channel shall immediately retune and be capable of normal detection. The visual fault indication shall remain active until reset by a momentary change in the mode or sensitivity setting, a momentary interruption of power or by pressing a reset switch.

33. Call output for each detector channel shall provide detect durations in response to an automobile over a three or four turn 6-foot by 6-foot square inductive loop to enable accurate speed, length and occupancy measurements by external devices.

    a. The detector with a 100 microhenry loop/lead-in attached to each channel shall, for any negative inductive change which exceeds its sensitivity threshold, generate a ground true logic level output response within 13 milliseconds for a sensitivity setting of 128 nanohenries.

    b. The detector with a 100 microhenry loop/lead-in attached to each channel shall, for any negative inductive change which exceeds its sensitivity threshold, generate a ground true logic level output response within 20 milliseconds for a sensitivity setting of 64 nanohenries.

34. The output shall become open within the same time limits when such an inductive change is removed.

35. Loop detectors shall have a multi-position switch to Reset all channels and to provide Normal and Fast Recovery modes of operation.

a. The Fast Recovery setting shall cause the detector to adapt instantly to large changes of apparent inductance in the non-call direction.

b. The Normal Recovery mode shall cause the detector to adapt, at a default rate of 0.5 thresholds per second, to apparent changes of inductance in both directions.

36. Loop detectors shall have a Remote Reset input pin on the card edge connector. The unit shall reset and establish a new reference for each loop that is turned ON, when voltage on Pin C is less than eight volts DC for a period of greater than 17 milliseconds.

37. Delay Timing shall be adjustable from zero to 31 seconds, minimum, in increments of 1.0 seconds in lieu of NEMA TS2-2021 increments. When Green Gating is enabled (using the interface software) delay timing shall only occur if the green input is false.

38. Extension Timing shall be adjustable from zero to 7.75 seconds, minimum, in increments of 0.25 seconds in lieu of NEMA TS2-2021 increments. When Green Gating is enabled (using the interface software) extension timing shall only occur if the green input is true.

39. Setting the Delay or Extend DIP switches on the printed circuit board to OFF or selecting 0.0-seconds shall disable timing for that channel unless the override switch is off and Configuration Source is selected to be EEPROM using the interface software.

40. Each channel shall be capable of being assigned a Long-loop Count mode using the software.

    a. Each channel enabled for Long-loop Count mode shall count each individual vehicle moving onto or over a single inductive loop which has a length greater than 20 feet, regardless of previous vehicles being stationary on, moving over or leaving the detection zone.

    b. Each channel shall be configurable for Long-loop Count mode via the serial communication ports.

    c. The Long-loop Count shall be readable via the serial ports.

    d. The call output in the Long-loop Count mode shall be a Presence output.

41. Two channels (channels 1 and 2) shall be capable of being assigned to Directional Detection mode using the software.

    a. The two channels shall be capable of detecting the direction of travel of a vehicle over two 6-foot by 6-foot overlapping loops.

b. The leading edge to leading edge spacing of the overlapping loops shall be three feet.

c. The directional count shall be stored in the detector and shall be accessible via the serial ports.

d. The directional count shall be stored in the second channel that detects the vehicle in the direction of the vehicle's travel. A call output shall be generated by the second channel that detects the vehicle in the direction of the vehicle's travel.

42. The vehicle detector unit shall be capable of collecting and storing counts and occupancy in time bins for each channel.

a. The time bin interval of the vehicle detector shall be configurable from the serial port using the software.

b. The memory of the vehicle detector shall be capable of storing count and occupancy data in 15 minute time bins for all four channels for 36 hours.

c. The vehicle detector shall be designed to accommodate a plug-in memory module to expand the on-board memory used for storing the count and occupancy time bins.

d. With optional memory module, the vehicle detector shall be capable of storing count and occupancy data in 15-minute time bins for all four channels for 335 hours.

e. The count and occupancy stored in the time bins shall be retrievable remotely using the serial ports.

D. Connector Pinout Configuration

1. The following input-output connector pin terminations shall be provided on input file connectors as well as detector edge connector in accordance with NEMA TS2-2021 requirements.

2. The detector's edge connector pinout is specified in the table below and is shown looking into the front of a detector card rack or input files. Pin-1 is at the top of the component side of the detector and Pin-A is at the top of the non-component side of the detector.

FUNCTION / SIGNAL	PIN	PIN	FUNCTION / SIGNAL
CH 1 GREEN DC+	1	A	DC GND
CH 2 GREEN DC+	2	B	POWER (+10.8 to 37VDC)
DET ADDRESS 3	3	C	REMOTE EXTERNAL RESET
LOOP IN CH 1	4	D	LOOP IN CH 1
LOOP IN CH 1	5	E	LOOP IN CH 1
DET ADDRESS 0	6	F	CH 1 OUT +
STATUS OUTPUT CH 1	7	H	CH 1 OUT -
LOOP IN CH 2	8	J	LOOP IN CH 2
LOOP IN CH 2	9	K	LOOP IN CH 2
DET ADDRESS 3	10	L	CHASSIS GROUND
NO CONNECTION	11	M	NO CONNECTION
NO CONNECTION	12	N	NO CONNECTION
NO CONNECTION	13	P	NO CONNECTION
NO CONNECTION	14	R	NO CONNECTION
DET ADDRESS 2	15	S	NO CONNECTION
NO CONNECTION	16	T	NO CONNECTION
NO CONNECTION	17	U	NO CONNECTION
NO CONNECTION	18	V	NO CONNECTION
DATA TRANSMIT	19	W	CH 2 OUT +
STATUS OUTPUT CH 2	20	X	CH 2 OUT -
DATA RECEIVE	21	Y	NO CONNECTION
NO CONNECTION	22	Z	NO CONNECTION

E. Interface Software Requirements (for setting up communication and data collection, configuring binning, logging, travel direction detection, viewing diagnostics, fault monitoring and parameter setting features)

1. The detector unit shall be capable of remote configuration, system diagnostic measurements and real-time data collection. A communication link shall provide remote access to the detector, for reading its configuration, for fault identification and verification, for real-time monitoring and data collection on two channels. The link shall provide optional password protection to change unit configuration settings. Interface software shall display and report current loop inductance measurements, current or last (historical) fault information, and information specific to the last vehicle detected and vehicle counts. Vehicle information shall include vehicle change of inductance, speed, length and time over loop.

2. A Windows™ based interface and data acquisition software program shall be provided to perform these functions via a remote reporting device running under Windows 10 or latest version and shall be compatible with the City's controller and system software..

3. The software shall establish and maintain the communication link to a remote reporting device via a field modem or by direct connection to one of the serial ports on the detector.

4. The software shall be organized by application to simplify setup and monitoring of channel activity measurements, traffic counting, long-loop count, logging of vehicle speed and vehicle length, loop to loop travel time, detect durations, binning of count and occupancy, and sensing of vehicle travel direction with directional detection and call duration.

5. The software shall allow selection of PC's communication port and baud rate, and allow selection of English or metric measurements.

    a. Baud rate options shall be 1200, 2400, 4800, 9600, or 19200 BPS.

    b. Direct communication shall be via PC's serial port or with telephone modem communications using one of the PC's COM ports.

6. The software shall include a phone book and dialing utility.

7. The interface and data acquisition software shall provide a Read from Device command on the File menu.

    a. It shall also provide for a unit address to be selected and allow the selection of a "wildcard" address to establish remote communication.

8. The Initial screen shall open with a Settings icon, a Real-Time Vehicle Logging icon and a Traffic Data Binning icon. After communications have been established with a detector, the other icons shall appear. These shall include the Real-Time Activity Monitoring icon, Force ALL Outputs and LEDs icon, a Reset icon and the Scan-Time icon.

9. A Settings window shall be divided into nine tabs to organize the detector settings by functional application.

10. A General tab shall allow selection of the configuration source to be either from EEPROM or switches, the oscillator frequency for the unit, the vehicle count period and channel sensitivity and mode. When the interface software reads settings from a unit, whichever configuration source is currently active shall determine which settings are displayed in boldface type (EEPROM or switch settings).

11. A Communications tab shall provide for the setting of a field modem command string, transmit delay, selection of the communication baud rates on the front and rear ports, for setting a programmable address and to enable a backpanel address. There shall be provisions to establish, cancel and change a password.

a. If password protection is set up in a detector, the unit shall not respond to any requests to perform a reset or change settings until the correct password has been issued. After a verified password has been issued the detector shall respond to all requests for reset or settings changes for 60 minutes. After 60 minutes the unit shall revert back to password protected mode until the password has been issued.

12. Reset shall cause immediate reinstatement of password protection. Most setting changes initiate a reset.

13. A Timing tab shall provide for setting the Delay or Extend Time options and the timing increments for each channel. There shall be an option to select "Enable" Green gating to condition the timing functions to green inputs.

14. A Microloop tab shall provide for selecting microloop mode of operation and setting some of the parameters that are unique to the performance of microloop sensors in special applications.

15. A Long-loop tab shall provide for selecting the option to count vehicles over long loops set to operate in Presence mode. Setup options shall be included to allow for calibrating the algorithm to improve count accuracy on loops of from 20 feet long to 60 feet long. Vehicle counts shall be available over the serial communication ports.

16. A Directional tab shall provide the option of setting up travel direction sensing on channel pairs 1 & 2. With the paired channels connected to 6-foot by 6-foot loops that are overlapped by three feet, vehicles shall be counted in both directions. The directional detection call output shall be assigned to the last loop a vehicle crosses when traveling in the direction that is to be detected. Call Duration shall be selectable for the directional output on the trailing channel of the paired sets.

17. An Output tab shall provide for the option to enable the Status Output for NEMA TS2 Type controllers. Software provision shall also exist to disable the "fail-safe" Call Output for unique system sampling applications.

18. A Noise Immunity tab shall provide for selecting several noise options including a power line filter which can be enabled.

19. An Adapt tab shall provide for selecting the adaptation parameters for the detector unit, to modify default operation.

20. A Real-Time Vehicle Logging icon shall provide for setting up channels to perform vehicle speed and length measurements.

a. Facilities shall be provided to insert a loop description (ID label), a loop type (configuration) and a calibration utility to select effective magnetic field loop sizes to improve measurement accuracy. The utility shall also provide for setting up loop assignments and leading edge distances from loop to loop to calculate vehicle speeds. This information shall be saved in the detector's EEPROM.

b. Facilities shall be included to activate and view the log with channel IDs, the loop descriptions, dates, times, speeds, lengths, durations, loop to loop times displayed in real-time. Provisions shall be made to save the log to a file and print the log.

21. Traffic Data Binning icon shall open a window to setup and collect binned count and occupancy data from the detector.

a. A tab shall provide for setting up the channels to be binned, the start date and time, the end date and time, and the binning intervals.

b. The software shall inform the user when the detector will run out of memory based on the setup information provided. If continuous binning is selected the data shall "wrap-around" so that the oldest data will be overwritten with the latest entries.

22. A Real-Time Activity window shall be provided to display all current detection information pertaining to each channel, including current measurements, last fault (or historical fault) information, plus information specific to the last vehicle detected and traffic counts.

a. Measurements shall include: loop inductance, loop frequency, reference frequency, green input state and loop status.

b. Last Fault shall include fault type, time and date.

c. Last Vehicle data shall include Delta L in nanohenries, detect duration, detect time, and detect date.

d. Count shall display total count or directional count and the count period remaining.

23. The Activity window shall include a freeze capability to capture the current activity information and hold it for analysis while the software continues to display the most recent changes.

24. A utility window shall be included to verify the operation of a detector's outputs and LEDs and confirm the wiring of a control cabinet to issue the call output to a device or controller. This utility shall allow selection of specific Detect LEDs, Call Outputs, Fault LEDs, and channel Status Outputs to be "forced" ON or OFF for testing the system.

25. A utility window shall be included to remotely reset a detector. It shall be possible to select specific channels, all channels or the entire unit.

26. A utility window shall be included to provide a real-time view of the detector's self-measured scan-time. This interactive utility shall continuously read and display the detector's scan-time and display the theoretical detection performance based on user-selectable parameters such as loop to loop spacing, effective field lengths, channel sensitivity settings, and the effects of any noise immunity options selected.

27. The software shall allow printing of settings, activity measurements, and binned and logged vehicle data.

28. A comprehensive ON-LINE Help utility shall be included with detailed descriptions of unit features and setup information. The Help text shall include hyperlinks to all subjects related to applications or setup sequences. Help screens shall include a print function to print the page.

PART 3 EXECUTION

3.01 LOOP DETECTOR INSTALLATION

A. Each loop and its lead-in wires shall be separate and independent from any others. A minimum of twelve (12) inches shall be maintained between adjacent, parallel sawcuts. The Contractor shall be responsible for a good mechanical and electrical installation of the loop itself and the two lead-wires to and through the curb to the adjacent pull box or hand-hole. This responsibility shall remain with the Contractor until such time as the City can hook up, tune and test the loop for satisfactory operation.

B. Saw Cut: The sawed slot shall be 3/8 inch in width and a minimum of 2 inches in depth for concrete and asphalt. Sawcut shall be deep enough to provide one full inch of sealant above the installed loop wire(s). A sawed slot(s) must be continued from the nearest side or corner of the loop to the conduit thru the curb for the twisted lead-in wires to the adjacent pull box or junction point. The slots shall be brushed and cleared of any debris. Dry moisture-free compressed air shall be used to clear away the remaining dirt, dust and moisture. A one inch hole shall be drilled at each corner to eliminate sharp bends and damage to wire. Contractor shall remove sharp corner as illustrated on detail 3900-08 . Sawcuts shall overlap a sufficient distance to provide continuous full depth of the sawcut. There shall be no angle cuts for corners.

1. It is the City's desire that loops are not installed across pavement joints. If a proposed loop would cross an existing pavement joint, the Contractor shall request confirmation from the Engineer. With prior approval from the Engineer, City shall pay for additional sawcut to divide the proposed detection area into separate loops which cover the same effective area without crossing pavement joints.

C. The number of turns of loop wire shall be as shown on the drawings, or as follows:

Loop Perimeter, feet	Number of Turns
< 20 feet	4
<= 30 feet	3
> 30 feet	2

D. Positioning Wire: One continuous, unbroken, and unspliced length of wire shall be used to form the loop and its lead-in wires. This wire shall be of sufficient length for the required number of turns plus the distance to the adjacent pull box. The lead-in portion (pair of wires forming ends of loop) shall be twisted a minimum of five (5) turns per linear foot before insertion into slot. The twisted turns shall continue through the conduit at the curb and on to the pull box. Use a blunt tool to push wires into slot. The wires shall be held in place with rubber wedges or sections of insulation.

1. The sawcut, and loop wire installation shall be inspected by the City's Inspector prior to placement of sealant. Failure to obtain inspection prior to placement of sealant will be reason to require the Contractor to completely reinstall the loop.

E. Sealing: Before and after sealing wires in roadway, test the pair of wires at the pull box for continuity and resistance with an ohm meter. In addition, the integrity of the insulation shall be checked by applying a megger between each end of the loop lead-in and the nearest reliable electrical ground (e.g., street light, hydrant, etc.). In the event that no available ground exists, a suitable ground shall be established for the measurement (e.g., driven metal spike). A resistance of less than ten (10) megohms to ground indicates a faulty installation and must be corrected. Final readings on each detector shall be given to the Inspector or Engineer on the job.

F. Sealer: Use embedding sealer as per manufacturer's instruction or as directed by Engineer. Loop sealant shall be allowed to cure for a minimum of three (3) hours prior to opening the lane for traffic.

G. Conduit: Wires from curb to pull box must be enclosed in conduit as indicated on plan set (1 in. min.) and twisted a minimum of five (5) turns per foot. The conduit shall be rigid in place.

H. Contractor shall set up an adequate and safe traffic control based upon the Texas Department of Transportation Traffic Signal Work Typical Detail/Traffic Signal Barricade and Signs, I-82-8011 BTS and the Texas Manual on Uniform Traffic Control Devices, latest revision.

I. Contractor shall draw all loop outlines on pavement for approval by the Engineer, prior to beginning sawcut.

J. As a minimum requirement, Contractor shall use a self-propelled power saw with diamond blade or abrasive saw blades for sawing the pavement to the length, depth and width as shown on the intersection layout plan and the typical detail drawings. The power saw must be equipped with a depth measurement device, water valve and guide.

K. Contractor shall locate water supply (hydrant or water truck) to cool the blade and to clean out slots. Hydrant can only be used if proper permission has been obtained and water meter is used.

L. Contractor shall have an air compressor for the cleaning and drying out the sawed slots on site.

M. Drill hole through pavement for conduit to pull box.

N. Contractor shall obtain megger and ohm meter for checking integrity of loop insulation and the continuity and resistance of the wired loop.

1. Wire must have a megger reading before installation (on reel);

2. Megger reading after installation (before being sealed);

3. Megger reading after being sealed and splices made;

4. It shall be the Contractor's responsibility to obtain these readings and have them available for the signal inspector upon request.

O. Splicing kit materials and equipment for splicing the two #14 wires to the shielded balanced pair cable in the pull box. Only soldered connections are acceptable. All splices must be watertight. The drain wire of the loop lead-in cable shall be grounded to earth ground only at the controller or detector cabinet. The resistance from the drain wire to the ground rod shall be less than one (1) ohm, at the cabinet.

P. The loop wire shall be held in place every two (2) feet with strips of rubber, neoprene flexible tubing or polyethylene foam sealant, one (1) inch in length. These strips shall be left in place and slot filled with loop sealant.

Q. All wires shall be tagged to identify the loop number and lane. The tag identification shall correlate with the electrical schedule shown on the project plans. The tags shall be furnished and installed by the Contractor. Each tag shall be wrapped around the conductor twice. Wire marking tags shall be made of flame retardant reinforced epoxy tape 5.5 mils in thickness and ¼ inch minimum width. The tape shall be flexible and resistant to oil and water, and have a pressure sensitive acrylic adhesive backing. The adhesive shall be a high tack adhesive with good adhesion to clean neoprene, hypalon, nylon and PVC insulation materials. The film material shall conform to the flame retardant requirements of UL 510 and be rated at 150 degrees Centigrade. Appropriate numbers and letters shall be printed on wire tags for conductor identification.

END OF SECTION

SECTION 16730

INTELLIGENT TRANSPORTATION SYSTEM (ITS) CONTROLLER CABINET ASSEMBLY

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This specification defines the minimum detailed requirements applicable to traffic signal controller cabinets. The intent of specification is to set forth the minimum acceptable electrical and mechanical design and requirements within which all equipment operates satisfactorily and reliably, and the means by which the equipment shall be tested to determine whether it shall so operate.

B. These specifications describe the materials necessary to provide Intelligent Transportation System (ITS) traffic signal controller cabinets for use with Type 2070 Advanced Transportation Controller (ATC). The Type 2070 Controller Unit to be furnished with the ITS Controller Cabinet Assembly shall meet the requirements of Specification Section 16731.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 16731 – Model 2070 Controller Unit

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Measurement: Each ITS Controller Cabinet Assembly shall include a Model 2070 Controller Unit (Section 16731) and other components as specified in Table 2 of article 2.10.B of this specification. This Item will be measured as each controller cabinet assembly by type furnished.

2. The materials furnished in accordance with this Item and measured as provided under “Measurement” as each specified type assembly furnished.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. Abbreviations and Acronyms

1. Terms and Abbreviations. Wherever the following terms or abbreviations are used, the intent and meaning is interpreted as follows:

a. A: Ampere

b. AC: Alternating Current

c. AC+: 120 Volts AC, 60 hertz ungrounded power source

d. AC- :120 Volts AC, 60 hertz grounded return to the power source

e. ANSI: American National Standard Institute

f. ASCII: American Standard Code for Information Interchange

g. ASTM: American Society for Testing and Materials

h. AWG: American Wire Gage

i. C: Celsius

j. C Language: The ANSI C Programming Language

k. CPU: Central Processing Unit

l. CTS: Clear To Send

m. DAT Program: The CITY OF HOUSTON's Diagnostic and Acceptance Test Program

n. Db: Decibel

o. dBa: Decibels above reference noise, adjusted

p. DC: Direct Current

q. DCD: Data Carrier Detect (Receive Line Signal Detector)

r. DIN : Deutsche Industrie Norm

s. EG: Equipment Ground

t. EIA: Electronic Industries Association

u. EMI: Electro Magnetic Interference

v. EPROM: Ultraviolet Erasable, Programmable, Read Only Memory Device

w. EEPROM: Electrically Erasable, Programmable, Read Only Memory Device

x. ETL: Electrical Testing Laboratories, Inc.

y. FPA: Front Panel Assembly

z. HEX: Hexadecimal

aa. Hz: Hertz

bb. IC: Integrated Circuit

cc. I.D.: Identification

dd. IEEE: Institute of Electrical and Electronics Engineers

ee. ISO: Isolated

ff. KB: Kilobytes

gg. LCD: Liquid Crystal Display

hh. LED: Light Emitting Diode

ii. LOGIC: Negative Logic Convention (Ground True) State

jj. LSB: Least Significant Byte

kk. Lsb: Least Significant Bit

ll. MB: megabyte

mm. MSB: Most Significant Byte

nn. msb: Most Significant Bit

oo. m: Milli

pp. MCU/MPU/ IMP: Micro Controller Unit, Microprocessor Unit, or Integrated Multiprotocol Processor

qq. MIL: Military Specifications

rr. MODEM: Modulation/Demodulation Unit

ss. MOS: Metal-Oxide Semiconductor

tt. MOV: Metal-Oxide Varistor

uu. MS: Military Standards

vv. N: Newton: SI unit of force

ww. N.C.: Normally closed contact

xx. N.O.: Normally open contact

yy. NEMA: National Electrical Manufacturer's Association

zz. NETA: National Electrical Testing Association, Inc.

aaa. N: nano

bbb. NLSB: Next Least Significant Byte

ccc. Nlsb: Next Least Significant Bit

ddd. NMSB: Next Most Significant Byte

eee. Nmsb: Next Most Significant Bit

fff. PCB: Printed Circuit Board

ggg. PDA: Power Distribution Assembly

hhh. PLA/PAL: Programmable Array Logic Device

iii. Ppm: Parts per million

jjj. PWM: Pulse Width Modulation

kkk. RAM: Random Access Memory

lll. RF: Radio Frequency

mmm. RMS: Root-Mean-Square

nnn. ROM: Read Only Memory Device

ooo. RTS: Request to Send

ppp. R/W: Controller Unit Read/Write Control Line

qqq. RxD: Received Data

rrr. SCI: Serial Communications Interface

sss. SDLC: Synchronous Data Link Control

ttt. S: Logic State

uuu. s: second

vvv. SRAM: Static Random Access Memory Device

www. SW: Switch

xxx. TB: Terminal Block

yyy. TOD: Time Of Day Clock

zzz. TTL: Transistor-Transistor Logic

aaaa. TxD: Transmitted Data

bbbb. u: Micro

cccc. UL: Underwriter's Laboratories, Inc.

dddd. VAC: Voltage Alternating Current (root mean square)

eeee. VDC: Voltage Direct Current

ffff. VME: Versa Module Eurocard, VMEbus Standard IEEE P1014/D1.2

gggg. x: Number Value

hhhh. XX: Manufacturer's Option

B. Reference Standards

1. ANSI/IEEE C62.41 – Surge Voltages in Low Voltage Power Circuits

2. ASTM A 666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

3. ASTM B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

4. ASTM B 633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel

5. ATC 2070, v01.05 – Advanced Transportation Controller (ATC) Standards

6. DIN 41612 – Standard for Electrical Connectors

7. EIA/TIA 485 - Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems

8. Federal Specification QQ-P-416C - Plating, Cadmium (Electrodeposited)

9. ISO/IEC 3309 - Information Technology - Telecommunications and Information Exchange Between Systems - High-Level Data Link Control (HDLC) Procedures – Frame Structure

10. MIL–P-13949G - Plastic Sheet, Laminated Metal Clad (For Printed Wiring Boards)

11. MIL–PRF-55110J – Printed Wiring Board, Rigid

12. MIL-PRF-22684 - Resistors, Fixed, Film (Insulated)

13. MIL-W-16878E - Wire, Electrical, Insulated

14. NEMA TS2 – Traffic Controller Assemblies with NTCIP Requirements

1.05 DEFINITIONS

A. Assembly: A complete machine, structure or unit of a machine that was manufactured by fitting together parts and/or modules

B. Cabinet: An outdoor enclosure generally housing the controller unit and associated equipment

C. Certificate of Compliance: A certificate signed by the manufacturer of the material or the manufacturer of assembled materials stating that the materials involved comply in all respects with the requirements of the specifications

D. Channel: An information path from a discrete input to a discrete output.

E. City of Houston: The City of Houston director, acting either directly or through properly authorized agents, such agents acting within the scope of the particular duties delegated to them.

F. Component : Any electrical or electronic device

G. Contractor: The person or persons, Manufacturer, firm, partnership, corporation, vendor or combination thereof, who have entered into a contract with the CITY OF HOUSTON, as party of the second part or legal representative

H. Controller Unit: That portion of the controller assembly devoted to the operational control of the logic decisions programmed into the assembly

I. Devices: Comply to function, pin out, electrical and operating parameter requirements, access times and interface parameters of the specified device

J. DRAM: Dynamic random access memory. Random access means that the processor can access any part of the memory or data storage space directly rather than having to proceed sequentially from some starting place. DRAM is dynamic in that it needs to have its storage cells refreshed or given a new electronic charge every few milliseconds.

K. Equal Connectors: Comply with physical dimensions, contact material, plating and method of connection.

L. Firmware: A computer program or software stored permanently in PROM, EPROM, ROM or semi-permanently in EEPROM

M. FLASH: A +5 VDC powered IC Memory Device with nonvolatile, electrically erasable, programmable, 100K read/write minimum cycles and fast access time features

N. Jumper : A means of connecting/disconnecting two or more conductive by soldering/desoldering a conductive wire or by PCB post jumper

O. Keyed: Means by which like connectors can be physically altered to prevent improper insertion.

P. Laboratory: The established laboratory of the CITY OF HOUSTON or other laboratories authorized by the CITY OF HOUSTON to test materials involved in the contract

Q. Module: A functional unit that plugs into an assembly

R. Motherboard: A printed circuit connector interface board with no active or passive components

S. NA: Presently Not Assigned. Cannot be used by the Manufacturer for other purposes

T. Power Conditions: 16.7 ms (one 60 Hertz cycle) reaction period is allowed to be included in the 50 milliseconds timing or added to (67 milliseconds duration). The hysteresis between power failure and power restoration voltage settings must be a min. of 5 VAC with a threshold drift of no more than 0.2 VAC.

U. Power Failure: A Power Failure is said to have occurred when the incoming line voltage falls below 92 +/- 2 VAC for 50 milliseconds. See Power Conditions.

V. Power Restoration: Power is said to be restored when the incoming line voltage equals or exceeds 97 +/- 2 VAC for 50 milliseconds. See Power Conditions.

W. Second Sourced: Produced by more than one Manufacturer

X. Triac: Silicon-Controlled Rectifier which controls power bilaterally in an AC switching circuit

Y. Thumb Screw Device (TSD): A retractable screw fastener with projecting stainless steel screw, spring and natural aluminum knob finish. (TSD No.2 must be flat black.)

1. TSD No.1 - 8-32 SOUTHCO #47-62-301-20 or equal.

2. TSD No.2 - 8-32 SOUTHCO #47-62-301-60 or equal.

3. TSD No.3 - M3 SOUTHCO #47-82-101-10 or equal.

Z. WDT (Watchdog Timer): A monitoring circuit, external to the device watched, which senses an Output Line from the device and reacts

1.06 WARRANTY

A. All materials furnished will be warranted by the supplier for a period of two (2) years from date of delivery.

1.07 SUBMITTALS

A. Manuals. Two copies of Manual Documentation must be supplied for each item purchased. The manual must be bound in durable covers made of either 65-pound stock paper or clear plastic. The manual must be printed on paper measuring 8-1/2 in. by 11 in., with the exception that schematics, layouts, parts lists and plan details may be on sheets measuring 11 in. by 17 in., with each sheet neatly folded to a size of 8-1/2 in. by 11 in. A minimum of Times New Roman or Arial 10 point font must be used for all manual text, excluding drawings and schematics. Drawing text may use a smaller font size.

1. Cabinet Wiring Diagrams. Two copies of Cabinet Wiring Diagrams must be included in each cabinet. Cabinet Wiring Diagrams must be on non-fading, minimum 22 in. x 34 in., sheets.

a. Manual Contents. Each manual must utilize the following outline, to the extent possible:

(1) Table of Contents

(2) Glossary

(3) Manufacturer Contact Information

(a) Address

(b) Telephone Number

(c) Fax Number

(d) General Email Address

(4) General Description

(5) General Characteristics

(6) Installation

(7) Adjustments

(8) Theory of Operation

(a) Systems Description (include block diagram).

(b) Detailed Description of Circuit Operation.

(9) Maintenance

(a) Preventive Maintenance.

(b) Trouble Analysis.

(c) Trouble Shooting Sequence Chart.

(d) Wave Forms.

(e) Voltage Measurements.

(f) Alignment Procedures.

(10) Parts List (include circuit and board designation, part type and class, power rating, component manufacturer, mechanical part manufacturer, data specification sheets for special design components and original manufacturer's part number).

(11) Electrical Interconnection Details & Drawings.

(12) Schematic and Logic Diagram

(13) Assembly Drawings and a pictorial diagram showing physical locations and identification of each component or part.

(14) The date, serial numbers, model numbers and revision numbers of equipment covered by the manuals must be printed on the front cover of the manuals.

b. Manual Pouches. Manuals for the cabinet must be furnished in a weatherproof plastic pouch placed in the cabinet.

c. Draft Manual. A preliminary draft of the manual must be submitted, when required, to the CITY OF HOUSTON for approval prior to final printing.

1.08 DELIVERY, STORAGE AND HADLING

A. Packaging. Each item delivered must be individually packed in its own shipping container. When loose Styrofoam is used for packing the item, the item must be sealed in a plastic bag to prevent direct contact with the Styrofoam.

B. Delivery. Each item delivered for testing must be complete, including manuals, and ready for testing.

PART 2 PRODUCTS

2.01 MATERIALS

A. All sharp edges and corners must be rounded and free of any burrs.

1. Aluminum. Aluminum sheets must be Type 3003-H14 or Type 5052-H32 ASTM Designation B209 aluminum alloy. Rod, Bar and Extruded must be Type 6061-T6, or equal.

2. Stainless Steel. Stainless Steel sheets must be annealed or one-quarter-hard complying with the ASTM Designation: A666 for Type 304, Grades A or B, stainless steel sheet.

3. Cold Rolled Steel. Cold Rolled Steel sheet, rod, bar and extruded must be Type 1018/1020.

    a. Plating. All cold roll steel must be plated. All plating must be either cadmium plating meeting the requirements of Federal Specification QQ-P-416C, Type 2 Class l or zinc plating meeting the requirements of ASTM B633-85 Type II SC4.

B. Mechanical Hardware. All bolts, nuts, washers, screws, hinges and hinge pins must be stainless steel unless otherwise specified.

C. Electrical Isolation. Within the circuit of any device, module, or Printed Circuit Board (PCB), electrical isolation must be provided between DC logic ground, equipment ground and the AC- conductor. They must be electrically isolated from each other by 500 Megohms, minimum, when tested at the input terminals with 500 VDC.

D. Daughter Boards. Keyboards and LCD/LED Displays are considered daughter boards. Daughter boards must be mechanically secured with a minimum of four spacers/metal screws. Connectors must be either Flat Cable or PCB Headers. Components are allowed to be mounted under the daughter board.

2.02 COMPONENTS

A. General. All components must be second sourced and be of such design, fabrication, nomenclature or other identification as to be purchased from a wholesale distributor or from the component manufacturer, except as follows:

1. When a component is of such special design that it precludes the purchase of identical components from any wholesale distributor or component manufacturer, one spare duplicate component must be furnished with each 20, or fraction thereof, components used.

2. The electronic circuit design must be such that all components of the same generic type, regardless of manufacturer, function equally in accordance with the specifications.

B. Electronic Components.

1. No device to be socket mounted unless specifically called out.

2. No component to be operated above 80% of its maximum rated voltage, current or power ratings. Digital components must not be operated above 3% over their nominal voltage, current or power ratings.

3. Components must have been kept in the original packaging and stored in a proper environment, according to the manufacturers instructions. The design life of all components, operating for twenty-four hours a day and operating in their circuit application, must be ten years or longer.

4. Components must be arranged so they are easily accessible, replaceable and identifiable for testing and maintenance. Where damage by shock or vibration exists, the component must be supported mechanically by a clamp, fastener, retainer, or hold-down bracket.

5. The Manufacturer must submit detailed engineering technical data on all components at the request of the CITY OF HOUSTON. The Manufacturer must certify that the component application meets the requirements of this standard.

C. Capacitors. The DC and AC voltage ratings, as well as the dissipation factor, of a capacitor must exceed the worst-case design parameters of the circuitry by 150%. Capacitor encasements must be resistant to cracking, peeling and discoloration. All capacitors must be insulated and be marked with their capacitance values and working voltages. Electrolytic capacitors must not be used for capacitance values of less than 1.0 microfarad and be marked with polarity.

D. Potentiometers. Potentiometers with ratings from 1 to 2 watts must meet Military Type RV4 requirements. Under 1 Watt potentiometers must be used only for trimmer type function. The potentiometer power rating must be at least 100% greater than the maximum power requirements of the circuit.

E. Resistors. Fixed carbon film, deposited carbon, or composition-insulated resistors must conform to the performance requirements of Military Specifications MIL-PRF-22684. All resistors must be insulated and be marked with their resistance values. Resistance values must be indicated by the EIA color codes, or stamped value. The value of the resistors must not vary by more than 5% between -37 degrees C and 74 degrees C.

1. Special ventilation or heat sinking must be provided for all 2- watt or greater resistors. They must be insulated from the PCB.

F. Semiconductor Devices.

1. All transistors, integrated circuits, and diodes must be a standard type listed by EIA and clearly identifiable.

2. All metal oxide semiconductor components located in a sub-assembly must contain circuitry to protect their inputs and outputs against damage due to high static voltages or electrical fields.

3. Device pin "1" locations must be properly marked on the PCB adjacent to the pin.

G. Transformers and Inductors. All power transformers and inductors must have the manufacturer's name or logo and part number clearly and legibly printed on the case or lamination. All transformers and inductors must have their windings insulated, be protected to exclude moisture, and their leads color coded with an approved EIA color code or identified in a manner to facilitate proper installation.

H. Triacs. Each triac with a designed circuit load of greater than 0.5 Amperes at 120 VAC must be mounted to a heat sink with thermal conductive compound or material, in addition to being mechanically secured.

I. Circuit Breakers. Circuit breakers must be listed by UL or ETL. The trip and frame sizes must be plainly marked (marked on the breaker by the manufacturer), and the ampere rating must be visible from the front of the breaker. Contacts must be silver alloy and enclosed in an arc quenching chamber. Overload tripping must not be influenced by an ambient air temperature range of from -18 degrees C to 50 degrees C. The minimum Interrupting Capacity must be 5,000 Amperes, RMS when the breaker is secondary to a UL approved fuse or primary circuit breaker and both breakers in concert provide the rated capacity. For circuit breakers 80 Amperes and above, the minimum interrupting capacity must be 10,000 Amperes, RMS. Circuit breakers must be the trip-free type with medium trip delay characteristic (Carlingswitch Time Delay Curve #24 or equal).

1. Load Circuit Breaker Auxiliary Internal Switches. The Load Circuit Breakers located on the PDA that are used to control Output Assembly Model 200 Switch Packs must have auxiliary switches. The auxiliary switches must “open” when the load breaker has tripped and the system will transfer the power from the Main Contactor to the Flash or Blank condition.

J. Fuses. All Fuses that are resident in a bayonet style fuse holder must have the fuse size rating labeled on the holder or on the panel adjacent to the holder. Fuses must be easily accessible and removable without use of tools.

K. Switches.

1. Dip. Dual-inline-package, quick snap switches must be rated for a minimum of 30,000 operations per position at 50 milliamperes, 30 VDC. The switch contact resistance must be 100 milliohms maximum at 2 milliamperes, 30 VDC. The contacts must be gold over brass.

2. Logic. The switch contacts must be rated for a minimum of 1 Ampere resistive load at 120 VAC and be silver over brass (or equal). The switch must be rated for a minimum of 40,000 operations.

3. Control. The switch contacts must be rated for a minimum of 5 Amperes resistive load at 120 VAC or 28 VDC and be silver over brass (or equal). The switch must be rated for a minimum of 40,000 operations.

4. Power. Ratings must be the same as CONTROL, except the contact rating must be a minimum of ten Amperes at 125 VAC.

L. Terminal Blocks. The terminal blocks must be barrier type, rated at 20 Amperes and 600 VAC RMS minimum. The terminal screws must be 0.3125 in. minimum length nickel plated brass binder head type with screw inserts of the same material. Screw size is called out under the associated file, panel or assembly.

M. Screw Lug and Cam Driven Connectors. Provided the connectors mate, screw lug cam driven devices or crimp pin connectors must be allowable if the interface is part of a harness. For field termination, screw lug and cam driven assemblies are interchangeable for field wiring termination, provided they both accommodate 22-gauge wire on the inputs and 22-gauge wire on the outputs.

N. Wiring, Cabling and Harnesses.

1. Harnesses must be neat, firm and properly bundled with external protection. They must be tie-wrapped and routed to minimize crosstalk and electrical interference. Each harness must be of adequate length to allow any conductor to be connected properly to its associated connector or termination point. Conductors within an encased harness have no color requirements. Printed circuit motherboards are to be used where possible to eliminate or reduce cabinet wiring.

2. Wiring containing AC must be bundled separately or shielded separately from all DC logic voltage control circuits.

3. Wiring must be routed to prevent conductors from being in contact with metal edges. Wiring must be arranged so that any removable assembly may be removed without disturbing conductors not associated with that assembly.

4. All conductors, except those that can be readily traced, must be labeled. Labels attached to each end of the conductor must identify the destination of the other end of the conductor.

5. All conductors must conform to MIL-W-16878E/1 or better and have a minimum of 19 strands of copper. The insulation must be polyvinyl chloride with a minimum thickness of 10 mils or greater. Where insulation thickness is 15 mils or less, the conductor must conform to MIL-W-16878/17.

6. Conductor color identification must be as follows:

AC- circuits - white
Equip. Ground - solid green or continuous green color with 1 or more yellow stripes.
DC logic ground - continuous white with a red stripe.
AC+ circuits - continuous black or black with colored stripe
DC logic ungrounded or signal - any color not specified

O. Indicators and Character Displays. All indicators and character displays must be readily visible at a radius of up to 1.2 m (4 feet) within the cone of visibility when the indicator is subjected to 97,000 lux (9,000 foot-candles) of white light with the light source at 45 degrees (+/-2 degrees) to the front panel.

1. Indicators. All indicators and character displays must have a minimum 90 degrees cone of visibility with its axis perpendicular to the panel on which the indicator is mounted. All indicators must be self-luminous. All indicators must have a rated life of 100,000 hours minimum. Each LED indicator must be white or clear when off. Indicators supplied on equipment requiring handles must be mounted such that a horizontal clearance is provided.

2. Character Displays. Liquid Crystal Displays (LCD) must be readable at temperatures of -20 degrees C to +70 degrees C.

P. Connectors. Connectors must be keyed to prevent improper insertion of the wrong connector where equipment damage or operator injury may result. The mating connectors must be designated as the connector number and male/female relationship, such as C1P (plug or PCB edge connector) and C1S (socket).

1. Type T. Type T connector must be a single row, 10 position, feed through terminal block. The terminal block must be a barrier type with 6-32, 0.25 in. or longer, nickel plated brass binder head screws. Each terminal must be permanently identified as to its function.

2. Plastic Circular and Type M. Pin and socket contacts for connectors must be beryllium copper construction subplated with 1.27 microns nickel and plated with 0.76 microns gold. Pin diameter must be 0.0618 in. All pin and socket connectors must use the AMP #601105-1 or #91002-1 contact insertion tool and the AMP #305183 contact extraction tool.

3. Card Edge and Two-Piece PCB.

a. Edge connectors must have bifurcated gold-plated contacts. The PCB receptacle connector must meet or exceed the following:

Operating Voltage:	600 VAC (RMS)
Current Rating:	5.0 Amperes
Insulation Material:	Diallyl Phthalate or Thermoplastic
Insulation Resistance:	5,000 Megohms
Contact Material:	Copper alloy plated with 0.00005 in. of nickel and 0.00010 in. of gold
Contact Resistance:	0.006 Ohm maximum

b. The two-piece PCB connector must meet or exceed DIN 41612.

(1) The PCB 22/44 Connector must have 22 independent contacts per side; dual sided with 0.156 in. contact centers.

4. Wire Terminal. Each wire terminal must be solderless with PVC insulation and a heavy duty short-locking spade type connector. All terminal connectors must be crimped using a Controlled-Cycle type crimping tool.

5. Flat Cable. Each flat cable connector must be designed for use with 26 AWG cable; have dual cantilevered phosphor bronze contacts plated with 0.00015 of gold over 0.00005 in. of nickel; and have a current rating of 1 Ampere minimum and an insulation resistance of 5 Megohms minimum.

6. PCB Header Post. Each PCB header post must be 0.025 in. square by 0.3425 in. high from the plane of the PCB to the end of the pin; be mounted on 0.10 in. centers; and be tempered hard brass plated with 0.00015 in. of gold over 0.00005 in. of nickel.

7. PCB Header Socket. Each PCB header socket block must be nylon or diallyl phthalate. Each PCB header socket contact must be removable, but crimp-connected to its conductor. The Manufacturer must list the part number of the extraction tool recommended by its manufacturer. Each PCB header socket contact must be brass or phosphor bronze plated with 0.00010 in. of gold over 0.00005 in. of nickel.

Q. Surge Protection Device. The surge suppression device must comply with ANSI/IEEE C62.41 (100 Kilohertz Ring Wave, the 1.2/50 microseconds – 8/20 Combination Wave and the EFT Burst) at voltages and currents specified at "Location Category B2" and at "Test Severity" level III (i.e. up to 4.0 Kilovolts, open-circuit).

2.03 MECHANICAL REQUIREMENTS

A. Assemblies. All assemblies must be modular, easily replaceable and incorporate plug-in capability for their associated devices or PCBs. Assemblies must be provided with two guides for each plug-in PCB or associated device (except relays). The guides must extend to within 0.75 in. from the face of either the socket or connector and front edge of the assembly. If Nylon guides are used, the guides must be securely attached to the file or assembly chassis.

B. Locking Devices. All screw type fasteners must utilize locking devices or locking compounds except for finger screws, which must be captive.

C. PCB Design and Connectors. No components, traces, brackets or obstructions must be within 0.125 in. of the board edge (guide edges). The manufacturer's name or logo, model number, serial number, and circuit issue or revision number must appear and be readily visible on all PCBs.

D. Model and Serial Numbers.

1. The manufacturer's model number and circuit issue or revision number must appear on the rear panel of all equipment supplied (where such panel exists). In addition to any assignment of model numbers by the manufacturer, the TYPE number must be displayed on the front panel in bold type, at least 0.25 in. high.

E. Workmanship. Workmanship must conform to the requirements of this specification and be in accordance with the highest industry standards.

F. Tolerances. The following mechanical tolerances must apply, except as specifically shown on the plans or in these specifications:

TYPE	DIMENSIONAL TOLERANCE
Sheet Metal	+/-0.0525 in.
PCB	+0 in., - 0.010 in.
Edge Guides	+/-0.015 in.

*Note: These dimensional tolerances do not apply to material gauge or thickness.

2.04 CABINET OVERVIEW

A. The cabinet utilizes concepts from both the NEMA and Model 170 traffic signal equipment. From the Model 170 it takes the concept of rack-mounted subassemblies. From NEMA, it borrows the basic serial connections between the controller and subassemblies.

B. The cabinet provides the communications paths between the various subsystems, as well as a system to monitor their operation. The cabinet provides power supplies suitable for the various electronic subassemblies mounted throughout the cabinet. The ITS cabinet is an extension of the original cabinet used for the Model 170 controller in that it is based upon the EIA/TIA standard 19 in. equipment rack. In this rack, the subsystems that comprise the field controller assembly are mounted in a manner so as to facilitate user access. The controller and other subassemblies are also similar in concept to the Model 170 system in that they are essentially interchangeable circuit cards or device cages. This does not preclude other cabinet constructs that may be proposed for inclusion in this standard at some later date. An example might be that retrofitting to existing NEMA TS1 and TS2 type cabinets or other more specialized cabinets might one day be accommodated, so long as the architecture of the serial buses are maintained.

C. Each of the subassemblies is connected to the controller using a serial bus, similar to that used in the NEMA TS2 Type 1 specification. Using a serial interconnection between subassemblies allows for easy system expansion. The system supports up to twenty-eight switch packs (also known as solid state load switches) in six and fourteen switch pack increments and ninety-six detector channels in twenty-four channel increments. This serial bus may also be extended using inexpensive fiber optic transceivers, as an example, insomuch as multiple remote switching/data collection cabinets can be supported from a single controller.

D. The ITS Cabinet is essentially a platform within which modular components may be added to serve a variety of ITS applications.

E. Cabinet Subsystems. The major subsystems that may be installed in a cabinet housing are:

1. Controller.

2. Input Assemblies.

3. Output Assemblies.

4. Power Distribution Assemblies.

5. Fiber Optic Termination Panel.

6. Service Panel Assembly.

7. DC Power/Communications Assembly & Extension.

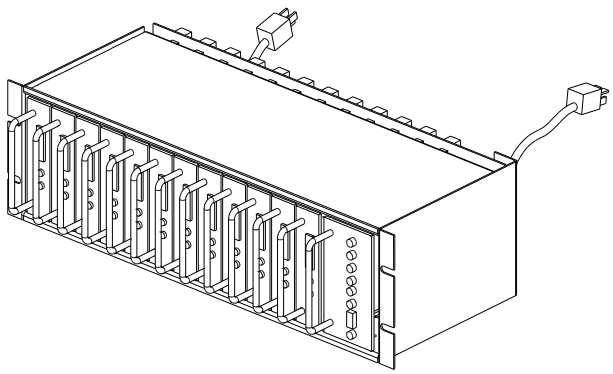
8. RAW/CLEAN AC Power Assembly & Extension.

9. Cabinet Monitoring System.

F. The cabinet is constructed in a modular manner with power distribution and serial connectors conveniently located throughout the cabinet to facilitate a wide variety of configurations and future expansion. Each of these subassemblies is discussed below. A separate standard describes the controller.

G. Input Assembly. The input assembly provides services for the typical inductive loop detectors currently in use, as well as other more advanced systems that might provide the controller with serial data instead of the typical contact closure. Each assembly accommodates one Serial Interface Unit (SIU) to communicate with the controller. The rack has space for twelve two-channel detector units or six four-channel detector units. The system can address (i.e. the Serial Bus addressing structure supports) up to four of these assemblies.

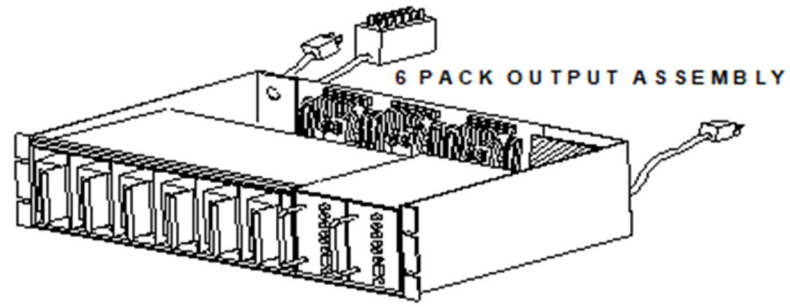
H. The detectors in the assembly can communicate to the controller in the form of either a contact closure or use of serial data strings. The back plane of this assembly includes a serial bus to transmit data to and from detectors. This serial data is then transmitted to the controller by Serial Bus 1, which is described below. This allows for the use of "smart" detectors that can pass additional information such as vehicle classification, Automatic Vehicle Identification/Location information, speed information directly to the controller unit. Each slot provides general purpose power and input/output signals and a serial interface.

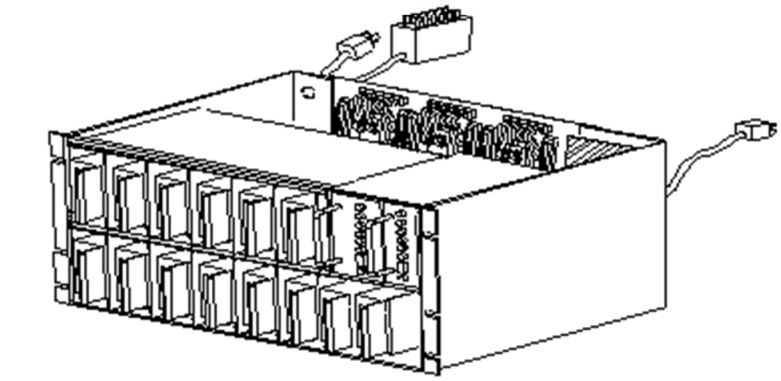


Input Assembly

I. The input "slots" can also accommodate the standard collection of Model 170 or NEMA TS2 type cards, including preemption devices, and isolation modules, using the contact closure interface.

J. Output Assembly 6 and 14 Pack. The output assembly handles the switching of 120 VAC power to the signal heads. There are two versions of this assembly, one to accommodate six switch packs and one for fourteen switch packs. It also has an SIU and an Auxiliary Monitor Unit (AMU). The AMU is described in more detail in a following section. The output assembly includes provisions for managing cabinet flash with Flash Transfer Relays and flash configuration jumpers.





K. To support the AMU function of current monitoring, the output assembly includes current monitoring transformers for each switch pack. These current monitor transformers enable the detection of a "no-load" condition on a signal without having to wait for the signal to cycle.

L. The system can address (i.e. the Serial Bus addressing structure supports) ten combinations of six switch and fourteen switch assemblies. For a maximum configuration the system can address two fourteen switch pack modules for a total of twenty-eight switch packs or physical channels, plus four virtual channels for a total of thirty-two logical channels.

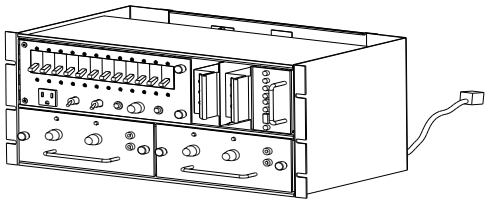
M. The field wires can also be connected to the back of this unit using plug-in type connectors. The field wires are terminated in these connectors, which are then be plugged into the back of the Assembly. This facilitates the change out of the assembly or the whole controller and housing assembly.

N. Power Distribution Assembly (PDA 5 IP or EP). The PDA provides protected power distribution to the various devices and subassemblies within the cabinet. This assembly also houses Emergency Flasher Units, control relays, signal power contactor, and the Cabinet Monitor Unit (CMU).

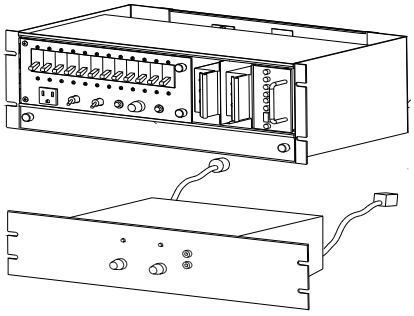
O. The PDA IP houses two low voltage DC power supplies. One provides power to 24 VDC devices, the other to 12 VDC devices. Each of these power supplies is packaged as a slide-out subassembly.

P. The PDA EP provides protected power distribution to the various devices and subassemblies within the cabinet. This assembly also houses Emergency Flasher Units, control relays, signal power contactor, and the Cabinet Monitor Unit (CMU).

Q. The PDA EP requires an external rack mounted low voltage DC power supply for power to 24 VDC devices such as detectors and switchpacks. Dual Rack Cabinets may require an additional 12 VDC Supply if more than 3 Input Assemblies are required. Each of these power supplies is packaged as a rack mount assembly.



PDA 5 IP with internal Power Supplies



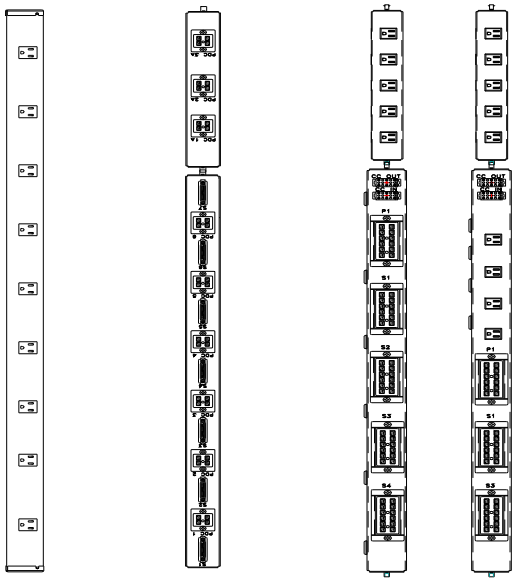
PDA 5 EP with Rack Mount Power Supplies

Figure 1
PDA 5 IP and EP

R. Modular Buses. The modular buses are assemblies that are mounted on the rack rails in the back of the cabinet and provide a pluggable interconnection of the Assembly units to the controller unit and power. These assemblies control and protect the wiring between these key subsystems, provides additional shielding from electromagnetic interference. Their biggest benefit is to simplify cabinet assembly.

S. The cabinet may have any combination of these bus units depending upon the particular application. For example, a cabinet designed as a communications hub may only have a Modular Power Assembly unit. A small pole mounted cabinet (proposed but not included in this standard) may not have any of them and those installed in Cabinet Housing 2 would not use the extensions.

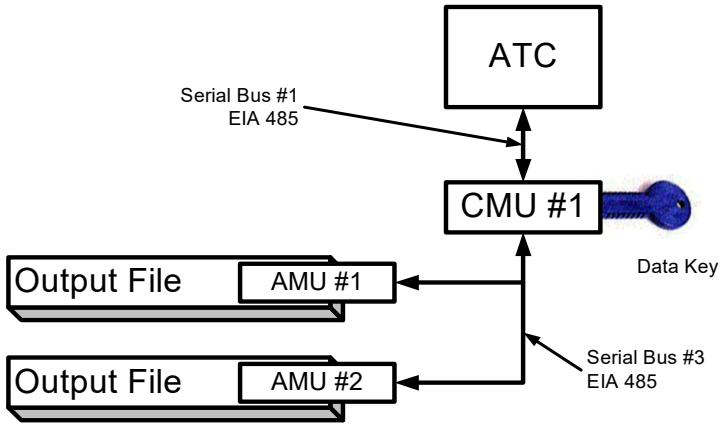
T. Raw/Clean AC Power Assemblies. The Raw/Clean AC Power Assembly attaches to the right rear rack rail. This assembly is internally wired to provide 120 VAC "clean power" to the controller, output assemblies and auxiliary devices needed within the Cabinet, as well as Signal and flasher power from the PDA is distributed by P1 and S1 to S4 to the Output Assemblies. The Raw/Clean Bus Assemblies are available in two configurations, a four socket and a two socket version. With the advent of the 14 Pack Output Assembly the two socket version provides adequate power distribution for most applications and with the additional clean power sockets it will eliminate the need for the extension. Extension Bus Assemblies are provided for additional clean power service when needed and room permits. A AC Clean Modular Assembly is used to power the left hand rack in Housing 3. This assembly is primarily meant for those cabinets without output assemblies or for use in the dual rack system.



Modular AC Clean Assembly | DC Power/COMM Modular Assembly | Raw/Clean AC Power Assembly 4 Socket 2 Socket

U. DC Power /Communications Assembly and Extension. This modular bus assembly provides 12 VDC and 24 VDC power to cabinet assemblies. It also houses the wiring for the serial buses 1 and 2 communications between the SIUs, CMUs, AMUs and the ATC Controller Unit. The Extension provides additional DC Power when needed.

V. Cabinet Monitoring System. The cabinet monitoring system provides a fail-safe mechanism for the entire collection of subassemblies. The system for the ATC is a departure from its predecessors in that it has been split into sub components, the Cabinet Monitor Unit (CMU) and the Auxiliary Monitor Unit (AMU). The adjacent diagram illustrates the architecture.



Cabinet Monitoring System

W. The real power of this architecture is that it allows the user a much greater degree of flexibility in cabinet configurations than previously possible. This diagram shows the control system for a single intersection. The use of serial communications to the CMU is a very powerful concept. Serial communications to multiple CMUs allow for the response to a conflict at a single intersection and not impact other intersections/ramps/etc. operated by the same controller. Therefore, one intersection could go to flash independently of the others, provided that each cabinet (or each independent output assembly) has a PDA within which a CMU is installed.

X. Cabinet Monitor Unit (CMU). The CMU is housed in the PDA. There should only be one of these installed in each cabinet, or each grouping of output assemblies. It is the main processor unit of the cabinet monitoring system. It monitors main cabinet functions, such as the condition of cabinet power, door status, and status of the flasher. It communicates with the AMUs located in the output assemblies and compares requested actions (from the controller) with the actual cabinet operation (switch pack outputs) to detect errors, conflicts, and other anomalies. It can then direct the cabinet to a flashing or fail-safe condition.

Y. The exception here is the Cabinet Housing 3, which could contain two separate groupings of input, output and power distribution assemblies for two separate intersections all controlled by a single controller.

Z. The configuration and operational characteristics of the CMU is determined by software. This programming may be customized to user needs and desires. There is also a specific reporting format, in order to address the minimum mandatory functionality of this unit. The minimum functionality is at least that provided by the NEMA TS2 Malfunction Monitoring Unit.

AA. To allow full programmability of the CMU, without a massive number of physical jumpers, the Model 210 and NEMA diode based conflict programming board is replaced by a serial memory key. This serial memory key contains all information to configure the monitoring system as well as other cabinet configuration information.

BB. The CMU might carry an address so that multiple CMUs could be used to provide multiple intersection control assemblies controlled by a single controller. The CMU addressing is accomplished through address jumper programming on the rear of the PDA. A maximum of four CMUs are allowed.

CC. Auxiliary Monitor Unit (AMU). The AMU is housed in each output assembly. This unit does the basic monitoring of the output of the switch packs and reports their status to the CMU. It is essentially a device that monitors the output voltage and current of each circuit of each switch pack. This module communicates to the CMU via Serial Bus 3. Having this unit as a separate module from the CMU allows greater modularity of the cabinet. The cabinet can contain any grouping of between one and four output assemblies. However, the grouping of output assemblies and associated CMU connected via a single Serial Bus 3 would remain as an associated grouping and not be split to different cabinets.

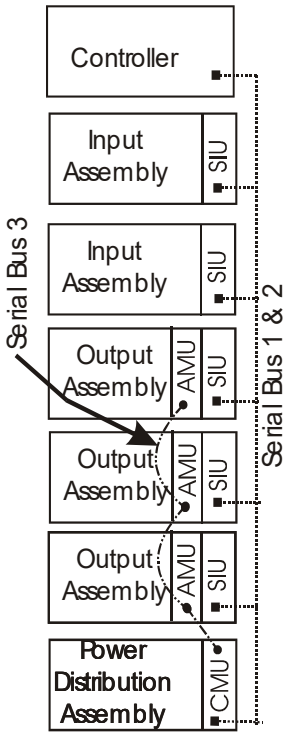
DD. Serial Memory Key. This key is essentially a non-volatile computer memory device. There are two of these devices in the system, one in the controller and one in the CMU. It contains all the specific information to define unit operations and malfunctions. In general, the key in the CMU replaces the Model 210 and NEMA Conflict Monitor Programming Card, plus any information previously programmed into those units. The CMU serial memory key does not contain the controller operating and application software. Start-up processes within the cabinet allow the CMU, and the controller, to verify a compatible configuration before starting normal operation.



Serial Memory Key

EE. Cabinet Communications Systems. The controller communicates with the various cabinet subassemblies via a serial bus arrangement. There are three separate serial buses employed. These buses are similar to those used in the NEMA TS2 specification and communicate using a Synchronous Data Link Control (SDLC) protocol. The Cabinet Block Diagram illustrates how this system is configured. The electrical characteristics of this communications circuit are defined by EIA/TIA 485 specifications.

FF. Serial Interface Unit (SIU). The SIU functions as the cabinet communications and control unit. The SIU communicates with the ATC Controller Unit through Serial Bus 1 and Serial Bus 2 via the Modular Bus Assembly. In the case where the input and/or output assembly is mounted remotely, communications would be over a data grade interconnect cable. This cable might be a fiber optic cable because of its high noise immunity and reliability.



Cabinet Monitor System Block Diagram

GG. A SIU is needed for each input assembly and each output assembly connected to the ATC Controller Unit.

HH. Serial Bus 1. This bus communicates real time information required to operate the system. It handles the highest priority, time sensitive data exchange between the SIUs in the input and output assemblies, controller unit and the CMU. An example would be the commands to the switch packs to change signal color or data from detection inputs. Serial Bus 1 is designed for a communications rate of 614,400 bits per second.

II. Serial Bus 2. This bus communicates less time critical information between the SIUs in the input and output assemblies, and the controller unit. An example would be servicing requests for general program information as might be requested from a central computer system. Serial Bus 2 is designed for an allowable communications rate of 614,400 bits per second.

JJ. Serial Bus 3. This bus is dedicated to communications between the AMUs and the CMU. It is used to allow the CMU to monitor the various voltages, operating conditions, and currents in the output assemblies to determine actual switch pack conditions. Serial Bus 3 has an operating communications rate of 153,600 bits per second.

KK. Service Assembly. The service assembly houses critical modules used within the rack system. Each assembly accommodates three Serial Interface Units (SIU), three Auxiliary Monitor Units (AMU), and one Cabinet Monitor Unit (CMU).

LL. Standard Cabinet Assemblies. There are three different cabinet assemblies, which consist of a specific collection of the subassemblies described above. Each of these assemblies is installed in a cabinet that is designed for a particular group of applications and is sized to hold the equipment required. The cabinets have doors both on the front and the back. The equipment is mounted on a standard EIA 19 in. rack that is fitted inside each cabinet.

MM. Each cabinet includes at least the following common features:

- Enclosure
- Doors
- Latches/Locks
- Hinges and Door Catches
- Gasketing
- Police Panel
- Ventilation and Air Filtration
- Assembly Supports and Mounting

NN. Cabinet Housing 1. This Cabinet Housing is very similar to the Type 332 series of cabinet used for the Model 170 Controller system. It is a single rack cabinet with sufficient capacity to operate a full eight-phase traffic signal. Dimensions are width 24.25 in., depth 30.25 in., and height 66.78 in.

OO. Cabinet Housing 2. This shorter version of Cabinet Housing 1 is very similar to the Type 336S series of cabinet used for the Model 170 Controller system and is meant for applications that require less space for inputs and outputs. This cabinet might be found at small two through eight-phase traffic signals, ramp meters, data stations and similar less space demanding applications. Dimensions are width 24.25 in., depth 20.25 in., and height 46.25 in.

PP. Cabinet Housing 3. This is a large two rack, four door cabinet with bottom details and a bolt pattern similar in size to the NEMA P cabinet. It is meant for installations requiring a lot of equipment. An example application may be a traffic signal controller with a communications hub or a ramp meter, or perhaps additional input/output assemblies. Dimensions are width 44.50 in., depth 26.00 in., height 66.38 in.

2.05 CABINET REQUIREMENTS

A. All furnished equipment must be new and unused. Vacuum or gaseous tubes and electro-mechanical devices (unless specifically called out) will not be used.

1. References. Reference is made to the following documents:

a. ATC 2070 v01.05, Advanced Transportation Controller (ATC) Standard for the Type 2070 Controller, dated March 29, 2001

2. Interchangeability. Assemblies and their associated devices must be electrically and mechanically interchangeable at both the assembly and device levels:

ASSEMBLIES	ASSOCIATED DEVICES
Input Assembly	Model 222, 232 & 224 Sensor Unit Model 242 and 252 Isolator Unit Type 218 Serial Interface Unit (SIU)
Output Assembly	Model 200 Switch Pack Unit Model 205 Transfer Relay Unit Model 214 Auxiliary Monitor Unit Type 218 SIU Unit
PDA ITS	Model 204 Flasher Units Model 212 Cabinet Monitor Unit Model 216-12 & 216-24 Power Supply Units
Service Assembly	Type 218 Serial Interface Unit (SIU) Model 214 Auxiliary Monitor Unit (AMU) Model 212 Cabinet Monitor Unit (CMU)

2.06 ENGINEERING

A. Human Engineering. The equipment must be engineered for simplicity, ease of operation and maintenance.

1. Knobs must be a minimum of 0.5 in. in diameter and a minimum separation of 0.5 in. edge to edge.

2. PCBs must slide smoothly in their guides while being inserted into or removed from the frame and fit snugly into the plug-in PCB connectors. PCBs must require a force no less than 5 pounds-force or greater than 50 pounds-force for insertion or removal.

B. Design Engineering. The design must be inherently temperature compensated to prevent abnormal operation. The circuit design must include such compensation as is necessary to overcome adverse effects due to temperature in the specified environmental range. The design must take into consideration the protection of personnel from all dangerous voltages.

C. Generated Noise. No item, component or subassembly must emit an audible noise level exceeding the peak level of 55 dBa when measured at a distance of one meter away from its surface, except as otherwise noted. No item, component or subassembly must emit a noise level sufficient to interfere with processing and communication functions of the controller circuits.

2.07 PRINTED CIRCUIT BOARDS

A. Design, Fabrication and Mounting.

1. All contacts on PCBs must be plated with a minimum thickness of 0.00003 in. gold over a minimum thickness of 0.000075 in. nickel.

2. PCB design must be such that when a component is removed and replaced, no damage is done to the board, other components, conductive traces or tracks.

3. Fabrication of PCBs must be in compliance with Military Specification MIL-P-13949, except as follows:

   a. NEMA FR-4 glass cloth base epoxy resin copper clad laminates 0.0625 in. minimum thickness must be used. Inter-component wiring must be by laminated copper clad track having a minimum weight of 0.2 ounces per square foot with adequate cross section for current to be carried. All copper tracks must be plated or soldered to provide complete coverage of all exposed copper tracks. Jumper wires to external PCB components must be from plated-through padded holes and as short as possible.

   b. All PCBs must conform to Section 3.3 of Military Specification MIL-P-13949G Grade of Pits and Dents, and be of Grade B quality (3.5.1.3) or better. The class of permissible bow or twist must be Class C (Table V) or better. The class of permissible warp or twist must be Class A (Table II) or better.

   c. Sections 4.2 through 6.6 of Military Specification MIL-P-13949G (inclusive) must be omitted except as referenced in previous sections of this specification.

   d. The mounting of parts and assemblies on the PCB must conform to the following:

      (1) Semiconductor devices that dissipate more than 250 milliwatts or cause a temperature rise of 10 degrees C, or more, be mounted with spacers, transipads or heat sinks to prevent contact with the PCB.

      (2) When completed, all residual flux must be removed from the PCB.

      (3) The resistance between any two isolated, independent conductor paths must be at least 100 Megohms when a 500 VDC potential is applied.

      (4) All PCBs must be coated with a moisture resistant coating.

(5) Where less than 0.25 in. lateral separation is provided between the PCB (or the components of a PCB) and any metal surface, a 0.0625 in. (+/-0.0005 in.) Thick Mylar (polyester) plastic cover must be provided on the metal to protect the PCB.

e. Each PCB connector edge must be chamfered at 30 degrees from board side planes. The key slots must also be chamfered so that the connector keys are not extracted upon removal of board or jammed upon insertion. The key slots must be 0.045 in. (+/-0.005 in.) for 0.1 in. spacing and 0.055 in. (+/-0.005 in.) for 0.156 in. spacing.

B. Soldering.

1. Automatic flow soldering must be a constant speed conveyor system with the conveyor speed set at optimum to minimize solder peaks or points. The temperature must be controlled to within +/-8 degrees C of the optimum temperature. The soldering process must result in the complete coverage of all copper runs, joints and terminals with solder except that which is covered by an electroplating process. Wherever clinching is not used, a method of holding the components in the proper position for the flow process will be provided.

2. If exposure to the temperature bath is of such a time-temperature duration as to come within 80% of any component's maximum specified time-temperature exposure, that component must be hand soldered to the PCB after the flow process has been completed.

C. Definitions. Definitions for the purpose of this section on PCBs must be taken from MIL-PRF-55110J Section 3.3 and any current addendum.

D. Jumpers. Jumpers are not allowed unless called out in the specifications or approved by the CITY OF HOUSTON.

2.08 QUALITY CONTROL

A. Components. All components must be lot sampled to assure a consistent high conformance standard to the design specification of the equipment.

B. Subassembly, Unit or Module. Complete electrical and environmental compliance testing must be performed on each module, unit, printed circuit or subassembly. Housing, chassis, and connection terminals must be inspected for mechanical sturdiness, and harnessing to sockets must be electrically tested for proper wiring sequence. The equipment must be visually and physically inspected to assure proper placement, mounting, and compatibility of subassemblies.

C. Pre-delivery Repair.

1. Any defects or deficiencies found by the inspection system involving mechanical structure or wiring must be returned through the manufacturing process or special repair process for correction.

2. PCB flow soldering is allowed a second time if copper runs and joints are not satisfactorily coated on the first run. Under no circumstances will a PCB be flow soldered more than twice.

3. Hand soldering is allowed for printed circuit repair.

2.09 ELECTRICAL, ENVIRONMENTAL AND TESTING REQUIREMENTS

A. The framework of this section, along with the specific test requirements contained herein, is excerpted with modifications from NEMA TS2-2003 - Section 2 by permission of NEMA. Excerpt © 2002 AASHTO / ITE / NEMA.

B. General. This section establishes the limits of the environmental and operational conditions in which the Cabinet Assembly will perform. This section defines the minimum test procedures that may be used to demonstrate conformance of a device type with the provisions of the standard. These test procedures do not verify equipment performance under every possible combination of environmental requirements covered by this standard. Nothing in this testing profile must be construed as to relieve the requirement that the equipment provided must fully comply with these standards/specifications under all environmental conditions stated herein.

1. The City of Houston may wish to extend the testing profile or introduce additional tests to verify compliance. (Authorized Engineering Information).

C. Inspection. A visual and physical inspection must include mechanical, dimensional and assembly conformance to all parts of this standard.

D. Testing Requirements.

1. A complete quality control / final test report must be supplied with each item. Quality control procedures must be submitted to the City of Houston prior to production. The test report must indicate the name of the tester and be signed by a responsible manager.

2. The quality control procedure and test report format must be supplied to the City of Houston for approval upon request. The quality control procedure must include the following, in the order shown:

a. Design Acceptance testing of all supplied components.

b. Physical and functional testing of all modules and items.

c. Environmental testing reports for all equipment.

d. Physical and functional testing of all items.

3. Separate certifications must be provided for Design and Production. Design Acceptance testing must be performed with a fully loaded and functional Cabinet Assembly. Production testing must be performed as part of the City of Houston's procurement delivery procedures and that testing should be performed at the Major Unit level. (Authorized Engineering Information).

4. Certain portions of the test procedures contained in this standard my cause damage to the unit (e.g. protection devices may be aged) and are not recommended for routine Production testing. (Authorized Engineering Information)

E. Definitions of Major Units of the Cabinet Assembly. For the purpose of this section, "Major units of the Cabinet Assembly" must include the Controller Unit, Application Software for implementing the desired functionality, Cabinet Monitor Unit (CMU), Auxiliary Monitor Unit (AMU), Serial Interface Units (SIUs), Power Distribution Unit (PDA), Switch Packs, Flasher(s), and Detector(s).

F. Environmental and Operating Requirements. The requirements (voltage, temperature, etc.) of this section must apply in any combination.

1. Voltage and Frequency.

a. Operating Voltage. The nominal voltage must be 120 VAC, unless otherwise noted.

b. Operating Frequency. The operating frequency range must be 60 hertz (+/-3.0 hertz), unless otherwise noted.

2. Transients, Power Service. The Test Unit must maintain all defined functions when the independent test pulse levels specified below occur on the alternating-current power service.

3. Nondestructive Transient Immunity Requirements.

a. The Test Unit (with protection in place and operational) must be capable of withstanding a high energy transient having the following characteristics repeatedly applied to the alternating current input terminals (AC power applied) without failure of the test specimen:

(1) Amplitude: 2000 Volts (+/-5 percent), both positive and negative polarity.

(2) Energy Source: Capacitor, oil filled, 15 microfarads (+/-10 percent), internal surge impedance less than 1 ohm.

(3) Repetition: Applied to the Test Unit once every 2 seconds for a maximum of three applications for each polarity.

(4) After the foregoing, the Test Unit must perform all defined functions upon the application of nominal alternating current power.

b. This test is considered to be a minimum test requirement for the Test Unit complying with ANSI/IEEE C62.41 (100 Kilohertz Ring Wave, the 1.2/50 microseconds – 8/20 Combination Wave and the EFT Burst) at voltages and currents specified at "Location Category B2" and at "Test Severity" level III (i.e. up to 4.0 Kilovolts, open-circuit). Regional conditions may warrant additional testing as described in ANSI/IEEE C62.41. (Authorized Engineering Information)

4. Transients, Input-Output Terminals.

a. The Test Unit (without protection in place or operational) must maintain all defined functions, when the test pulse occurs on selected input-output terminals.

(1) Amplitude: 300 Volts, both positive and negative polarity.

(2) Pulse Source: 1000 ohms nominal impedance.

(3) Repetition: 1 pulse per second, for a minimum of 5 pulses per selected terminal.

(4) Pulse rise time: 1 microsecond.

(5) Pulse width: 10 microseconds.

b. This test is considered to be a minimum test requirement for the Test Unit complying with ANSI/IEEE C62.41. Regional conditions may warrant additional testing as described in ANSI/IEEE C62.41. (Authorized Engineering Information)

5. Temperature and Humidity. The Test Unit must maintain all programmed functions when the temperature and humidity ambients are within the specified limits defined herein.

a. Ambient Temperature.

(1) The operating ambient temperature range must be from -37 degrees C to +74 degrees C. The storage temperature range must be from -45 degrees C to +85 degrees C.

(2) The rate of change in ambient temperature must not exceed 18 degrees C per hour, during which the relative humidity must not exceed 95 percent.

b. Humidity.

(1) The relative humidity must not exceed 95 percent non-condensing over the temperature range of -37 degrees C to +74 degrees C.

(2) Above +46 degrees C, constant absolute humidity must be maintained. This will result in the relative humidity shown in Exhibit 3-1 for dynamic testing.

Table 1
AMBIENT TEMPERATURE VERSUS RELATIVE HUMIDITY
AT BAROMETRIC PRESSURES (29.92 In. Hg.) (NON-CONDENSING)

Ambient Temperature/ Dry Bulb (in degrees C)	Relative Humidity (in percent)	Ambient Temperature/ Wet Bulb (in degrees C)
-37.0 to 1.1	10	-17.2 to 42.7
1.1 to 46.0	95	42.7
48.8	70	42.7
54.4	50	42.7
60.0	38	42.7
65.4	28	42.7
71.2	21	42.7
74.0	18	42.7

G. Test Facilities. All instrumentation required in the test procedures, such as voltmeters, ammeters, thermocouples, pulse timers, etc. must be selected in accordance with good engineering practice. In all cases where time limit tests are required, the allowance for any instrumentation errors must be included in the limit test.

1. Variable Voltage Source: A variable source capable of supplying 20 amperes from 100 VAC to 135 VAC.

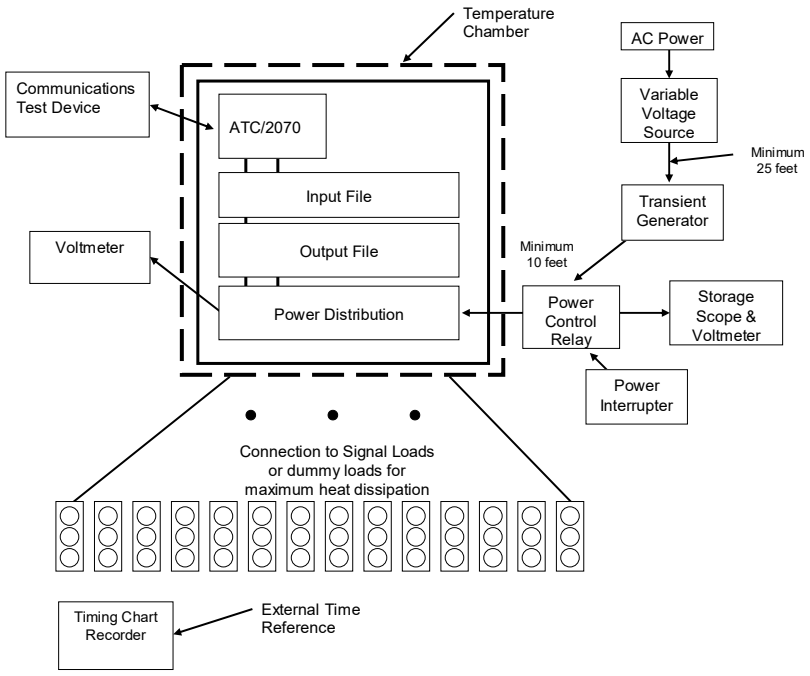
2. Environmental Chamber: An environmental chamber capable of attaining temperatures of -37 degrees C to +74 degrees C and relative humidity given in Table 1.

3. Transient Generators: Transient generators capable of supplying the transients outlined above.

H. Test Procedure: Transients, Temperature, Voltage, and Humidity

1. Test A: Placement in Environmental Chamber and Check-Out of Hook-Up

a. Place the test unit in the environmental chamber. Connect the test unit AC input circuit to a variable voltage power transformer, voltmeter, and transient generator. The transient generator must be connected to



the AC input circuit at a point at least 25 feet from the AC power source and not over 10 feet from the input to the test unit.

b. Connect test switches to the appropriate terminals to simulate the various features incorporated into the test unit. Place these switches in the proper position for desired operation.

c. Verify the test hook-up. Adjust the variable-voltage power transformer to 120 VAC and apply power to the test unit. Verify that the test unit goes through its prescribed startup sequence and cycles properly in accordance with the operation determined by the positioning of test switches in item b.

d. Upon the satisfactory completion and verification of the test hook-up, proceed with Test B.

2. Test B: Nondestructive Transient Immunity:

a. Turn off the AC power input to the test unit from the variable-voltage power source.

b. Apply the following high-energy transient to the AC voltage input terminals of the test unit (no other power connected to terminals):

(1) Amplitude: 1000 V, both positive and negative polarity.

(2) Peak Power Discharge: Capacitor, oil-filled, 15 microfarads.

(3) Maximum Repetition Rate: Applied to the Cabinet Assembly once every 2 seconds for a maximum of three applications for each polarity.

c. Upon completion of the foregoing, apply 120 VAC to the test unit and verify that the test unit goes through its prescribed startup sequence and cycles properly in accordance with the programmed functions. The first operation of the over-current protective device during this test is not considered a failure of the test unit.

NOTE—Test C through G follow the profile indicated in Figure 2 to demonstrate the ability of the test unit to function reliably under stated conditions of temperature, voltage, and humidity.

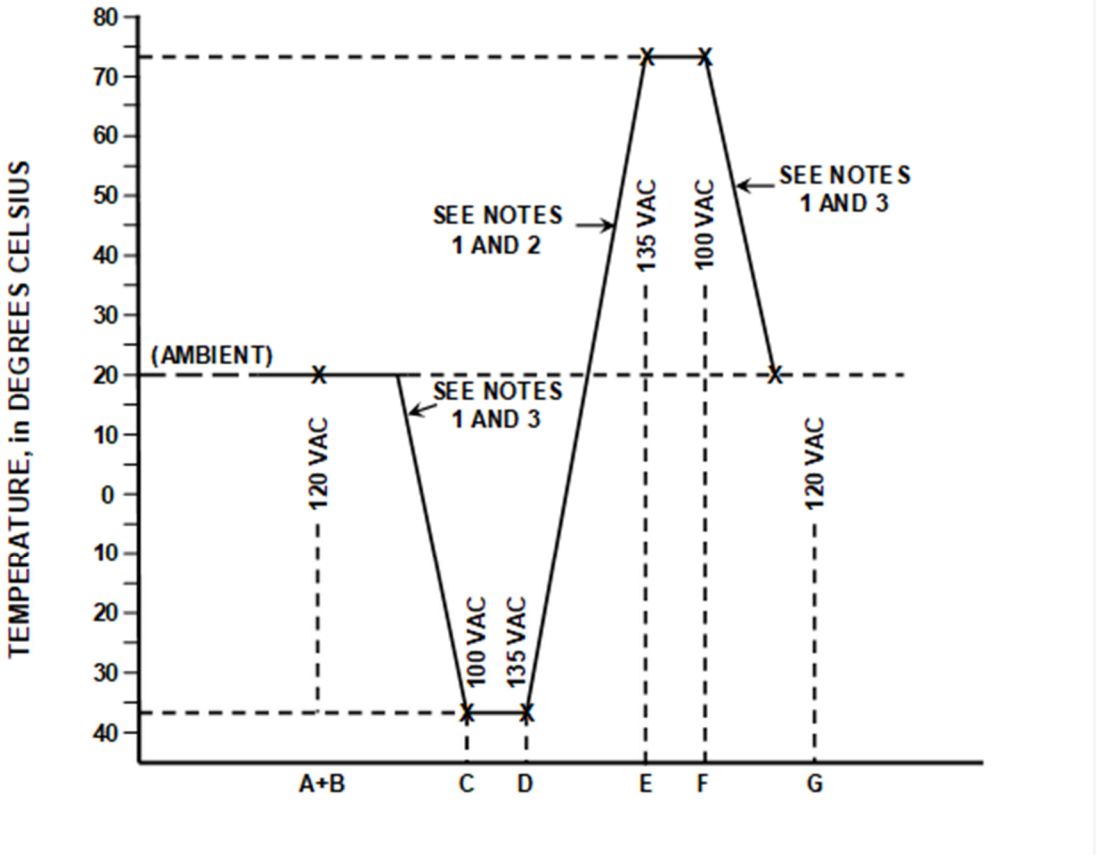


Figure 2
Test Profile

NOTES:
1. The rate of change in temperature must not exceed 18 degrees C per hour
2. Humidity controls must be set in conformance with the humidity given in Exhibit 3-1 during the temperature change between Test D and Test E.
3. If a change in both voltage and temperature are required for the next test, the voltage must be selected prior to the temperature change.

3. Test C—Low-Temperature Low-Voltage Tests

   a. Definition of Test Conditions

      (1) Environmental Chamber Door: Closed.

      (2) Temperature: -37 degrees C.

      (3) Low Voltage: 100 VAC.

      (4) Humidity Control: Off.

   b. Test Procedure: While at room temperature, adjust the input voltage to 100 VAC and verify that the test unit is still operable.

      (1) With the test unit cycling through normal operations, lower the test chamber to -37 degrees C at a rate not exceeding 18 degrees C per hour. Allow the test unit to cycle for a minimum of 5 hours at -37 degrees C with the humidity controls in the off position. Then operate the test switches as necessary to determine that all functions are operable.

      (2) Remove power from the test unit for a minimum period of 5 hours. Upon restoration of power, the test unit must go through its prescribed startup sequence and then resume cycling.

      (3) With the test unit at -37 degrees C and the input voltage at 100 VAC, evaluate the following items against the respective standards:

         (a) Power Interruption Tests

   c. On satisfactory completion of this test, proceed with Test D.

4. Test D—Low-Temperature High-Voltage Tests

   a. Definition of Test Conditions

      (1) Environmental Chamber Door: closed.

      (2) Low Temperature: -37 degrees C.

      (3) High Voltage: 135 VAC.

      (4) Humidity Controls: Off.

b. Test Procedure: While at -37 degrees C and with humidity controls off, adjust the input voltage to 135 VAC and allow the test unit to cycle for 1 hour. Then operate the test switches as necessary to determine that all functions are operable.

(1) With the test unit at -37 degrees C and the input voltage at 135 VAC (humidity controls off), evaluate the following items against the respective standards:

(a) Power Interruption Tests

c. On satisfactory completion of this test, proceed to Test E.

5. Test E—High-Temperature High-Voltage Tests

a. Definition of Test Conditions

(1) Environmental Chamber Door: Closed.

(2) High Temperature: +74 degrees C.

(3) High Voltage: 135 VAC.

(4) Humidity Controls: In accordance with the humidity given in Table 1.

b. Test Procedure—With the test unit cycling, raise the test chamber to +74 degrees C at a rate not to exceed 18 degrees C per hour. Verify the input voltage is 135 VAC.

(1) Set the humidity controls to not exceed 95 percent relative humidity over the temperature range of +1.1 degrees C to +46 degrees C. When the temperature reaches +46 degrees C, readjust the humidity control to maintain constant absolute humidity; +42.7 degrees C wet bulb that results in the relative humidity shown in Table 1. Verify that the test unit continues to cycle satisfactory during the period of temperature increase and at established levels of relative humidity.

(2) Allow the test unit to cycle for a minimum of 15 hours at +74 degrees C and 18 percent relative humidity. Then operate the test switches as necessary to determine that all functions are operable.

(3) With the test unit at +74 degrees C and 18 percent relative humidity and the input voltage at 135 VAC, evaluate the following items against the respective standards:

(a) Power Interruption Tests

c. On satisfactory completion of this test, proceed to Test F.

6. Test F—High-Temperature Low-Voltage Tests

a. Definition of Test Conditions

(1) Environmental Chamber Door: Closed.

(2) High Temperature: +74 degrees C.

(3) Low Voltage: 100 VAC.

(4) Humidity Controls: 18 percent relative humidity and +42.7 degrees C wet bulb.

b. Test Procedure: Adjust the input voltage to 100 VAC and proceed to operate the test switches to determine that all functions are operable. With the test unit at +74 degrees C and 18 percent relative humidity, +42.7 degrees C wet bulb, and the input voltage at 100 VAC, evaluate the following items against the respective standards:

(1) Power Interruption Tests

c. On satisfactory completion of this test, proceed to Test G.

7. Test G—Test Termination

a. Program the test unit to cycle.

b. Adjust the input voltage to 120 VAC.

c. Set the controls on the environmental chamber to return to room temperature, +20 degrees C (+/-5 degrees C), with the humidity controls in the off position. The rate of temperature change must not exceed 18 degrees C per hour.

d. Verify the test unit continues to cycle through normal operations properly.

e. Allow the test unit to stabilize at room temperature for 1 hour. Proceed to operate the test switches to determine that all functions are operable.

8. Test H—Appraisal of Equipment under Test

a. A failure is defined as any occurrence that results in other than normal operation of the equipment. (See item 2 for details.) If a failure occurs, the test unit must be repaired or components replaced, and the test during which failure occurred must be restarted from its beginning.

b. The test unit is considered to have failed if any of the following occur:

(1) If the test unit skips normal program intervals/steps or portions thereof when in normal operation, places false inputs, presents false outputs, exhibits disruption of normal sequence of operations, or produces changes in parameters beyond specified tolerances, or

(2) If the test unit fails to satisfy the requirements of Tests A to G, inclusive.

c. An analysis of the failure must be performed and corrective action taken before the test unit is retested in accordance with this standard. The analysis must outline what action was taken to preclude additional failures during the tests.

d. When the number of failures exceeds two, it must be considered that the test unit fails to meet these standards. The test unit may be completely retested after analysis of the failure and necessary repairs have been made in accordance with item c.

e. Upon completion of the tests, visually inspect the test unit. If material changes are observed which will adversely affect the life of the test unit, the cause and conditions must be corrected before making further tests.

I. Power Interruption Test Procedures. Conduct the following power interruption tests at low input voltage (100 VAC) and high input voltage (135 VAC) at -37 degrees C, and +74 degrees C.

1. Short Power Interruption. While the Test Unit is cycling through normal operations, remove the input voltage for a period not to exceed 475 milliseconds. Upon restoration of the input voltage, check to insure that the Test Unit continues normal operation as though no power interruption has occurred. Repeat this test three times.

2. Voltage Variation. All circuits of the Test Unit must be subjected to slowly varying line voltage during which the Test Unit must be subjected to line voltage that is slowly lowered from a nominal 120 VAC line voltage to 0 VAC at a rate of not greater than 2 Volts per second. The line voltage must then be slowly raised to 100 VAC at which point the Test Unit must resume normal operation without operator intervention. Perform this test at both -37 degrees C and +74 degrees C, at a nominal 120 VAC line voltage. Repeat this test three times.

3. Rapid Power Interruption. Subject the Test Unit to rapid power interruption testing of the form that the power is off for 350 milliseconds and on for 650 milliseconds for a period of 2 minutes. Perform power interruption through electromechanical contacts of an appropriate size for the load. During this testing, the controller must function normally and continue normal sequencing (operation) at the conclusion of the test. This test must be performed at both -37 degrees C and +74 degrees C, at a nominal 120 VAC line voltage. Repeat this test three times.

2.10 AUXILIARY CABINET UNITS

A. General Requirements.

1. Models 200 and 204 General.

a. The unit chassis must be made of metal suitable to meet rigid support and environmental requirements. Where electrical isolation is the only requirement, plastic insulation material may be used in lieu of metal.

b. The unit control circuitry and switches must be readily accessible by the use of a screwdriver or wrench. Only one type of screw head end (Slotted or Phillips) to be used.

c. The unit must be constructed so that no live voltage is exposed. A handle must be attached to the front panel for insertion or removal from the unit mating connector.

d. The unit must be so constructed that its lower surface must be no more than 2.06 in. below the centerline of the connector and no part extend more than 0.9 in. to the left or 1.1 in. to the right of the connector centerline.

e. Continuous edge guides must be provided on the unit.

f. Each switch must be capable of switching any current from 0.050 Amperes to 10.0 Amperes (AC) load with power factor of 0.85 or higher.

g. Unit indicators must be vertically centered on the front panel with indicators positioned no more than 1 in. from said center.

2. Model Plug Connectors. Model plug connectors must be:

a. Model 200 BEAU P 5412 - LAB or approved equal.

b. Model 204 BEAU P 5406 - LAB or approved equal.

B. Model 200 Switch Pack Unit.

1. General.

   a. The Model 200 Switch Pack Unit must be a modular plug-in device containing three solid-state switches. Each switch must open or close a connection between applied power and external load.

   b. A Ground True Controller Unit Input (0 VDC to 6 VDC) must cause the switch to conduct (ON) and a Ground False (16 VDC or more) must cause it to not conduct (OFF), State transition must occur between 6 VDC and 16 VDC. The input must not sink more than 20 milliamperes or be subjected to more than 30 VDC. The input must have reverse polarity protection.

   c. With all switches ON, the unit must not draw more than 60 milliamperes at +16 VDC or more from the +24 VDC cabinet power supply.

   d. Each switch must have an OFF state dv/dt rating of 100 Volts per microsecond or better. Each switch must provide isolation between inputs and outputs of at least 2000 Vdc and at least 100 megaohms resistive.

   e. The unit front panel must have an indicator on the input to each switch. The indicator must be labeled or color-coded “Red”-top switch, “Yellow”-middle switch, and “Green”-bottom switch. The middle switch indicator must be vertically centered on the unit front panel with the other indicators positioned 1 in. above and below.

   f. The resistance between the AC+ input terminal and the AC+ output terminal of each switch must be a minimum of 15K Ohms when the switch is in open (OFF) state. When the switch is in the OFF state, the output current through the load must not exceed 10 milliamperes peak.

C. Model 204 Flasher Unit and Model 205 Flash Transfer Relay Unit.

1. Model 204 Flasher Unit.

   a. The FLASHER UNIT must be a modular plug-in device containing a flasher control circuit and two solid-state switches. The unit’s function is to alternatively open and close connections between applied power and external load.

   b. The unit must generate its own internal DC power from the AC Line.

   c. The unit must commence flashing operation when AC power is applied providing 50 to 60 flashes per minute per switch with a 50 % duty cycle.

d. Each switch must have an OFF state dv/dt rating of 200 V/microsecond or better. The resistance between the AC+ input terminal and the AC+ output terminal of each switch must be a minimum of 15K Ohms when the switch is in open (OFF) state. When the switch is in OFF state the output current must not exceed 10 milliamperes peak.

e. An indicator showing each switch output state must be provided. The two indicators must be centered with 1 in. minimum spacing.

f. Each circuit must be designed to operate in an open-circuit condition without load for 10 years minimum.

g. A surge arrestor must be provided between AC (pin 11) and Flasher Output (pins 7 &

(1) The arrestor must meet the following requirements:

(a) Recurrent Peak Voltage 212 Volts

(b) Maximum Energy Rating 50 Joules

(c) Average Power Dissipation 0.85 Watts

(d) Peak I for pulses less than 6 microseconds 2000 Amperes

(e) Standby I less than 1 Ma

2. Model 205 Flash Transfer Relay Unit. Each switch must be designed for a minimum of 100,000 (reference is a 10-year lifespan) operations while switching a tungsten load of 1000 Watts at 70 degrees C. Switch isolation between DC input and AC output circuit must be at least 10,000 Megohms at 2000 VDC.

a. The Flash Transfer Relay Unit must be of electromechanical type, designed for continuous duty.

b. Each unit must be enclosed in a removable, clear plastic cover. The manufacturer's name, electrical rating, and part number must be placed on the cover. They must be durable, permanent and readily visible.

c. Each unit must be provided with DPDT contacts. The contact points must be of fine silver, silver alloy or a superior alternate material. Contact points and arms must be capable of switching 20 Amperes or 1 Kilowatt Tungsten Load at 120 VAC per contact at least 100,000 operations without contact welding or excessive burning, pitting or cavitation. The points and arms must be able to withstand 10 Gs, 10 – 55 Hertz without contact chatter.

d. The relay coil must have a power consumption of 10 Volt - Ampere maximum.

e. Each relay must withstand a potential of 1500 VAC at 60 Hertz between insulated parts and between current carrying or non-carrying parts. Each relay must have a one cycle surge rating of 175 Amperes RMS and pickup and drop out within 20 milliseconds.

D. Model 212 ITS Cabinet Monitor Unit (CMU).

1. General. The CMU is the principle part of the ITS Cabinet Monitoring System. It is resident in the Power Distribution Assembly. The role of the CMU is to query various cabinet conditions and, if the application requires action, the CMU will transfer control from the ATC Controller Unit to a safe control mode, examples include Signalized Intersection, Ramp Metering or other applications. Some applications may not require any action, only data gathering and report back to the ATC Controller Unit.

2. The CMU is composed of a microprocessor, memory devices including non-volatile memory, communications circuitry to interface with Serial Buses #1 and #3, front panel indicators, front panel communication connector and a serial memory key device. The Operating Program must be resident in the Non-volatile memory. The serial memory key Memory must possess the conditions and function selections of the Unit.

3. Traffic Control Application. The Model 212 is intended for traffic control applications.

4. Failed State Action (FSA). Only Unit Reset must reset the CMU from a LATCHED FAILED STATE ACTION (LFSA). Only a Unit Reset or a CMU Power Fail must reset a LATCHED RESETTABLE FAILED STATE ACTION (LFSA-R).

a. A NONLATCHED FAILED STATE ACTION (NFSA) must be reset if the fault conditions causing the NFSA have been removed. An NFSA must last for the programmed Minimum Flash time at a minimum.

b. Only one LFSA, LFSA-R or NFSA fault state must be set at any time.

5. Unit Reset. The CMU must be reset from a FSA as a result of the front panel reset button or the EXTERNAL TEST RESET input. This reset command must be a one-time event, such that a continuous reset command does not prevent the CMU from operating. The EXTERNAL TEST RESET input must be isolated from the AC+ Raw circuitry.

    a. The EXTERNAL TEST RESET input must be True when the voltage is less than 8 VDC. The EXTERNAL TEST RESET input must be False when the voltage is greater than 16 VDC. A minimum True pulse width on the EXTERNAL TEST RESET input of 100 milliseconds is required for a Unit Reset.

6. Exit From Failed State Action. Prior to the CMU transferring the Output Relay contacts from the Fault state to the No Fault state, a transition period of 500 milliseconds must occur. During the transition period the Output Relay contacts must be in the Fault state and the CMU must set the Start-Up Flash Call bit in the Type 189 Frame to 1. At all other times the Start-Up Flash Call bit of the Type 189 Frame must be set to 0.

7. Monitor Functions.

    a. Cabinet Power Supply. The CMU must sense the Cabinet +24 VDC and +12 VDC power supply sources to +/-5% accuracy. The CMU must also sense the Cabinet +24 VDC state in each Output Assembly as reported by each AMU. Voltages equal to or greater than +22 VDC and +11 VDC respectively must NOT cause a LFSA. Voltages at or less than +18 VDC and +9 VDC for 500 milliseconds or longer must cause a LFSA. If the sensed voltage is less than +22 VDC or +11 VDC for 200 milliseconds or less, the CMU must NOT cause a LFSA. All other timing or voltage conditions may or may not cause LFSA. A +24 VDC failure or +12 VDC failure during the programmed Minimum Flash time or during a CMU Power Failure must not cause a LFSA. The CMU must report the value of the +24 VDC and +12 VDC power supply sources in the Type 189 response frame.

        (1) There must be programming in the serial memory key to disable +12 VDC power supply monitoring.

b. Conflicting Channels. For purpose of conflict determination, an active signal on either of the Green/Walk or Yellow inputs associated with any of the thirty-two channels must be considered as that channel being active. The serial memory key must contain the permissive channel pair programming. When any conflicting channels are detected as concurrently active for less than 200 milliseconds the CMU must not cause a LFSA. When any conflicting channels are detected as concurrently active for 500 milliseconds or more, the CMU must cause a LFSA. When any conflicting channels are detected as concurrently active for more than 200 milliseconds but less than 500 milliseconds, the CMU may or may not cause a LFSA. The time interval between the beginning of the concurrently conflicting channels and the transfer to the LFSA must not exceed 500 milliseconds.

c. Serial Bus Error. The CMU communicates with both Serial Bus (SB) #1 and #3. In SB #1 the CMU is a Secondary, polled by the ATC Controller Unit Primary. On SB #1, the CMU must respond to the Serial Bus #1 Address defined by the ADDRESS 0 and ADDRESS 1 pins. In SB #3 the CMU is the Primary, polling each AMU Secondary.

(1) Serial Bus #1 Error. The CMU must cause a FSA when a Type 61 or Type 67 Frame has not been received from the ATC Controller Unit for greater than 1000 milliseconds. The first and second failures in a 24-hour period must be a NFSA. The third failure in a 24-hour period must be a LFSA-R. If a CMU Power Fail resets the LFSA-R, the SB #1 timeout count must be reset to 2 such that the next SB #1 timeout results in a LFSA-R.

(a) A SB #1 timeout failure during the programmed Minimum Flash time or during a CMU Power Failure must not cause a FSA. The SB #1 Timeout function must be disabled if the SB #1 DISABLE input is at a True (Low) state.

(b) The SB #1 DISABLE input must be True when the voltage is less than 8 VDC. The SB #1 DISABLE input must be False when the voltage is greater than 16 VDC. The SB #1 DISABLE input must be isolated from the AC+ Raw circuitry.

(2) Serial Bus #3 Error. The CMU must cause a FSA when a Type 129 or Type 130 Frame has not been received from each AMU for greater than 300 milliseconds. The first and second failures in a 24-hour period must be a NFSA. The third failure in a 24-hour period must be a LFSA-R. If a CMU Power Fail resets the LFSA-R, the SB #3 timeout count must be reset to 2 such that the next SB #3 timeout results in a LFSA-R. A SB #3 timeout failure during the programmed Minimum Flash time or during a CMU Power Failure must not cause a FSA.

d. Type 62 – Send to Local Flash Command Message. If the "N" bit is set in a Type 62 – Send to Local Flash Command message, the CMU must react by causing a NFSA. The NFSA must remain until the receipt of a Type 62 – Send to Local Flash Command message with the "N" bit cleared or until the CMU is reset by a Unit Reset or CMU Power Fail. The NFSA must last for the programmed Minimum Flash time at a minimum. If the "L" bit is set in a Type 62 – Send to Local Flash Command message, the CMU must react by causing a LFSA.

e. Diagnostics.

(1) Diagnostics Error. The CMU must be provided with a resident series of self-check diagnostic capabilities. The CMU must contain provisions to verify all memory elements on power-up. When a fault is detected, the LFSA-R must be set and the DIAGNOSTIC indicator illuminated.

(2) RAM Diagnostic. This test must verify that all RAM elements are operating correctly at power-up or following a Unit Reset. Patterns must be written to RAM. Each write must be followed by a read to verify that it contains the written pattern.

(3) Nonvolatile Diagnostic. This test must verify that the nonvolatile ROM(s) contain the proper program. The routine must perform a check on each ROM and make a comparison with a preprogrammed check value. This test must be performed at power-up and at a minimum rate of 1024 bits per second during operation.

(4) Serial Memory Key Memory Diagnostic. This test must verify whether the non-volatile serial memory key contains valid data and that the data has not changed since the last write. The routine must perform a check on each nonvolatile memory element at power-up and whenever read and make a comparison with a preprogrammed check value. The serial memory key not present must cause a LFSA if the DOOR SWITCH FRONT input is sensed as not active (door closed).

(5) Internal MPU Monitor. The CMU must monitor the operation of its microprocessor with an independent circuit. At a minimum, the monitoring circuit must receive logic state transitions at least once every 50 milliseconds from the microprocessor. When the logic state transition is not received for 500 milliseconds the monitor circuit must force a LFSA-R and illuminate the DIAGNOSTIC indicator.

f. Multiple Input. The CMU must be capable of monitoring for the presence of an active signal on two or more inputs of a channel. When the presence of an active signal on two or more inputs of a channel is detected for less than 200 milliseconds, the CMU must not cause a LFSA. When the presence of an active signal on two or more inputs to a channel is detected for 450 milliseconds or more, the CMU must cause a LFSA. When the presence of an active signal on two or more inputs to a channel is detected for more than 200 milliseconds but less than 450 milliseconds, the CMU may or may not cause a LFSA. Multiple Input monitoring must be disabled when the MAIN CONTACTOR COIL STATUS input is not active. There must be programming in the serial memory key to disable Multiple Indication monitoring on a color combination basis (G+Y, Y+R, G+R).

g. Lack of Signal Inputs. The unit must detect the absence of any required signal voltage OR signal current (CSU) on the inputs of a channel. For voltage purposes a required signal on the Green or Yellow or Red inputs associated with a channel must be considered as that channel being active. When an absence of an active channel is detected for less than 700 milliseconds, the CMU must not cause a LFSA. When an absence of an active channel is detected for 1000 milliseconds or more, the CMU must cause a LFSA. When an absence of an active channel is detected for more than 700 milliseconds but less than 1000 milliseconds, the CMU may or may not cause a LFSA. Lack of Signal Input monitoring must be disabled for all channels when the MAIN CONTACTOR COIL STATUS input is not active. There must be programming in the serial memory key to disable Lack of Signal Input monitoring on a per channel basis.

(1) Lack of Signal Input monitoring must also be disabled for any channel which has the DARK CHANNEL MAP bit set to "1" in the serial memory key programming for the DARK CHANNEL MAP addressed by the DARK CHANNEL MAP SELECT bits in a Type 61 message. The CSU monitor function is hardwired to twenty-eight physical channels, thus Virtual Channels do not have CSU monitoring capability. The CSU monitor function must be disabled for any physical channel that has an input remapped to a Virtual Channel.

h. Yellow Clearance. The CMU must verify that the Yellow Change interval is at least 2.7 seconds (+/-0.1 seconds). When the minimum Yellow Change interval is not satisfied, the CMU must cause a LFSA. The CMU must report a Skipped Yellow Clearance when the Yellow Change interval is less than 100 milliseconds. The CMU must report a Short Yellow Clearance when the Yellow Change interval is less than 2.7 seconds (+/-0.1 seconds) and greater than 100 milliseconds.

(1) Minimum Yellow Change interval monitoring must be disabled when the MAIN CONTACTOR COIL STATUS input is not active. There must be programming in the serial memory key to disable Minimum Yellow Change interval monitoring on a per channel basis.

i. Yellow Plus Red Clearance. The CMU must verify that the Yellow Change plus Red Clearance interval between the end of an active GREEN signal and the beginning of the next conflicting GREEN signal is at least 2.7 (+/-0.1 seconds). When the minimum Yellow Change plus Red Clearance interval is not satisfied, the CMU must cause a LFSA. Minimum Yellow Change plus Red Clearance monitoring must be disabled when the MAIN CONTACTOR COIL STATUS input is not active. There must be programming in the serial memory key to disable Minimum Yellow Change plus Red Clearance interval monitoring on a per channel basis.

j. Local Flash Status. The CMU must monitor the LF STATUS input. When this signal is sensed as not active for greater than 500 milliseconds, the CMU must cause a NFSA. When this signal is sensed as not active for less than 200 milliseconds, the CMU must not cause a NFSA.

(1) Local Flash Status Recovery. Recovery from Local Flash Status NFSA must occur when this signal is sensed as active for greater than 500 milliseconds. When this signal is sensed as active for less than 200 milliseconds, the CMU must not cause recovery from Local Flash Status NFSA.

k. Circuit Breaker Trip Status. The CMU must monitor the CB TRIP STATUS input. When this signal is sensed as not active for greater than 500 milliseconds, the CMU must cause a LFSA. When this signal is sensed as not active for less than 200 milliseconds, the CMU must not cause a LFSA.

l. Flasher Unit Output Failed. The CMU must monitor the FLASHER 1-1, FLASHER 1-2, FLASHER 2-1, and FLASHER 2-2 voltage states reported by each AMU. These inputs must be considered active when the input voltage exceeds 89 Volts RMS. These inputs must not be considered active when the input voltage is less than 70 Volts RMS. Signals between 89 Volts RMS and 70 Volts RMS may or may not be considered active. When a transition from the inactive state to the active state or a transition from the active state to the inactive state is absent for greater than 2500 milliseconds, the CMU must set a status bit in the Type 189 frame. This alarm condition must not cause a FSA. It should cause the appropriate response in the ATC Controller Unit. This status is non-latching, such that once a status bit has been set, the sensing of five valid transitions of the input must clear the status bit.

m. CMU Power Failure. The CMU must monitor the AC+ Raw input and the NRESET and POWERDOWN cabinet control inputs to determine a CMU Power Failure response. The POWERDOWN signal in the low state indicates loss of AC+ Raw in the Controller Unit. A CMU Power Failure must be recognized when both the POWERDOWN and NRESET signals are active low for greater than 100 milliseconds or the AC+ Raw voltage is less than 82 Volts RMS (+/-2 Volts RMS).

n. AC+ Raw Level Sense. The CMU must monitor the AC+ Raw input and AC+ Raw inputs reported by each AMU. When any AC+ Raw voltage is less than 82 Volts RMS (+/-2 Volts RMS) for greater than 650 milliseconds (+/-100 milliseconds) the CMU must cause a NFSA. Once NFSA has been set, the POWERDOWN and NRESET signals must not be monitored until all AC+ Raw voltages have exceeded 87 Volts RMS (+/-2 Volts RMS).

o. Power Interrupt. The CMU must disable monitoring of the +12VDC and +24VDC power supply inputs when either the POWERDOWN or NRESET input is low. When the POWERDOWN and NRESET signals are both low the CMU must cause a NFSA.

p. Power Recovery. When the POWERDOWN input is high and the NRESET signal goes from low to high the CMU must begin timing the programmed Minimum Flash Interval. During the Minimum Flash Interval the CMU must be in NFSA.

q. Power Up. Following initial application of AC+ Raw voltage the CMU must maintain a NFSA until the POWERDOWN input is high and the NRESET signal goes from low to high. The CMU must then begin timing the programmed Minimum Flash Interval. During the Minimum Flash Interval the CMU must be in NFSA.

r. Minimum Flash Interval. The CMU must be in NFSA during the Minimum Flash Interval. The Minimum Flash Interval must be programmed in the serial memory key between the limits of 6 seconds to 16 seconds with an incremental adjustment of 1 second. The CMU must not set a FSA during the Minimum Flash Interval.

8. Field Output Check.

a. Field Check Mode. The CMU must compare the active states of the field signals with the states reported by the ATC Controller Unit in the Type 61 frame. When a mismatch is detected for less than 700 milliseconds the CMU must not cause a LFSA. When a mismatch is detected for 1000 milliseconds or more, the CMU must cause a LFSA. When a mismatch is detected for more than 700 milliseconds but less than 1000 milliseconds, the CMU may or may not cause a LFSA. Field Output Check monitoring must be disabled when the MAIN CONTACTOR COIL STATUS input is not active. There must be a programming in the serial memory key to disable Field Output Check monitoring on a field input basis.

b. Field Check Status. The CMU must compare the active states of the field signals with the states reported by the ATC Controller Unit in the Type 61 frame. When a mismatch is detected while a Conflict, Lack of Signal, or Multiple fault is timing, Field Check Status must be reported with the fault to indicate the faulty channel(s) and color(s). Field Output Check monitoring must be disabled when the MAIN CONTACTOR COIL STATUS input is not active. There must be a programming in the serial memory key to disable Field Output Check monitoring on a field input basis.

9. CMU Temperature. The CMU must measure the temperature at the CMU and report this value in the Type 182 frame. Temperature accuracy must be +/-6 degrees C over the operating temperature range of the CMU.

10. Input Signals.

a. Field Signal Inputs. A Green or Yellow signal input must be sensed active when it exceeds 25 Volts RMS and must not be sensed active when it is less than 15 Volts RMS. A Green or Yellow signal between 15 Volts RMS and 25 Volts RMS may or may not be sensed active. There must be a programming in the serial memory key to disable the Yellow input for each physical channel. A Red signal input must be sensed active when it exceeds 70 Volts RMS and must not be sensed active when it is less than 50 Volts RMS. A Red signal between 50 Volts RMS and 70 Volts RMS may or may not be sensed active.

b. Switch Pack Current. A channel must be sensed active when the load current exceeds 105% of the Channel Current Sense Threshold programmed for that channel in the serial memory key. A channel must not be sensed active when the load current is less than 95% of the Channel Current Sense Threshold programmed for that channel in the serial memory key. A load current value between 95% and 105% of the Channel Current Sense Threshold may or may not be sensed active.

c. PDA Control Signal Inputs.

(1) Local Flash Status. This input must be internally connected to the CMU Output Relay COM pin. This input must be considered active when the input voltage exceeds 89 Volts RMS. This input must not be considered active when the input voltage is less than 70 Volts RMS. Signals between 89 Volts RMS and 70 Volts RMS may or may not be considered active. Operation of the cabinet in AUTO mode must place AC+ on this input. Operation of the cabinet in FLASH mode must be open circuit on this input. The CMU must report the state of this input in the Type 189 frame.

(2) Main Contactor Coil Status. The MAIN CONTACTOR COIL STATUS input must be connected to the AC+ Raw side of the main contactor signal bus relay coil. An active signal on this input indicates the Signal Bus should be powering the Switch Packs. This input must be considered active when the input voltage exceeds 89 Volts RMS. This input must not be considered active when the input voltage is less than 70 Volts RMS. Signals between 89 Volts RMS and 70 Volts RMS may or may not be considered active. The CMU must report the state of this input in the Type 189 frame.

(3) Main Contactor Secondary Status. The MAIN CONTACTOR SECONDARY STATUS input must be connected to the output side of the main contactor signal bus relay. This input must be considered active when the input voltage exceeds 89 Volts RMS. This input must not be considered active when the input voltage is less than 70 Volts RMS. Signals between 89 Volts RMS and 70 Volts RMS may or may not be considered active. The CMU must report the state of this input in the Type 189 frame.

(4) FTR Coil Drive Status. The FTR COIL DRIVE STATUS input must be connected to the FTR COIL DRIVE signal in the AC SIGNAL POWER BUS. This input must be considered active when the input voltage exceeds 89 Volts RMS. This input must not be considered active when the input voltage is less than 70 Volts RMS. Signals between 89 Volts RMS and 70 Volts RMS may or may not be considered active. The CMU must report the state of this input in the Type 189 frame.

(5) Circuit Breaker (CB) Trip Status. The CB TRIP STATUS input must be connected to the Auxiliary Switch output of the circuit breaker unit. This input must be considered active when the input voltage exceeds 89 Volts RMS. This input must not be considered active when the input voltage is less than 70 Volts RMS. Signals between 89 Volts RMS and 70 Volts RMS may or may not be considered active. The CMU must report the state of this input in the Type 189 frame.

(6) Front/Rear Door Switch. The CMU must monitor the DOOR SWITCH FRONT and DOOR SWITCH REAR inputs. These inputs must be considered active (door open) when the input voltage exceeds 89 Volts RMS. These inputs must not be considered active (door closed) when the input voltage is less than 70 Volts RMS. Signals between 89 Volts RMS and 70 Volts RMS may or may not be considered active. The CMU must report the state of these inputs in the Type 189 frame.

(7) Monitor Interlock. The MONITOR INTERLOCK input must be connected to VDC GROUND within the CMU.

(8) CMU Address Inputs. The Address Select input pins ADDRESS 0 and ADDRESS 1 define the Serial Bus #1 address of the CMU. The pins are left open for a logical False, and are connected to VDC GROUND for a logical True.

ADDRESS 1	ADDRESS 0	SB #1 Address
False	False	0x0F
False	True	0x10
True	False	0x11
True	True	0x12

11. Power and Circuit Requirements.

a. AC+ Raw. The CMU must be operational over the voltage range of 80 Volts RMS to 135 Volts RMS. It must be capable of insertion and removal while AC power is applied to the cabinet. Surge current on AC+ Raw must be less than 2 Amperes peak.

(1) +24VDC Power Supply. The CMU must not use the Cabinet +24VDC Power Supply to run any of its internal circuitry. The +24 VDC MONITOR and +12 VDC MONITOR input circuits must be optically isolated from the AC+ Raw circuitry. The maximum current into the +24 VDC or +12 VDC Monitor inputs over the voltage range of 0 VDC to 30 VDC must be less than 20 milliamperes.

(2) Failed State Output Circuit. The Output relay of the CMU must have one set of isolated Form C contacts. These relay contacts must be rated for a minimum of 3 Amperes at 120 Volts RMS and 100,000 operations. Contact opening/closing time must be 30 milliseconds or less. The relay coil must be energized in the No Fault state and de-energized in the FSA state.

12. Front Panel Devices.

a. Indicators. All indicators must be clear LEDs. Clear LEDs must not depend on a reflector or diffusion as part of its design. Clear LEDs must only show the die and not appear to be ON when exposed to ambient light. The following indicators must be provided (Top to Bottom).

b. Power. A green POWER indicator must illuminate to indicate AC+ Raw voltage is proper. It must flash at a 2 Hertz rate when the NRESET or POWERDOWN input is True. It must remain off when the voltage is less than 80 Volts RMS (+/-2 Volts RMS).

c. 24 VDC Fail. A red 24VDC FAIL indicator must illuminate when the CMU is in FSA as a result of a 24VDC cabinet power supply fault.

d. 12 VDC Fail. A red 12VDC FAIL indicator must illuminate when the CMU is in FSA as a result of a 12VDC cabinet power supply fault. The 12VDC FAIL indicator must flash at a 2 Hertz rate when the 12 VDC monitor function is disabled.

e. Conflict. A red CONFLICT indicator must illuminate when the CMU is in FSA as a result of a Conflicting Channels fault.

f. Lack of Signal. A red LACK OF SIGNAL indicator must illuminate when the CMU is in FSA as a result of a Lack of Signal Inputs fault.

g. Multiple. A red MULTIPLE indicator must illuminate when the CMU is in FSA as a result of a Multiple Inputs fault.

h. ATC/Local Flash. A red ATC/LOCAL FLASH indicator must illuminate when the CMU is in FSA as a result of a Type 62 – Send to Local Flash Command from the ATC Controller Unit, the LOCAL FLASH STATUS input sensed inactive, or CB TRIP STATUS active.

i. Clearance. A red CLEARANCE indicator must illuminate when the CMU is in FSA as a result of a Yellow Clearance or Yellow Plus Red Clearance fault.

j. Field Check. A red FIELD CHECK indicator must illuminate when the CMU is in FSA as a result of a Field Output Check fault. The indicator must flash at a 2 Hertz rate when the CMU is in FSA with Field Check Status as a result of Conflict, Lack of Signal, or Multiple fault.

k. SB #1 Error. A red SB #1 ERROR indicator must illuminate when the CMU is in FSA as a result of a Serial Bus #1 fault.

l. SB #3 Error. A red SB #3 ERROR indicator must illuminate when the CMU is in FSA as a result of a Serial Bus #3 fault.

m. Diagnostic. A red DIAGNOSTIC indicator must illuminate when the CMU is in FSA as a result of a Diagnostic fault. The DIAGNOSTIC indicator must flash at a 4 Hertz rate if the serial memory key is not present and a FSA state does not exist.

n. SB #1 Rx. A yellow indicator must illuminate for 40 milliseconds (+/- 5 milliseconds) each time the CMU correctly receives a frame on Serial Bus #1.

o. SB #3 Rx. A yellow indicator must illuminate for 40 milliseconds (+/- 5 milliseconds) each time the CMU correctly receives a frame on Serial Bus #3.

13. Serial Bus #3 Terminations. The Serial Bus #3 RxD+ input must be terminated on the CMU to the Serial Bus #3 EIA-485 supply voltage through a 560 Ohm resistor. The Serial Bus #3 RxD- input must be terminated on the CMU to AC Raw- through a 560 Ohm resistor. A 120 Ohm resistor must be connected on the CMU between RxD+ and RxD-. The CMU Serial Bus #3 TxD drivers must remain in the mark state with drivers enabled when the CMU is not transmitting a command frame. Note: A 120 Ohm resistor must be connected between TxD+ and TxD- on the Serial Bus #3 cable assembly in the last Output Assembly installed in the Serial Bus #3 daisy chain.

14. Terminal Port. An EIA-232-E Data Terminal Equipment (DTE) interface and connector must be provided for interconnecting to a personal computer. Where differences occur between the EIA-232 standard and this document, this document must govern.

a. Physical. The connector must be mounted on the front panel and must be a 9-position subminiature D-type connector with metal shell. The connector must utilize female contacts with 15 millionths of an inch gold plating in the mating areas.

Pin #	Function	I/O
1	Reserved	-
2	RxD	I
3	TxD	O
4	Reserved	-
5	Signal Ground	-
6	Reserved	-
7	Reserved	-
8	Reserved	-
9	Reserved	-

b. Receive Data (RxD). The RxD input must contain the serial data input to the CMU.

c. Transmit Data (TxD). The TxD output must contain the serial data output from the CMU.

d. Signal Ground. All signals must be referenced to Signal Ground and must be optically isolated from the CMU.

e. Data Link Layer. Transmission must be in asynchronous start/stop mode. The format must be 8 bit data, 1 stop bit, even parity, and 9600 bits per second (+/-2%) at a minimum. The CMU must be capable of full duplex operation. Flow control must use XON/XOFF procedures.

15. Monitor Unit Serial Memory Key. The CMU must have a Datakeytm model KC4210 Keycepticletm socket or equivalent serial memory key receptacle, which will intermate with the Datakeytm model LCK4000-RED, mounted on the front panel. The CMU must be provided with a Datakeytm model LCK4000-RED serial memory key or equivalent. The serial memory key must be rated for –40 to +80 degrees C operation. Note: Datakeytm and Keycepticletm are registered trademarks of Datakey, Inc.

a. Monitor Unit Serial Memory Key Interface. The CMU must not provide the capability to program the serial memory key. Writing to the serial memory key may be accomplished through the use of a serial memory key writer. The serial memory key must be used as a read only device. The 16 bit Frame Check Sequence (FCS) procedure defined in clause 4.6.2 of ISO/IEC 3309 must be used to verify the integrity of the read data. Failure to read the serial memory key correctly must result in LFSA. Interface circuitry to the device must utilize the LOFO switch on the serial memory key socket to ensure the device is removed and inserted with no power applied to the interface pins (i.e. dead socket).

b. Serial Memory Key Data. All bytes and bits marked as "reserved" must be set to "0".

Byte #	Contents	Description
1	0x01	Serial Memory Key Version
2	Ch 1-9, …, 1-2	Permissive Programming for channels 1-32: A bit set to "1" programs a channel pair to the permissive state. In the event the CMU has fewer than 32 channels, the bit positions corresponding to the nonexistent channels must be 0. Default programming must be 0. The Contents parameter contains on channel pair per bit position. For example, the contents of byte #5, "Ch 2-3, …, 1-26", is as follows: b0 = channel pair 1-26 b1 = channel pair 1-27 b2 = channel pair 1-28 b3 = channel pair 1-29 b4 = channel pair 1-30 b5 = channel pair 1-31 b6 = channel pair 1-32 b7 = channel pair 2-3 If b1 is set, then channel 1 is permissive with channel 27.
3	Ch 1-17, …, 1-10	
4	Ch 1-25, …, 1-18	
5	Ch 2-3, …, 1-26	
6	Ch 2-11, …, 2-4	
7	Ch 2-19, …, 2-12	
8	Ch 2-27, …, 2-20	
9	Ch 3-6, …, 2-28	
10	Ch 3-14, …, 3-7	
11	Ch 3-22, …, 3-15	
12	Ch 3-30, …, 3-23	
13	Ch 4-10, …, 3-31	
14	Ch 4-18, …, 4-11	
15	Ch 4-26, …, 4-19	
16	Ch 5-7, …, 4-27	
17	Ch 5-15, …, 5-8	
18	Ch 5-23, …, 5-16	
19	Ch 5-31, …, 5-24	
20	Ch 6-13, …, 5-32	
21	Ch 6-21, …, 6-14	
22	Ch 6-29, …, 6-22	
23	Ch 7-12, …, 6-30	
24	Ch 7-20, …, 7-13	
25	Ch 7-28, …, 7-21	
26	Ch 8-12, …, 7-29	
27	Ch 8-20, …, 8-13	
28	Ch 8-28, …, 8-21	
29	Ch 9-13, …, 8-29	
30	Ch 9-21, …, 9-14	

Byte #	Contents	Description
31	Ch 9-29, …, 9-22	
32	Ch 10-15, …, 9-30	
33	Ch 10-23, …, 10-16	
34	Ch 10-31, …, 10-24	
35	Ch 11-18, …, 10-32	
36	Ch 11-26, …, 11-19	
37	Ch 12-14, …, 11-27	
38	Ch 12-22, …, 12-15	
39	Ch 12-30, …, 12-23	
40	Ch 13-19, …, 12-31	
41	Ch 13-27, …, 13-20	
42	Ch 14-17, …, 13-28	
43	Ch 14-25, …, 14-18	
44	Ch 15-16, …, 14-26	
45	Ch 15-24, …, 15-17	
46	Ch 15-32, …, 15-25	
47	Ch 16-24, …, 16-17	
48	Ch 16-32, …, 16-25	
49	Ch 17-25, …, 17-18	
50	Ch 18-19, …, 17-26	
51	Ch 18-27, …, 18-20	
52	Ch 19-22, …, 18-28	
53	Ch 19-30, …, 19-23	
54	Ch 20-26, …, 19-31	
55	Ch 21-23, …, 20-27	
56	Ch 21-31, …, 21-24	
57	Ch 22-29, …, 21-32	
58	Ch 23-28, …, 22-30	
59	Ch 24-28, …, 23-29	
60	Ch 25-29, …, 24-29	
61	Ch 26-31, …, 25-30	
62	Ch 28-30, …, 26-32	
63	Ch 31-32, …, 28-31	
64	Ch 8:1	Lack of Signal Input Enable: A bit set to "1" enables the Lack of Signal Input monitoring function for that channel. This bit must be set to "0" for any channel that has an input mapped to a virtual channel. In the event the CMU has fewer than 32 channels, the bit positions corresponding to the nonexistent channels must be 0. Default programming must be 1.
65	Ch 16:9	
66	Ch 24:17	
67	Ch 32:18	
68	Ch 8:1	Dark Channel Map #1 A bit set to "1" disables the Lack of Signal
69	Ch 16:9	

Byte #	Contents	Description
70	Ch 24:17	Input monitoring function for that channel. For channels that are set to 0, Lack of Signal Input Enable programming must determine Lack of Signal Input operation. Default programming must be 0.
71	Ch 32:18	
72	Ch 8:1	Dark Channel Map #2 A bit set to "1" disables the Lack of Signal Input monitoring function for that channel. For channels that are set to 0, Lack of Signal Input Enable programming must determine Lack of Signal Input operation. Default programming must be 0.
73	Ch 16:9	
74	Ch 24:17	
75	Ch 32:18	
76	Ch 8:1	Dark Channel Map #3 A bit set to "1" disables the Lack of Signal Input monitoring function for that channel. For channels that are set to 0, Lack of Signal Input Enable programming must determine Lack of Signal Input operation. Default programming must be 0.
77	Ch 16:9	
78	Ch 24:17	
79	Ch 32:18	
80	Ch 8:1	Dark Channel Map #4 A bit set to "1" disables the Lack of Signal Input monitoring function for that channel. For channels that are set to 0, Lack of Signal Input Enable programming must determine Lack of Signal Input operation. Default programming must be 0.
81	Ch 16:9	
82	Ch 24:17	
83	Ch 32:18	
84	Ch 8:1	GY Multiple Channel Enable: A bit set to "1" enables the Green/Yellow Multiple Channel monitoring function for that channel. This bit must be set to "0" for any channel that has had a Green or Yellow input remapped to a virtual channel. In the event the CMU has fewer than 32 channels, the bit positions corresponding to the nonexistent channels must be 0. Default programming must be 1.
85	Ch 16:9	
86	Ch 24:17	
87	Ch 32:18	
88	Ch 8:1	YR Multiple Channel Enable: A bit set to "1" enables the Yellow/Red Multiple Channel monitoring function for that
89	Ch 16:9	
90	Ch 24:17	

Byte #	Contents	Description
91	Ch 32:18	channel. This bit must be set to "0" for any channel that has had a Yellow or Red input remapped to a virtual channel. In the event the CMU has fewer than 32 channels, the bit positions corresponding to the nonexistent channels must be 0. Default programming must be 1.
92	Ch 8:1	GR Multiple Channel Enable: A bit set to "1" enables the Green/Red Multiple Channel monitoring function for that channel. This bit must be set to "0" for any channel that has had a Green or Red input remapped to a virtual channel. In the event the CMU has fewer than 32 channels, the bit positions corresponding to the nonexistent channels must be 0. Default programming must be 1.
93	Ch 16:9	
94	Ch 24:17	
95	Ch 32:18	
96	Ch 8:1	Minimum Yellow Change Enable: A bit set to "1" enables the Minimum Yellow Change monitoring function for that channel. In the event the CMU has fewer than 32 channels, the bit positions corresponding to the nonexistent channels must be 0. Default programming must be 1.
97	Ch 16:9	
98	Ch 24:17	
99	Ch 32:18	
100	Ch 8:1	Minimum Yellow Change Plus Red Clearance Enable: A bit set to "1" enables the Minimum Yellow Change Plus Red monitoring function for that channel. In the event the CMU has fewer than 32 channels, the bit positions corresponding to the nonexistent channels must be 0. Default programming must be 1.
101	Ch 16:9	
102	Ch 24:17	
103	Ch 32:18	
104	Ch 8:1	Yellow Input Disable: A bit set to "1" forces the Yellow input to the OFF state for that channel. In the event the CMU has fewer than 28 physical channels, the bit positions corresponding to the nonexistent channels must be 0. Default programming must be 0.
105	Ch 16:9	
106	Ch 24:17	
107	Ch 28:25	
108	Ch 8:1	Current Sense Enable: A bit set to "1" enables the Lack of Indication current monitoring function for that channel.
109	Ch 16:9	
110	Ch 24:17	

Byte #	Contents	Description
111	Ch 28:25	This bit must be set to "0" for any channel that has an input mapped to a virtual channel. In the event the CMU has fewer than 28 physical channels, the bit positions corresponding to the nonexistent channels must be 0. Default programming must be 1.
112	Ch 4:1	Current Sense Full Scale Parameter These bits must define the Full Scale (FS) parameter for the Current Sense circuit for each channel. Default programming must be 00. b1,b0 = channel n b3,b2 = channel n+1 b5,b4 = channel n+2 b7,b6 = channel n+3 00 = 0.25 Amperes 01 = 0.33 Amperes 10 = 0.50 Amperes 11 = 1.0 Amperes
113	Ch 8:5	
114	Ch 12:9	
115	Ch 16:13	
116	Ch 20:17	
117	Ch 24:21	
118	Ch 28:25	
119	Channel 1	Channel Current Sense Threshold The threshold value for channel current sense must be programmed in percent (0 to 95) of full scale (FS). This value should be set in accordance with minimum accuracy tolerances defined in AMU section 3.8.5.1, AC RMS CURRENT SENSING. Default programming must be 25 (25% of 1.0 Amp full scale = 250 milliamperes).
120	Channel 2	
121	Channel 3	
122	Channel 4	
123	Channel 5	
124	Channel 6	
125	Channel 7	
126	Channel 8	
127	Channel 9	
128	Channel 10	
129	Channel 11	
130	Channel 12	
131	Channel 13	
132	Channel 14	
133	Channel 15	
134	Channel 16	
135	Channel 17	
136	Channel 18	
137	Channel 19	
138	Channel 20	
139	Channel 21	
140	Channel 22	
141	Channel 23	
142	Channel 24	
143	Channel 25	

Byte #	Contents	Description
144	Channel 26	
145	Channel 27	
146	Channel 28	
147	Red Ch 8:1	Field Output Check Enable: A bit set to "1" enables the Field Output Check monitoring function for that input. This bit must be set to "0" for any input that has been remapped to a virtual channel. In the event the CMU has fewer than 32 channels, the bit positions corresponding to the nonexistent inputs must be 0. Default programming must be 1.
148	Red Ch 16:9	
149	Red Ch 24:17	
150	Red Ch 32:25	
151	Yellow Ch 8:1	
152	Yellow Ch 16:9	
153	Yellow Ch 24:17	
154	Yellow Ch 32:25	
155	Green Ch 8:1	
156	Green Ch 16:9	
157	Green Ch 24:17	
158	Green Ch 32:25	
159	Minimum Flash Time	Minimum Flash Time Values of 0 thru 5 must result in 6 seconds of minimum flash. Maximum value is 15. Default programming must be 6.
160	+12 VDC Enable	+12 VDC Power Supply Monitor Enable Bit 0 set to 1 must enable the +12 VDC Power Supply monitor. Default programming must be 0x01.
161	Ch 29 Red	Virtual Channel Assignment Channels that have not been assigned must be set to 0. Default programming must be 0. Bits 4:0 specify the physical channel number (1 to 28) Bits 6:5 specify the physical input 01 = Red 10 = Yellow 11 = Green Bit 7 = reserved
162	Ch 29 Yellow	
163	Ch 29 Green	
164	Ch 30 Red	
165	Ch 30 Yellow	
166	Ch 30 Green	
167	Ch 31 Red	
168	Ch 31 Yellow	
169	Ch 31 Green	
170	Ch 32 Red	
171	Ch 32 Yellow	
172	Ch 32 Green	
173	AMU Position 1	AMU Configuration The number of Switch Pack positions in each output Assembly position must be
174	AMU Position 2	
175	AMU Position 3	

Byte #	Contents	Description
176	AMU Position 4	programmed in each byte. CMU channel numbers must be assigned sequentially starting with AMU position #1. Default programming must be 14,0,0,0. 0: Position not used 6: Six Pack Output Assembly 14: Fourteen Pack Output Assembly The 14 Pack is valid only for position #1 (#1=14, #2=0) and #3 (#3=14, #4=0). All other values are reserved.
177:216	ASCII string	Monitor ID A packed 40 character ID must be stored in ASCII format. Allowable characters are 020h through 07Eh. If less than 40 characters are used, the unused locations must be set to 00h. Default programming must be 00h.
217:256	ASCII string	User ID A packed 40 character ID must be stored in ASCII format. Allowable characters are 020h through 07Eh. If less than 40 characters are used, the unused locations must be set to 00h. Default programming must be 00h.
257:510	0x00	Reserved for future use.
511	FCS lsb	16 bit Check Value FCS Polynomial calculation of bytes #1 through #510.
512	FCS msb	

16. CMU Connector. The CMU Connector must be a DIN 4161264 Header Type. The CMU Connector pin assignments must be as shown on drawing 4-11-5.

17. Serial Bus #1 Frames.

a. Type 60 Command – Module ID.

Byte #	Contents	Description
a.	60	Frame Type

b. Type 188 Response – Module ID.

Byte #	Contents	Description
1	188	Frame Type
2	CMU address	Serial Bus #1 Address

c. Type 61 Command – Switch Pack Drivers. The destination for this frame must be the CMU. The Channel numbers in the Description column below refer to the channel numbers of the CMU. The ATC Controller Unit must include a definition, via program entry, of the CMU Channel to ATC Controller Unit signal driver group utilization. The Dark Channel Map Select bits must select a preprogrammed mask in the CMU serial memory key that disables Lack of Signal Input monitoring for the selected channels.

Byte #	Contents	Description
1	61	Frame Type
2	Channel 8:1 Red	Switch Pack Status A bit set to 1 indicates the Switch Pack output is set ON.
3	Channel 16:9 Red	
4	Channel 24:17 Red	
5	Channel 28:25 Red	
6	Channel 8:1 Yellow	
7	Channel 16:9 Yellow	
8	Channel 24:17 Yellow	
9	Channel 28:25 Yellow	
10	Channel 8:1 Green	
11	Channel 16:9 Green	
12	Channel 24:17 Green	
13	Channel 28:25 Green	
14	Map Select	Dark Channel Map Select Bit 1 and bit 0 must select one of four Dark Channel Maps programmed in the serial memory key that disables Lack of Signal Input monitoring for a selected channel. Bits 2 thru 7 are reserved. 00 = Mask #1 01 = Mask #2 10 = Mask #3 11 = Mask #4

d. Type 61 Response – CMU Status. If the CMU is in FSA (byte #2, Fault Type not equal to 0), then all bytes of the information field of this frame except Control Status 1, Control Status 2, and Output Assembly Flasher Status must contain an exact image of the signals that were applied to the CMU at the point in time of the detection of the failure. Control Status 1, Control Status 2, and Output Assembly Flasher Status must always reflect current status. If a channel block is not used (AMU not present) the Channel Fault Status bits, Channel Input Status bits, and Channel Input Voltage values bits for that block must be set to 0.

Byte #	Contents	Description
1	189	Frame Type
2	Fault Type	Enumerated fault code 00 = No Fault 01 = CMU/AMU +24 VDC 02 = CMU +12 VDC 03 = Conflict 04 = Serial Bus #1 05 = Serial Bus #3 06 = ATC LFSA Flash (Type 62) 07 = ATC NFSA Flash (Type 62) 08 = Diagnostic 09 = Multiple 10 = Lack of Signal Input 11 = Short Yellow Clearance 12 = Skipped Yellow Clearance 13 = Yellow + Red Clearance 14 = Field Output Check 15 = Serial Memory Key absent 16 = Serial Memory Key FCS error 17 = Serial Memory Key Data error 18 = Local Flash 19 = CB Trip 20 = CMU/AMU AC+ Raw Fail 21 = NRESET Active 22:127 = Reserved 128:255 = Spare
3	Channel Fault Status 8:1	Channel Fault Status Channel Fault Status bits must be set to 1 for channels that were detected in fault for fault types 03, 09, 10, 11, 12, 13, and 14. For fault type 01, 05, and 20 a bit must be set in Channel Fault Status 8:1 for each enabled AMU that failed. Bit 0 must be set if the CMU detected a failure: b0 = CMU b1 = AMU #1 b2 = AMU #2 b3 = AMU #3 b4 = AMU #4 For all other fault types the Channel Fault Status bits must be set to 0.
4	Channel Fault Status 16:9	
5	Channel Fault Status 24:17	
6	Channel Fault Status 32:25	
7	Channel Red Status 8:1	Channel Color Status Channel Color Status bits must be set to 1 for channels that are sensed active. For channel inputs that have
8	Channel Red Status 16:9	
9	Channel Red Status 24:17	

Byte #	Contents	Description
10	Channel Red Status 32:25	been remapped to a virtual channel (29-32), the Channel Fault Status bits must be set to 0. For virtual channel (29-32) inputs that have not been assigned to a physical output, the Channel Fault Status bits must be set to 0.
11	Channel Yellow Status 8:1	
12	Channel Yellow Status 16:9	
13	Channel Yellow Status 24:17	
14	Channel Yellow Status 32:25	
15	Channel Green Status 8:1	
16	Channel Green Status 16:9	
17	Channel Green Status 24:17	
18	Channel Green Status 32:25	
19	Channel Red Status 8:1	Field Check Status Field Check Status bits must be set to 1 for channels that are sensed with field check status. For channel inputs that have been remapped to a virtual channel (29-32), the Field Check Status bits must be set to 0. For virtual channel (29-32) inputs that have not been assigned to a physical output, the Field Check Status bits must be set to 0.
20	Channel Red Status 16:9	
21	Channel Red Status 24:17	
22	Channel Red Status 32:25	
23	Channel Yellow Status 8:1	
24	Channel Yellow Status 16:9	
25	Channel Yellow Status 24:17	
26	Channel Yellow Status 32:25	
27	Channel Green Status 8:1	
28	Channel Green Status 16:9	
29	Channel Green Status 24:17	
30	Channel Green Status 32:25	
31	Control Status #1	Control Status #1 b7 = Start-up Call (1=Exit from Flash) b6 = Flasher Output Fail (1 = Fail) b5 = Rear Door (1=Open) b4 = Front Door (1=Open) b3 = MAIN CONTACTOR Coil (1=Active) b2 = MAIN CONTACTOR Secondary (1=Active) b1 = FTR Coil Drive (1= Active) b0 = Output Relay Transfer (1=Fault)
32	Control Status #2	Control Status #2 b7 = Reserved b6 = Reserved b5 = Reserved b4 = Reserved b3 = Reserved b2 = Reserved b1 = Reserved b0 = Configuration Change This bit set to 1 indicates the configuration programming has changed since the last poll of message 65. It must also be set to 1 when the CMU is exiting flash (Start-up Call bit changes from 0 to 1) and at CMU power-up.

Byte #	Contents	Description
33	AC+ Raw Voltage	CMU AC+ Raw Voltage
34	Assembly #1 AC+ Raw Voltage	Assembly AC+ Raw Voltage
35	Assembly #1 AC+ Raw Voltage	
36	Assembly #1 AC+ Raw Voltage	
37	Assembly #1 AC+ Raw Voltage	
38	Channel 1 Red Voltage	Channel Input Voltages The Channel input voltages must be the most recent values reported from the AMUs. For channel inputs that have been remapped to a virtual channel (29-32), the Channel Voltage value must be set to 0. For virtual channel (29-32) inputs that have not been assigned to a physical output, the Channel Voltage value must be set to 0.
39	Channel 2 Red Voltage	
40	Channel 3 Red Voltage	
41	Channel 4 Red Voltage	
42	Channel 5 Red Voltage	
43	Channel 6 Red Voltage	
44	Channel 7 Red Voltage	
45	Channel 8 Red Voltage	
46	Channel 9 Red Voltage	
47	Channel 10 Red Voltage	
48	Channel 11 Red Voltage	
49	Channel 12 Red Voltage	
50	Channel 13 Red Voltage	
51	Channel 14 Red Voltage	
52	Channel 15 Red Voltage	
53	Channel 16 Red Voltage	
54	Channel 17 Red Voltage	
55	Channel 18 Red Voltage	
56	Channel 19 Red Voltage	
57	Channel 20 Red Voltage	
58	Channel 21 Red Voltage	
59	Channel 22 Red Voltage	
60	Channel 23 Red Voltage	
61	Channel 24 Red Voltage	
62	Channel 25 Red Voltage	
63	Channel 26 Red Voltage	
64	Channel 27 Red Voltage	
65	Channel 28 Red Voltage	
66	Channel 29 Red Voltage	
67	Channel 30 Red Voltage	
68	Channel 31 Red Voltage	
69	Channel 32 Red Voltage	
70	Channel 1 Yellow Voltage	
71	Channel 2 Yellow Voltage	
72	Channel 3 Yellow Voltage	

Byte #	Contents	Description
73	Channel 4 Yellow Voltage	
74	Channel 5 Yellow Voltage	
75	Channel 6 Yellow Voltage	
76	Channel 7 Yellow Voltage	
77	Channel 8 Yellow Voltage	
78	Channel 9 Yellow Voltage	
79	Channel 10 Yellow Voltage	
80	Channel 11 Yellow Voltage	
81	Channel 12 Yellow Voltage	
82	Channel 13 Yellow Voltage	
83	Channel 14 Yellow Voltage	
84	Channel 15 Yellow Voltage	
85	Channel 16 Yellow Voltage	
86	Channel 17 Yellow Voltage	
87	Channel 18 Yellow Voltage	
88	Channel 19 Yellow Voltage	
89	Channel 20 Yellow Voltage	
90	Channel 21 Yellow Voltage	
91	Channel 22 Yellow Voltage	
92	Channel 23 Yellow Voltage	
93	Channel 24 Yellow Voltage	
94	Channel 25 Yellow Voltage	
95	Channel 26 Yellow Voltage	
96	Channel 27 Yellow Voltage	
97	Channel 28 Yellow Voltage	
98	Channel 29 Yellow Voltage	
99	Channel 30 Yellow Voltage	
100	Channel 31 Yellow Voltage	
101	Channel 32 Yellow Voltage	
102	Channel 1 Green Voltage	
103	Channel 2 Green Voltage	
104	Channel 3 Green Voltage	
105	Channel 4 Green Voltage	
106	Channel 5 Green Voltage	
107	Channel 6 Green Voltage	
108	Channel 7 Green Voltage	
109	Channel 8 Green Voltage	
110	Channel 9 Green Voltage	
111	Channel 10 Green Voltage	
112	Channel 11 Green Voltage	
113	Channel 12 Green Voltage	
114	Channel 13 Green Voltage	
115	Channel 14 Green Voltage	
116	Channel 15 Green Voltage	

Byte #	Contents	Description
117	Channel 16 Green Voltage	
118	Channel 17 Green Voltage	
119	Channel 18 Green Voltage	
120	Channel 19 Green Voltage	
121	Channel 20 Green Voltage	
122	Channel 21 Green Voltage	
123	Channel 22 Green Voltage	
124	Channel 23 Green Voltage	
125	Channel 24 Green Voltage	
126	Channel 25 Green Voltage	
127	Channel 26 Green Voltage	
128	Channel 27 Green Voltage	
129	Channel 28 Green Voltage	
130	Channel 29 Green Voltage	
131	Channel 30 Green Voltage	
132	Channel 31 Green Voltage	
133	Channel 32 Green Voltage	
134	Channel 1	Scaled Channel Load Current The value reported must be the measured current in Amperes times 256 divided by the Full Scale (FS) parameter. For 1 primary turn, FS=10 (range is 0 to 10 Arms) For 2 primary turns, FS=5 (range is 0 to 5 Arms) For 3 primary turns, FS= 3.3 (range is 0 to 3.3 Arms) For 4 primary turns, FS=2.5 (range is 0 to 2.5 Arms)
135	Channel 2	
136	Channel 3	
137	Channel 4	
138	Channel 5	
139	Channel 6	
140	Channel 7	
141	Channel 8	
142	Channel 9	
143	Channel 10	
144	Channel 11	
145	Channel 12	
146	Channel 13	
147	Channel 14	
148	Channel 15	
149	Channel 16	
150	Channel 17	
151	Channel 18	
152	Channel 19	
153	Channel 20	
154	Channel 21	
155	Channel 22	
156	Channel 23	
157	Channel 24	
158	Channel 25	
159	Channel 26	
160	Channel 27	

Byte #	Contents	Description
161	Channel 28	
162	Binary Seconds	CMU Time and Date
163	Binary Minutes	
164	Binary Hours (0:23)	
165	Binary Date	
166	Binary Month	
167	Binary Year	
168	Voltage * 4	24 VDC Supply Voltage
169	Voltage * 8	12 VDC Supply Voltage
170	degrees F + 40	CMU Temperature (Fahrenheit)
171	Channel 8:1	Channel Current Sense Status Status bits must be set to 1 for channels that are sensed active. Status bits must be set to 0 for channels that have the Current Sense monitor function disabled.
172	Channel 16:9	
173	Channel 24:17	
174	Channel 28:25	
175	Assembly 2:1	Output Assembly Flasher Status (1=Fail) b0 = Assembly #1 (#3) FL1-1 b1 = Assembly #1 (#3) FL1-2 b2 = Assembly #1 (#3) FL2-1 b3 = Assembly #1 (#3) FL2-2 b4 = Assembly #2 (#4) FL1-1 b5 = Assembly #2 (#4) FL1-2 b6 = Assembly #2 (#4) FL2-1 b7 = Assembly #2 (#4) FL2-2
176	Assembly 4:3	
177		Reserved
178		Reserved

e. Type 62 – Send to Local Flash Command – SET FSA.

Byte #	Contents	Description
1	62	Frame Type
2	FSA mode	Set Failed State Action b0 = Set LFSA (L) b1 = Set NFSA (N) b2:7 = reserved

f. Type 190 Response – Send to Local Flash Response – Set FSA.

Byte #	Contents	Description
1	190	Frame Type

g. Type 65 Command – Get CMU Configuration. The ATC Controller Unit must request the serial memory key programming using this message and validate that the CMU Permissive Program settings are equal or less permissive than the ATC Controller Unit programming, and that the AMU Configuration programming is consistent with Output Assembly SIU assignment. If the programming of the CMU is not proper, the ATC Controller Unit must issue a Type 62 frame with the L bit set causing a LFSA in the CMU. This check must be performed at initialization and when the Type 189 or Type 195 Control Status 2, Configuration Change bit is set to 1.

Byte #	Contents	Description
1	65	Frame Type

h. Type 193 Response – CMU Configuration.

Byte #	Contents	Description
1	193	Frame Type
2:513	Bytes #1 thru #512	Serial Memory Key Contents

i. Type 66 Command – Time and Date Command.

Byte #	Contents	Description
1	66	Frame Type
2	0x01:0x0C	Month
3	0x01:0x1F	Day
4	0x00:0x63	Year
5	0x00:0x17	Hour
6	0x00:0x3B	Minutes
7	0x00:0x3B	Seconds
8	0x00:0x3B	Tenth Seconds

(1) This frame must be transmitted from the ATC Controller Unit once every second. The destination address must be the All Station Address of 255 (0xFF). No response from secondary devices is allowed to the All Station Address. The transmission of this frame must begin within +/-100 milliseconds of the ATC Controller Unit real time contained within the frame.

j. Type 67 Command – Switch Pack Drivers. The format of this command frame must be identical to Message 61 but requests a short status response from the CMU. This frame may be used as an alternate to Message 61. The destination for this frame must be the CMU. The Channel numbers in the Description column below refer to the channel numbers of the CMU. The ATC Controller Unit must include a definition, via program entry, of the CMU Channel to ATC Controller Unit signal driver group utilization.

(1) The Dark Channel Map Select bits must select a preprogrammed mask in the CMU serial memory key that disables Lack of Signal Input monitoring for the selected channels.

Byte #	Contents	Description
1	67	Frame Type
2	Channel 8:1 Red	Switch Pack Status A bit set to 1 indicates the Switch Pack output is set ON.
3	Channel 16:9 Red	
4	Channel 24:17 Red	
5	Channel 28:25 Red	
6	Channel 8:1 Yellow	
7	Channel 16:9 Yellow	
8	Channel 24:17 Yellow	
9	Channel 28:25 Yellow	
10	Channel 8:1 Green	
11	Channel 16:9 Green	
12	Channel 24:17 Green	
13	Channel 28:25 Green	
14	Map Select	Dark Channel Map Select Bit 1 and bit 0 must select one of four Dark Channel Maps programmed in the serial memory key that disables Lack of Signal Input monitoring for a selected channel. Bits 2 thru 7 are reserved. 00 = Mask #1 01 = Mask #2 10 = Mask #3 11 = Mask #4

k. Type 195 Response – CMU Short Status. If the CMU is in FSA (byte #2, Fault Type not equal to 0), then the Channel Color Status bytes must contain an exact image of the signals that were applied to the CMU at the point in time of the detection of the failure. Control Status 1, Control Status 2, and Output Assembly Flasher Status must always reflect current status.

(1) If a channel block is not used (AMU not present), the Channel Fault Status bits and Channel Color Status bits for that block must be set to 0.

Byte #	Contents	Description
1	195	Frame Type
2	Fault Type	Enumerated fault code 00 = No Fault 01 = CMU/AMU +24 VDC 02 = CMU +12 VDC 03 = Conflict 04 = Serial Bus #1 05 = Serial Bus #3 06 = ATC LFSA Flash (Type 62) 07 = ATC NFSA Flash (Type 62) 08 = Diagnostic 09 = Multiple 10 = Lack of Signal Input 11 = Short Yellow Clearance 12 = Skipped Yellow Clearance 13 = Yellow + Red Clearance 14 = Field Output Check 15 = Serial Memory Key absent 16 = Serial Memory Key FCS error 17 = Serial Memory Key Data error 18 = Local Flash 19 = CB Trip 20 = CMU/AMU AC+ Raw Fail 21 = NRESET Active 22:127 = Reserved 128:255 = Spare

Byte #	Contents	Description
3	Channel Fault Status 8:1	Channel Fault Status Channel Fault Status bits must be set to 1 for channels that were detected in fault for fault types 03, 09, 10, 11, 12, 13, and 14. For fault type 01, 05, and 20 a bit must be set in Channel Fault Status 8:1 for each enabled AMU that failed. Bit 0 must be set if the CMU detected a failure: b0 = CMU b1 = AMU #1 b2 = AMU #2 b3 = AMU #3 b4 = AMU #4 For all other fault types the Channel Fault Status bits must be set to 0.
4	Channel Fault Status 16:9	
5	Channel Fault Status 24:17	
6	Channel Fault Status 32:25	
7	Channel Red Status 8:1	Channel Color Status Channel Color Status bits must be set to 1 for channels that are sensed active. For channel inputs that have been remapped to a virtual channel (29-32), the Channel Fault Status bits must be set to 0. For virtual channel (29-32) inputs that have not been assigned to a physical output, the Channel Fault Status bits must be set to 0.
8	Channel Red Status 16:9	
9	Channel Red Status 24:17	
10	Channel Red Status 32:25	
11	Channel Yellow Status 8:1	
12	Channel Yellow Status 16:9	
13	Channel Yellow Status 24:17	
14	Channel Yellow Status 32:25	
15	Channel Green Status 8:1	
16	Channel Green Status 16:9	
17	Channel Green Status 24:17	
18	Channel Green Status 32:25	
19	Control Status #1	Control Status #1 b7 = Start-up Call (1=Exit from Flash) b6 = Flasher Output Fail (1 = Fail) b5 = Rear Door (1=Open) b4 = Front Door (1=Open) b3 = MC Coil (1=Active)

Byte #	Contents	Description
		b2 = MC Secondary (1=Active) b1 = FTR Coil Drive (1= Active) b0 = Output Relay Transfer (1=Fault)
20	Control Status #2	Control Status #2 b7 = Reserved b6 = Reserved b5 = Reserved b4 = Reserved b3 = Reserved b2 = Reserved b1 = Reserved b0 = Configuration Change This bit set to 1 indicates the configuration programming has changed since the last poll of message 65. It must also be set to 1 when the CMU is exiting flash (Start-up Call bit changes from 0 to 1) and at CMU power-up.
21	Assembly 2:1	Output Assembly Flasher Status (1=Fail) b0 = Assembly #1 (#3) FL1-1 b1 = Assembly #1 (#3) FL1-2 b2 = Assembly #1 (#3) FL2-1 b3 = Assembly #1 (#3) FL2-2 b4 = Assembly #2 (#4) FL1-1 b5 = Assembly #2 (#4) FL1-2 b6 = Assembly #2 (#4) FL2-1 b7 = Assembly #2 (#4) FL2-2
22	Assembly 4:3	
23		Reserved
24		Reserved

E. Model 214 ITS Auxiliary Monitor Unit (AMU).

1. General. The AMU must reside in each of the Output Assemblies. The AMU must interface to the CMU via Serial Bus #3. An AMU must operate in a fourteen-channel mode (14 Pack) or a six-channel mode (6 Pack) depending on the Address Select inputs.

   a. AMU Addressing. The Address Select input pins ADDRESS 0, ADDRESS 1, and ADDRESS 2 must define the Serial Bus #3 address of the AMU and the number of channels reported. The pins must be left open for a logical False, and are connected to ADDRESS COMMON for a logical True.

Mode / Position	ADDRESS 2	ADDRESS 1	ADDRESS 0	SB #3 ADDRESS
14 Ch/1 and 2	False	False	True	0x01
14 Ch/3 and 4	False	True	True	0x03
6 Ch/1	True	False	True	0x05
6 Ch/2	True	True	False	0x06
6 Ch/3	True	True	True	0x07
6 Ch/4	True	False	False	0x04

b. A 14 Pack Output Assembly configured in position 1 and 2 must respond as AMU #1 with AMU #2 reserved. A 14 Pack Output Assembly configured in position 3 and 4 must respond as AMU #3 with AMU #4 reserved.

c. The 6 Pack Output Assembly must have ADDRESS 2 permanently connected to ADDRESS COMMON on the assembly.

2. AC Voltage Sensing. All AC RMS voltage measurements must be made over an RMS period of 33.3 milliseconds (two AC Line cycles). All AC signals must be sampled at a minimum of 1920 samples per second. A True RMS voltage measurement must be made regardless of phase or wave-shape, including both positive and negative half wave sinusoids, over the voltage range of 0 Volts RMS to 135 Volts RMS. AC voltage measurements must be accurate to +/-2 Volts RMS.

3. Field Signal Sensing. Three inputs must be provided for each of fourteen channels (36 total) to permit the monitoring of voltages at the Green, Yellow, and Red signal field terminals. The AMU must be designed so that unused Green, Yellow, or Red signal inputs are not sensed as active signals. The AMU must sense an input at less than 15 Volts RMS when connected to AC Line through 1500 picofarads. Each field input voltage must be reported in the Type 129 or 130 frame.

4. AC Line Sensing. The AMU must include the capability of monitoring the AC Line voltage applied to its AC+ Raw input. The AC Line voltage must be reported in the Type 129 or 130 frame.

5. Flasher Input Sensing. Four inputs must be provided for sensing of voltages at the FLASHER #1-1, FLASHER #1-2, FLASHER #2-1, and FLASHER #2-2 signal input terminals of the Output Assembly. Each FLASHER input voltage must be reported in the Type 129 or 130 frame.

6. +24 VDC Sensing. The AMU must sense the state of the +24 VDC MONITOR input. Voltages at, or greater than, +22 VDC must be considered proper for Assembly operation. Voltages at, or less than, +18 VDC must be considered not proper for Assembly operation. The +24 VDC MONITOR state must be reported in the Type 129 or 130 frames. The +24 VDC MONITOR voltage section must be electrically isolated from the AC- Raw referenced circuitry.

7. Current Sensing.

   a. AC RMS Current Sensing. All AC RMS current measurements must be made over a period of two AC Line cycles (33.3 milliseconds). A True RMS current measurement must be made regardless of phase or wave-shape, including both positive and negative half wave sinusoids. AC current measurements must be accurate to +/-35%.

   b. Switch Pack Current Sensing. The AMU must sense the total output current of each Switch Pack. Each Switch Pack output current must be reported in the Type 129 or 130 frames.

      (1) The input impedance of the COIL+ input with respect to the COIL-input must be 1000 Ohms. Full-scale current is set by the number of primary turns through the transformer and must be a maximum of four turns. Unless specified otherwise, one turn must be provided.

   c. Current Transformer Parameters. The Switch Pack current sensing transformers must meet the following requirements:

Linearity	25% from 10 milliamperes to 1Ampere (single primary turn)
Accuracy	+/-25% (Rin = 1000 Ohms)
Primary Current	10 Amperes maximum
Minimum hole size	0.25 in. diameter
Insulation Resistance	100 Megohms at 500 VDC

      (1) The transformer must output a voltage of 1.0 Volts RMS (+/-5%) across 1K Ohms when driven by 1.0 Arms sinusoidal current through one primary turn. Sufficient secondary turns must be provided to compensate for differences in core material and losses to produce the 1.0 Volts RMS output.

8. Diagnostic Error. The AMU must be provided with a resident series of self-check diagnostic capabilities. At a minimum, the AMU must contain provisions to verify all memory elements on power-up and Reset. When an error is detected, the AMU must illuminate the DIAGNOSTIC indicator and disable the Serial Bus #3 port.

a. RAM Diagnostic. This test must verify that all RAM elements are operating correctly at power-up. Patterns must be written to RAM. Each Write must be followed by a Read to verify that it contains the written pattern.

b. Nonvolatile Memory Diagnostic. This test must verify that the nonvolatile ROM(s) contain the proper program. The routine must perform a check on each ROM and make a comparison with a preprogrammed check value. This test must be performed at power-up and at a minimum rate of 1024 bits per second during operation.

c. Internal MPU Monitor. The AMU must monitor the operation of its microprocessor. At a minimum, the monitoring circuit must be triggered at least every 100 milliseconds. The microprocessor must be reset and the DIAGNOSTIC indicator illuminated if the monitoring circuit has not been triggered for a maximum of 1000 milliseconds.

9. Power Requirements. The AMU must generate its own power supply voltage from the AC+ Raw input using no more than 5 Watts. It must be capable of insertion and removal while AC power is applied to the cabinet. Surge current on AC+ Raw input must be less than 2 Amperes peak.

a. Operating Voltage Range. The AMU must be operational over the voltage range of 80 Volts RMS to 135 Volts RMS. The AMU must be fully functional within 500 milliseconds following AC+ Raw voltage exceeding 80 Volts RMS or Reset.

b. Power Supply Holdup. During the loss of AC+ Raw voltage for 700 milliseconds or less the AMU must continue to operate.

10. AMU User Interface. All indicators must be clear LEDS. Clear LEDs must not depend on a reflector or diffusion as part of its design. Clear LEDs must only show the die and not appear to be ON when exposed to ambient light. The following indicators must be provided (Top to Bottom).

a. AC Power Indicator. A green POWER indicator must be provided. The indicator must be illuminated when the AC+ Raw input is 80 Volts RMS (+/-2 Volts RMS) or greater. This indicator must be labeled POWER.

b. Serial Bus #3 Indicator. A yellow Serial Bus #3 indicator must be provided. The indicator must pulse ON for 40 milliseconds each time the AMU correctly receives a frame with its address on the Bus #3 input. This indicator must be labeled SB #3 RX.

c. Diagnostic Indicator. A red DIAGNOSTIC indicator must be provided. The indicator must be ON when an internal diagnostic error is detected. This indicator must be labeled DIAGNOSTIC.

d. Reset Button. A recessed RESET switch must be provided which applies a direct reset to the microprocessor device on the AMU. All voltage and current data must be initialized to 0 following Reset. The access hole must be 0.25 in. in diameter.

e. AMU Connector. The AMU connector must be a DIN 4161296 Header Type. Pins A31 (Equipment Ground), B32 (AC-Raw), and C32 (AC-Raw) must pre-mate before all other pins. The AMU pin assignments must be as shown on drawing 4-11-6.

11. Bus #3 Profile.

a. Electrical. TxD+, TxD- and RxD+, RxD- must consist of two interface links conforming to the requirements of the Electronic Industries Association EIA-485, Standard for Electrical Characteristics of Generators and Receivers for use in Balanced Digital Multipoint Systems, dated April 1983. Where differences occur between the EIA-485 standard and this document, this document must govern.

(1) All voltage potentials on the Bus #3 TxD+, TxD-, RxD+, and RxD- interface links must be referenced to AC- Raw.

b. Data Link Layer. The data link layer protocol is based on a subset of HDLC as defined by ISO/IEC 3309. Each frame must consist of the following fields:

(1) Flag byte = 0x7E

(2) Address byte = 0x01 through 0x07

(3) Control byte = 0x13 (U Format)

(4) Information field = defined below in section, Frame Types

(5) Frame Check Sequence = 16 bit FCS procedure defined in clause 4.6.2 of ISO/IEC 3309.

(6) Flag byte = 0x7E

(7) Transmission must be in start/stop mode with basic transparency defined by clause 4.5.2.2 of ISO/IEC 3309 applied. The format must be 8 bit data, 1 stop bit, no parity, and 153,600 bits per second (+/-2%). Only asynchronous half duplex operation must be permitted.

c. Procedures. Frames transmitted by the CMU must be referred to as command frames and frames transmitted by the AMU must be referred to as response frames. Command frames must be transmitted only to those AMUs that are present, as determined by the programming entries made in the CMU. Response frames must only be transmitted as a result of correctly receiving a command frame. The first eight bits in each information field must contain the frame Type number. There must be a maximum of 64 different command frame types and 64 different response frame types. Additionally, there must be 64 different command frame types reserved for special application use and 64 different response frame types reserved for special application use, as outlined below.

FRAME TYPES	FUNCTION
1-63	Command frame defined by this standard
0, 64-127	Command frame reserved
128-191	Response frame defined by this standard
192-255	Response frame reserved

Reserved bits must always be set to zero by the transmitting station.

d. Service Time. The AMU must begin its response to command frames from the CMU within a designated period of time following the correct reception of a complete command frame including the closing flag. This period must be known as the Service Time and must have a maximum value of 500 microseconds. The AMU TxD link output must be in its high impedance state outside of the interval defined by the Service Time plus Response Time.

e. Response Time. The AMU must complete its transmission of the response frame including the closing flag within a designated time known as the Response Time, depending on the number of bytes transmitted in the response frame. The AMU TxD link output must be in its high impedance state a maximum of 200 microseconds following the transmission of the closing flag. The Response Time period must have a maximum value of (1.2)*(# of bytes in information field +6)*(10/153600). Note that due to the transparency mechanism, any occurrence of the flag byte (0x7E) or control escape byte (0x7D) in the information field adds a second byte to the count. Thus, the number of bytes in the information field could be doubled if all characters are 0x7E or 0x7D.

f. Dead Time. Following the transmission of each command frame, there must be a Dead Time during which the CMU does not transmit. This Dead Time must be a minimum of the Service Time plus the Response Time.

12. Frame Types.

a. Type 1 Command Frame. This frame must be transmitted from the CMU to each AMU-6 at least once every RMS period (33.3 milliseconds, two AC Line cycles, averaging time for RMS measurement). Its purpose is to request the status from an AMU-6. Polling the AMU-6 more often than the RMS period may result in the same response frame being repeated.

Byte #	Contents	Description
1	01	Frame Type

b. Type 129 Response Frame. This AMU-6 Status frame must be transmitted only if a Type 1 command frame has been correctly received from the CMU. The AMU-6 must report the data for the most recent RMS period calculated when the Type 1 command is received. The Type 1 command frame polling rate must not affect the accuracy or RMS period of the data.

Byte #	Contents	Description
1	129	Frame Type
2	AMU Status	6 Pack AMU Status b0 = set to 1 if +24 VDC MONITOR input is Low b1:4 = reserved b5 = set if AMU has reset since last poll b6 = set if last RMS period data was not transmitted b7 = diagnostic failure
3	0-135	AC+ Raw voltage
4	Channel 1 Red	Channel RMS Voltages
5	Channel 2 Red	
6	Channel 3 Red	
7	Channel 4 Red	
8	Channel 5 Red	
9	Channel 6 Red	
10	Channel 1Yellow	
11	Channel 2 Yellow	
12	Channel 3 Yellow	
13	Channel 4 Yellow	
14	Channel 5 Yellow	
15	Channel 6 Yellow	
16	Channel 1 Green	
17	Channel 2 Green	
18	Channel 3 Green	
19	Channel 4 Green	
20	Channel 5 Green	

Byte #	Contents	Description
21	Channel 6 Green	
22	Flasher #1-1	Flasher RMS Voltages
23	Flasher #1-2	
24	Flasher #2-1	
25	Flasher #2-2	
26	Channel 1	Channel Load Current The current value reported must be the measured current in Amperes times 255 divided by the Full Scale (FS) parameter. For 1 primary turn, FS =1.0 (range is 0 to 1.0 Arms) For 2 primary turns, FS =0.5 (range is 0 to 0.5 Arms) For 3 primary turns, FS = 0.33 (range is 0 to 0.33 Arms) For 4 primary turns, FS =0.25 (range is 0 to 0.25 Arms)
27	Channel 2	
28	Channel 3	
29	Channel 4	
30	Channel 5	
31	Channel 6	
32	0	Reserved
33	0	Reserved

c. Type 2 Command Frame. This frame must be transmitted from the CMU to each AMU-14 at least once every RMS period. Its purpose is to request the status from an AMU-14. Polling the AMU-14 more often than the RMS period may result in the same response frame being repeated.

Byte #	Contents	Description
1	02	Frame Type

d. Type 130 Response Frame. This AMU-14 Status frame must be transmitted only if a Type 2 command frame has been correctly received from the CMU. The AMU-14 must report the data for the most recent RMS period calculated when the Type 2 command is received. The Type 2 command frame polling rate must not affect the accuracy or RMS period of the data.

Byte #	Contents	Description
1	130	Frame Type
2	AMU Status	14 Pack AMU Status b0 = set to 1 if +24 VDC MONITOR input is Low b1:4 = reserved b5 = set if AMU has reset since last poll b6 = set if last RMS period data was not

Byte #	Contents	Description
		transmitted b7 = diagnostic failure
3	0-135	AC+ Raw voltage
4	Channel 1 Red	Channel RMS Voltages
5	Channel 2 Red	
6	Channel 3 Red	
7	Channel 4 Red	
8	Channel 5 Red	
9	Channel 6 Red	
10	Channel 7 Red	
11	Channel 8 Red	
12	Channel 9 Red	
13	Channel 10 Red	
14	Channel 11 Red	
15	Channel 12 Red	
16	Channel 13 Red	
17	Channel 14 Red	
18	Channel 1Yellow	
19	Channel 2 Yellow	
20	Channel 3 Yellow	
21	Channel 4 Yellow	
22	Channel 5 Yellow	
23	Channel 6 Yellow	
24	Channel 7Yellow	
25	Channel 8 Yellow	
26	Channel 9 Yellow	
27	Channel 10 Yellow	
28	Channel 11 Yellow	
29	Channel 12 Yellow	
30	Channel 13 Yellow	
31	Channel 14 Yellow	
32	Channel 1 Green	
33	Channel 2 Green	
34	Channel 3 Green	
35	Channel 4 Green	
36	Channel 5 Green	
37	Channel 6 Green	
38	Channel 7 Green	
39	Channel 8 Green	
40	Channel 9 Green	
41	Channel 10 Green	
42	Channel 11 Green	
43	Channel 12 Green	
44	Channel 13 Green	

Byte #	Contents	Description
45	Channel 14 Green	
46	Flasher #1-1	Flasher RMS Voltages
47	Flasher #1-2	
48	Flasher #2-1	
49	Flasher #2-2	
50	Channel 1	Channel Load Current The current value reported must be the measured current in Amperes times 255 divided by the Full Scale (FS) parameter. For 1 primary turn, FS =1.0 (range is 0 to 1.0 Arms) For 2 primary turns, FS =0.5 (range is 0 to 0.5 Arms) For 3 primary turns, FS = 0.33 (range is 0 to 0.33 Arms) For 4 primary turns, FS =0.25 (range is 0 to 0.25 Arms)
51	Channel 2	
52	Channel 3	
53	Channel 4	
54	Channel 5	
55	Channel 6	
56	Channel 7	
57	Channel 8	
58	Channel 9	
59	Channel 10	
60	Channel 11	
61	Channel 12	
62	Channel 13	
63	Channel 14	
64	0	Reserved
65	0	Reserved

e. Type 128 Response Frame. This frame must be transmitted from the AMU to the CMU as a Negative Acknowledge response frame if the AMU correctly receives a command frame with an invalid parameter.

Byte #	Contents	Description
1	128	Frame Type (Negative Acknowledge)
2	Status	AMU SB #3 Error Type b0 = set to 1 if invalid frame type received b1:7 = reserved

F. Model 216-12 & 216-24 ITS Power Supply Units.

1. General Requirements.

a. The unit chassis must be vented. The power supply cage and transformers must be securely braced to prevent damage in transit. When resident in the PDA ITS, the units must be held firmly in place by its stud screws and wing nut.

b. Two units, 216-12 and 216-24 must provide +12 and +24 VDC, respectively, to the cabinet assemblies. They must be of ferro-resonant design. They must have no active components and conform to the requirements of this section.

(1) Line and load regulation must meet the two power supply ranges for +24 VDC (23.0 VDC to 26 VDC) and +12 VDC (11.65 VDC to 13.35 VDC). This includes ripple noise; from 90 VAC to 135 VAC at 60 Hertz, plus an additional 1.6% for each additional 1.0% frequency change; and current range from 1 Ampere to 5 Amperes with a maximum temperature rise of 30 degrees C above ambient.

(2) Design Center Voltage must be +24 VDC (+/-0.5 VDC) and +12 VDC (+/-0.5 VDC) at full load, at 30 degrees C, and with 115 VAC incoming after a 30-minute warm-up period.

(3) Full Load Current must be 5 AMPERES each for +24 VDC and +12 VDC, minimum.

(4) Ripple Noise must be 2 Volts peak-to-peak and 500 millivolts RMS at full load.

(5) Line Voltage must be 90 VAC to 135 VAC.

(6) Efficiency must be 70% minimum.

(7) Circuit capacitors must be rated for 40 Volts minimum.

c. When supplying only one 216-24, supply terminal pins 13 and 14 must be jumpered together.

d. The front panel must include AC and DC fuses, power ON light and banana clip test points for monitoring the output voltages. The unit, including terminals, must be protected with a 1K Ohm, 0.5 watt, resister to prevent accidental contact with energized parts.

G. Type 218 – Serial Interface Unit (SIU).

1. General. The SIU must be capable of processing fifty-four Input/Output pins and four Optical Input pins. When installed in an ITS Input Assembly, it processes twenty-four detector outputs (pins F and W), twenty-four detector status outputs, and provides six detector rest signals (per two slots). In advanced detectors, the status outputs may be converted to per channel resets. When installed in an ITS 14 Pack Output Assembly, the SIU controls fourteen Switch Pack Units (forty-two Outputs) and four Optical Inputs through the CDC socket.

2. Power Requirements. The SIU requires a nominal supply voltage of 24 VDC (+/-2 VDC). A voltage of 16 VDC or less must be considered loss of power and a voltage of 18 VDC or greater must be considered adequate for operation. The SIU must not require more than 300 milliamperes over the voltage range of 16 VDC to 30 VDC and the power surge must be limited to a maximum of 1.25 Amperes from initial application of DC power. The SIU must not be damaged by insertion to, or removal from, powered input or output assemblies. The SIU operates normally for 700 milliseconds after power loss.

3. Microprocessor. The SIU Controller Unit must include a microprocessor/controller unit together with all required clocking and support circuitry.

4. Memory. Operational software necessary to meet housekeeping and functional requirements must be provided resident in socketed firmware or internal Flash memory.

5. Control Signals. The SIU uses NRESET lines for SIU shut down/turn on operations matching the ATC Controller Unit CPU. The SIU must be fully initialized and providing specified operation upon NRESET Line going HIGH (Power Up). In the ATC Controller, the NRESET operation must cause the SIU program restart. No prior message operation data retention is required. The Request Module Status Response may report this restart as either a Power On or Watchdog. ATC Controller Unit LINESYNC is used as a system time reference. The microprocessor/controller unit is reset by any of the following:

    a. Pushbutton Reset

    b. NRESET Signal

    c. +5 VDC out of regulation

    d. Microprocessor/controller unit watchdog

6. Time Reference. The SIU includes a 1 Kilohertz Time Reference to provide system response time stamps. The 1 Kilohertz Time Reference must maintain a frequency accuracy of +/-0.01% (+/-0.1 counts per second).

7. Watchdog. A watchdog circuit must be provided. The SIU must power up with the watchdog enabled. Within the first watchdog time period, the watchdog value must be set to 200 milliseconds +/-100 milliseconds. The watchdog state must be reported in the SIU status byte as an indication that a watchdog has occurred, which will remain until cleared in the Request Module Status command. Failure of the SIU to reset the watchdog timer must result in hardware reset.

8. Millisecond Counter. A 32-bit Millisecond Counter must be provided for "time stamping." Each 1 Kilohertz reference must increment the Millisecond Counter.

9. Buffers. A Transition Buffer must be provided capable of holding a minimum of 1024 recorded entries. The Transition Buffer must default to empty. There must be two entry types: Transition and Rollover. The inputs must be monitored for state transition. At each transition (if the input has been configured to report transition, a transition entry must be added to the Transition Buffer. If multiple inputs change state during one input sample, these transitions must be entered into the Input Transition Buffer by increasing input number. The Millisecond Counter must be monitored for rollover. At each rollover transition ($xxxx FFFF - $xxxx 0000), a rollover entry must be added to the Transition Buffer. For rollover entries, all bits of byte 1 are set to indicate that this is a rollover entry. A new entry must be discarded when storage is not available for the new entry. Transition Buffer blocks are sent to the ATC Controller Unit upon command. Upon confirmation of their reception, the blocks must be removed from the Transition Buffer. The entry types are as follows:

Input Transition Entry

Description	msb							lsb	Byte Number
Transition Entry Identifier	S	Input Number (I0 – I59)							1
Timestamp NLSB	x	x	x	x	x	x	x	x	2
Timestamp LSB	x	x	x	x	x	x	x	x	3

Millisecond Counter Rollover Entry

Description	msb							lsb	Byte Number
Rollover Entry Identifier	1	1	1	1	1	1	1	1	1
Timestamp MSB	x	x	x	x	x	x	x	x	2
Timestamp NMSB	x	x	x	x	x	x	x	x	3

10. Power Up Initialization. At Power Up, the SIU loss of communications timer must indicate loss of communications until the user program sends the Request Module Status message to reset the "E" Bit and a subsequent set output command is processed.

11. Interrupts. All interrupts must be capable of asynchronous operation with respect to all processing and all other interrupts. The SIU includes three interrupt sources as follows:

    a. MILLISECOND Interrupt. MILLISECOND Interrupt must be activated by the Time Reference. A timestamp rollover flag set by Millisecond Counter (MC) rollover must be cleared only on command.

b. LINESYNC Interrupt. The LINESYNC signal must be generated by the controller power supply. LINESYNC Interrupt must be generated by both the 0-1 and 1-0 transitions of the LINESYNC signal. The LINESYNC interrupt must monitor the Millisecond Counter interrupt and set the Millisecond Counter error flag if there has not been an interrupt from the 1 Kilohertz source for 0.5 seconds (≥60 consecutive LINESYNC interrupts). The LINESYNC interrupt must synchronize the 1 KHz time reference with the 0-1 transition of the LINESYNC signal once a second. A LINESYNC error flag must be set if the LINESYNC interrupt has not successfully executed for 0.5 seconds or longer (≥500 consecutive millisecond interrupts).

c. Line Frequency Reference. The Line Frequency Reference input pin must receive a square wave signal from the cabinet power supply for the purposes of synchronizing SIU outputs with the AC line. Line Frequency Reference Interrupt must be generated by both the 0-1 and 1-0 transitions of the Line Frequency Reference signal. The Line Frequency Reference interrupt must monitor the Millisecond Counter interrupt and set the Millisecond Counter error flag if there has not been an interrupt from the 1 Kilohertz source for 0.5 seconds (≥60 consecutive Line Frequency Reference interrupts). The Line Frequency Reference interrupt must synchronize the Time Reference with the 0-1 transition of the Line Frequency Reference signal once a second. A Line Frequency Reference error flag must be set if the Line Frequency Reference interrupt has not successfully executed for 0.5 seconds or longer (≥500 consecutive millisecond interrupts). The electrical characteristics of the Line Frequency input are as follows:

(1) A voltage between 0 and 8 volts must be considered the LOW state, and must occur when the AC line is in the positive half cycle.

(2) A voltage between 16 and 26 volts must be considered the High state, and must occur when the AC line is in the negative half-cycle.

(3) The Line Frequency Reference input must exhibit a nominal impedance of 10K (+/-10%) to the +24 VDC input and must not have more than 1000 picofarads of load capacitance.

(4) The rise and fall time of the signal connected to this input must not exceed 50 microseconds.

(a) The SIU/BIU input must be used by the SIU to determine the AC timing source. If the SIU/BIU input is grounded, LINESYNC must be used as the interrupt source. If the SIU/BIU input is pulled up, Line Frequency Reference must be used as the interrupt source.

d. Communication Service Routine. A low-level communication service routine must be provided to handle reception, transmission, and EIA-485 communication faults. The communication server must automatically:

(1) For Transmission:

(a) Generate the opening and closing flags

(b) Generate the CRC value

(c) Generate the abort sequence (minimum of 8 consecutive '1' bits) when commanded by the Microprocessor Unit

(d) Provide zero bit insertion

(2) For Reception:

(a) Detect the opening and closing flags

(b) Provide address comparison, generating an interrupt for messages addressed to the SIU, and ignoring messages not addressed to the SIU

(c) Strip out inserted zeros

(d) Calculate the CRC value, compare it to the received value, and generate an interrupt on an error

(e) Generate an interrupt if an abort sequence is received

12. Communication Processing. The task must be to process the command messages received from the ATC Controller Unit, prepare, and start response transmission. The response message transmission must begin within 4 milliseconds of the receipt of the received message. The SIU must complete the execution of each command within 70 milliseconds of the end of each response message transmission.

13. Input Processing. This task must process the raw input data scanned in by the 1 milliseconds interrupt routine, perform all filtering, and maintain the transition queue entries.

14. Inputs and Outputs. The SIU must have four Optically Coupled Inputs, fifty-four Parallel Input/Outputs and four Serial Ports.

a. Optically-Coupled Inputs.

(1) Opto Common. The Opto Common input must be the common reference pin for four Opto Inputs.

(2) Opto Inputs. The Opto Inputs are intended to provide optical isolation for Pedestrian Detection, internal cabinet functions, Remote Interconnect or other auxiliary inputs. The Opto Inputs are intended to connect through external 27K Ohm, 1-Watt resistors for 120 VAC operations, and are intended for direct connection to 12 VAC for Pedestrian Detector applications. These inputs may also be used for low-true DC applications when the Opto Common pin is connected to -24 VDC. These inputs may function in the place of 242/252 isolator modules.

(a) The Opto Inputs must provide electrical isolation of 10 Megohms minimum resistance and 1000 VAC RMS minimum breakdown to all connector pins except the Opto Common pin, at a maximum breakdown leakage current of 1 milliamperes RMS.

(b) These inputs must exhibit nominal impedance to the Opto Common pin of 5000 Ohms, +10% to the Opto Common input.

(c) The Opto Inputs must not recognize 3 Volts RMS (AC sinusoid or DC) or less relative to the Opto Common input.

(d) The Opto Inputs must recognize 8 Volts RMS (AC sinusoid or DC) or more relative to the Opto Common input.

(e) Any steady state voltage applied between an Opto Input and the Opto Common must not exceed 35 VAC RMS.

(f) Opto Inputs must not be acknowledged when active for 25 milliseconds or less, and must be acknowledged when active for 50 milliseconds or more.

(g) The first Output Assembly assignments must be dedicated as follows:

PIN	1st OUTPUT ASSEMBLY	APPLICABLE HOUSING TYPE
Opto Input 1	Manual Control Enable	All
Opto Input 2	Interval Advance	All
Opto Input 3	Stop Time	All
Opto Input 4	Manual Flash	All
Opto Input Comon	AC-	All

b. Parallel Inputs and Outputs. SIU must control fifty-four input/output lines using ground-true logic.

(1) Input Section. Each input must be read logic "1" (ON) when the input voltage at its field connector input is less than 8 VDC, and must be read logic "0" (OFF) when the input voltage exceeds 16 VDC. Each input must have an internal pull-up to +24 VDC of 11K Ohms maximum, and must not deliver greater than 10 milliamperes to a short circuit to ground.

(2) Output Section. Each output written as a logic "1" (ON) must have a voltage at its field connector output of less than 4.0 VDC. Each output written as logic "0" (OFF) must provide an open circuit (1 Megohm or more) at its field connector output. Each output must consist of an open-collector capable of driving 40 VDC minimum and sinking 100 milliamperes minimum. Each output circuit must be capable of switching from logic "1" to logic "0" within 100 microseconds when connected to a load of 100K Ohms minimum. Each output circuit must be protected from transients of 10 microseconds (+/-2 microseconds) duration, +/-300 VDC from a 1K Ohm source, with a maximum rate of 1 pulse per second. Each output must latch the data written and remain stable until either new data is written or the active-low reset signal. Upon an active-low reset signal, each output must latch a logic "0" and retain that state until a new writing. The state of all output circuits at the time of Power Up or in Power Down state must be OFF. It must be possible to simultaneously assert all outputs within 100 microseconds of each other. An output circuit state not changed during a new writing must not glitch when other output circuits are updated.

(3) Input/Output Function. Each parallel Input/Output function contains all of the functions listed below of both the Input Function and Output Function.

(4) Input Section Function. Input scanning must begin at I0 (bit 0) and proceed to the highest numbered input, ascending from LSB to MSB. Each complete input scan must finish within 100 microseconds. Once sampled, the logic state of an input must be held until the next input scan. Each input must be sampled 1,000 times per second. The time interval between samples must be 1 milliseconds (+/-100 microseconds). The Millisecond Counter must be sampled within 10 microseconds of the completion of the input scan.

(5) Input Data Filtering. If configured, the inputs must be filtered by the SIU to remove signal bounce. The filtered input signals must then be monitored for changes as noted. The filtering parameters for each input must consist of Ignore Input Flag and the ON and OFF filter samples. If the Ignore Input flag is set, no input transition entries must be placed into the Input Transition buffer. The ON and OFF filter samples must determine the number of consecutive samples an input must be ON and OFF, respectively, before a change of state is recognized. If the change of state is shorter than the specified value, the change of state must be ignored. The ON and OFF filter values must be in the range of 0 to 255. A filter value of 0, for either or both values, must result in no filtering for this input. The default values for input signals after reset must be as follows:

Filtering:	Enabled
On and off filter values must be set to:	5
Transition monitoring:	Disabled (Timestamps are not logged)

(6) Output Function. Simultaneous assertion of all outputs must occur within 100 microseconds. Each output must be capable of being individually configured in state to ON, OFF, or a state synchronized with either phase of LINESYNC. The condition of the outputs must only be "ON" if the SIU continues to receive active communications from the ATC Controller Unit. If there is no valid communications with the ATC Controller Unit for 2.0 seconds, all outputs must revert to the OFF condition, and the SIU status byte must be updated to reflect the loss of communication from the ATC Controller Unit. The data and control bits in the ATC Controller Unit-SIU frame protocol must control each output as follows:

Output Bit Translation

Case	Output Data Bit	Output Control Bit	Function
A	0	0	Output in the OFF state
B	1	1	Output is a square wave, synchronized to the LINESYNC signal. When LINESYNC is ON (1), the output is OFF, and when LINESYNC is OFF (0), the output is ON.
C	0	1	Output is a square wave, synchronized to the LINESYNC signal. When LINESYNC is ON (1), the output is ON, and when LINESYNC is OFF (0), the output is OFF
D	1	0	Output is in the ON state.

(a) In Case A above, the corresponding output must be turned OFF if previously ON and if previously OFF remain OFF until otherwise configured. For half-cycle switching (cases B and C), all outputs to be changed must be changed within 50 microseconds after the corresponding LINESYNC transition and must remain in the same state during the entire half cycle. In Case D above, the corresponding output must be turned ON if previously OFF and if previously ON remain ON until otherwise configured. All outputs must never change state unless configured to do so.

(7) Serial Ports. The SIU must have a minimum of four serial ports, identified as SIU Ports 1-4. Serial Ports 1 and 3 are connected to the SIU microprocessor/controller unit, while Serial Ports 2 and 4 provide a buffered communications path from the ATC Controller Unit to the detectors, and are not connected to the microprocessor/controller unit. Communications circuitry must be capable of 614.4 Kilobits per second of data pass through.

(a) SIU Port 1 Operation. Port 1 must interface the SIU to Serial Bus 1 of the ITS cabinet Modular Bus Assemblies. All communications circuitry and protocol must match Serial Bus 1 requirements. The SIU must function as the "LOCAL" command node for this network responding with appropriate action. See ATC Controller Unit specification, CPU Field I/O, for protocol and requirements. The SP5 SDLC frame address assignments (Command/Responses) are as follows:

Address	SYSTEM ASSEMBLY / UNIT	SIU ADDRESS							
		A7	A6	A5	A4	A3	A2	A1	A0
0	Reserved								
1	14 Pack in position 1	0	0	0	0	0	0	0	1
2	Reserved								
3	14 Pack in position 3	0	0	0	0	0	0	1	1
4	6 Pack in position 4	0	0	0	0	0	1	0	0
5	6 Pack in position 1	0	0	0	0	0	1	0	1
6	6 Pack in position 2	0	0	0	0	0	1	1	0
7	6 Pack in position 3	0	0	0	0	0	1	1	1
8	Reserved								
9	Input #1	0	0	0	0	1	0	0	1
10	Input #2	0	0	0	0	1	0	1	0
11	Input #3	0	0	0	0	1	0	1	1
12	Input #4	0	0	0	0	1	1	0	0
13	Input #5	0	0	0	0	1	1	0	1
14	Reserved								
15	CMU #1	0	0	0	0	1	1	1	1
16	CMU #2	0	0	0	1	0	0	0	0
17	CMU #3	0	0	0	1	0	0	0	1
18	CMU #4	0	0	0	1	0	0	1	0
19	CPU	0	0	0	1	0	0	1	1
20	FI/O 2A or 8	0	0	0	1	0	1	0	0
21 to 254	Reserved								
255	Broadcast All	1	1	1	1	1	1	1	1

Note 1: A0 to A3 are Input to SIU with DC ground as common.
Note 2: 0 = open or ground false. 1= closed or ground true (shunted)

(b) SIU Port 2 Operation. SIU Port 2 must interface to Serial Bus 2 of the ITS cabinet Modular Bus Assemblies providing a communications path to the ATC Controller Unit for block data retrieval. No connection exists between SIU Port 1 and SIU Port 2. Similarly, no connection exists between SIU Port 2 and the microprocessor/controller unit. All data transfers between SIU Ports 1 and 2 must be accomplished by the ATC Controller Unit. For example, data sent back may include monitor diagnostic status and communication status; input diagnostics status (detector sensor or isolator); and processed channel inputs data such as rate counts, occupancies, average speeds, speed classification and incident/presence.

I. Synchronous Operation. If the ATC Controller Unit is communicating via Logical Port SP3S, SIU Port 2 must communicate in SDLC format and protocol, and the hardware requirements must match Serial Bus 2 (synchronous TX/RX using TxC from the ATC Controller Unit CPU for common clocking).

II. Asynchronous Operation. If the ATC Controller Unit is communicating via Logical Port SP3, SIU Port 2 must communicate in an asynchronous START BIT/STOP BIT format and protocol.

(c) SIU Port 3 Operation. The SIU Port 3 must be provided for communication to a personal computer via a front panel 9-position subminiature D-type connector and EIA-232 logic. Its purpose is to upload diagnostic information, and to download the SIU program. The SIU Port 3 protocol must be defined by the vendor, and operate with vendor-supplied software. The pin assignments of SIU Port 3 must match that of ATC Controller Unit C60 port.

(d) SIU Port 4 Operation. SIU Port 4 consists of Detector Rack signal INBUS TxD, INBUS RxD, INBUS TxC, and INBUS RxC, and must conform to the electrical standards of EIA-485, single-ended. In this scheme, the RxD- and RxC- inputs of the EIA-485 receivers are connected to 2.5 Volts, while the TxD- and TxC- outputs of the EIA-485 drivers are not used. SIU Port 4 receivers must withstand +/-25 Volts, suitable for reception of EIA-232 bipolar signals. All four INBUS signals must be terminated at each receiver with impedance of 6,800 Ohms (+/-5%), connected from signal to +5V Ground on the SIU. The detector vendor must define the SIU Port 4 messages. The detector vendor must define the SIU Port 4 protocol. The SIU provides one inversion to ensure a controller MARK equates to a detector MARK. The SIU must provide an LED indicator for TxD and RxD, such that is illuminated during a MARK (START Bit, for example) and extinguished during a SPACE (STOP Bit, for example). SIU Port 4 provides the buffering to SIU Port 2, allowing the ATC Controller Unit to communicate directly to the detectors, as follows:

I. Synchronous Operation. If the ATC Controller Unit is communicating to detectors via Logical Port SP3S, the SIU Port 4 buffers must convert SIU Port 2 TxD+ and TxD- to EIA-485 which must then be transmitted to the detectors via INBUS TxD. Likewise, the SIU Port 4 buffers must convert SIU Port 2 TxC+ and TxC- to EIA-485, which must then be transmitted to the detectors via INBUS TxC.

II. If the ATC Controller Unit is communicating to detectors via Logical Port SP3S, the SIU Port 4 buffers must convert INBUS RxD from EIA-485, which must then be transmitted to the ATC Controller Unit via SIU Port 2 RxD+ and RxD-. Likewise, the SIU Port 4 buffers must convert INBUS RxC from EIA-485, which must then be transmitted to the ATC Controller Unit via SIU Port 2 RxC+ and RxC-.

III. Asynchronous Operation. If the ATC Controller Unit is communicating to detectors via Logical Port SP3, the SIU Port 4 buffers must convert SIU Port 2 TxD+ and TxD- to EIA-485 which must be transmitted to the detectors via INBUS TxD.

IV. If the ATC Controller Unit is communicating to detectors via Logical Port SP3, the SIU Port 4 buffers must convert INBUS RxD is from EIA-485, which must be transmitted to the ATC Controller Unit via SIU Port 2 RxD+ and RxD-.

V. Asynchronous operation must not use Port 2 TxC+, TxC-, RxC+, RxC-, nor Port 4 INBUS TxC, or INBUS RxC.

VI. Assembly Address Output. The SIU must sense the rack address block and generate a square wave on the ASSEMBLY ADDRESS signal as follows:

ASSEMBLY ADDRESS	ASSEMBLY ADDRESS FREQUENCY (Hertz)(+/-15%)
1	60
2	30
3	15
4	7.5
5	3.75

VII. INBUS RTS Input. The INBUS RTS line must be pulled to +24 Volts via a 10K Ohm resistor on the SIU. In systems using legacy detectors that do not use INBUS RTS, this line must not be used (no connection). Detectors equipped with INBUS RTS must drive this line low when transmitting data from that detector to the SIU via INBUS. When not transmitting data, this line must not be driven low and is pulled to +24V via the 10K Ohm resistor.

VIII. Serial Bus 2 Control. The controller transmits a message on Serial Bus 2 which must be received by each detector via the SIU INBUS TxD and INBUS TxC. If the detector is asynchronous, INBUS TxC must be ignored. Each detector must compare the address field of the message with its own slot address and assembly address. If the address matches, that detector must respond with data on INBUS RxD and INBUS RxC. If the detector is asynchronous, INBUS RxC must not be used. The SIU of the responding detector must enable its EIA-485 line drivers to transmit the response from INBUS to SB2. This driver must be enabled by any of the three following conditions:

i. Activity on INBUS RxD

ii. Activity on INBUS RxC

iii. INBUS RTS at low (true)

IX. This driver must be disabled by either of the following two conditions:

i. Lack of activity on both INBUS RxD and RxC for 1.5 milliseconds

ii. Inbus RTS transitions from low (true) to high (false)

15. Data Communications Protocol. All communication with the ATC Controller Unit must be SDLC-compatible command-response protocol, support 0-bit stuffing, and operate at a data rate of 614.4 Kilobits per second. The ATC Controller Unit must always initiate the communication and should the command frame be incomplete or in error, no SIU response must be transmitted.

a. Frame Type. The frame type must be determined by the value of the first byte of the message. The command frames type values $70 - $7F and associated response frame type values $F0 - $FF are allocated to the Manufacturer diagnostics. All other frame types not called out are reserved. The command-response Frame Type values and message times must be as follows:

Frame Types

Module Command	I/0 Module Response	Description	Minimum Message Time	Maximum Message Time
49	177	Request Module Status	250 microseconds	275 microseconds
50	178	MILLISECOND CTR. Mgmt.	222.5 microseconds	237.5 microseconds
51	179	Configure Inputs	344.5 microseconds	6.8750 milliseconds
52	180	Poll Raw Input Data	317.5 microseconds	320 microseconds
53	181	Poll Filtered Input Data	317.5 microseconds	320 microseconds
54	182	Poll Input Transition Buffer	300 microseconds	10.25 milliseconds
55	183	Command Outputs	405 microseconds	410 microseconds
56	184	Config. Input Tracking Functions	340 microseconds	10.25 milliseconds
57	185	Config. Complex Output Functions	340 microseconds	6.875 milliseconds
58	186	Reserved	---	---
59	187	Reserved	---	---
60	188	SIU Identification	222.5 microseconds	222.5 microseconds
61-62	189-190	Reserved (note below)	---	---
63	191	Reserved	---	---
64	192	Reserved	---	---
65	193	Reserved (note below)	---	---
66	---	Reserved (note below)	---	---
67	195	Reserved (note below)	---	---

b. Messages 61/189, 62/190, 65/193, and 67/195 must be for ITS Cabinet Monitor Unit. See ITS Cabinet Monitor System Serial Bus #1 for Command and Response Frames. Message 66/No Response is a Broadcast Message to Address 255 containing the current time. Any device may receive and process this message if it has the software capacity.

c. Request Module Status. The Command must be used to request SIU status information response. Command/Response frames must be as follows:

Request Module Status Command

Description	msb							lsb	Byte Number
(Type Number = 49)	0	0	1	1	0	0	0	1	Byte 1
Reset Status Bits	P	E	K	R	T	M	L	W	Byte 2

Request Module Status Response

Description	msb							lsb	Byte Number
(Type Number = 177)	1	0	1	1	0	0	0	1	Byte 1
System Status	P	E	K	R	T	M	L	W	Byte 2
SCC Receive Error Count	Receive Error Count								Byte 3
SCC Transmit Error Count	Transmit Error Count								Byte 4
MC Timestamp MSB	MC Timestamp MSB								Byte 5
MC Timestamp NMSB	MC Timestamp NMSB								Byte 6
MC Timestamp NLSB	MC Timestamp NLSB								Byte 7
MC Timestamp LSB	MC Timestamp LSB								Byte 8

d. The response status bits are defined as follows:

P - Indicates SIU hardware reset
E - Indicates a communications loss of greater than 2 seconds
M - Indicates an error with the Millisecond Counter interrupt
L - Indicates an error in the LINESYNC
W - Indicates that the SIU has been reset by the Watchdog
R - Indicates that the EIA-485 receive error count byte has rolled over
T - Indicates that the EIA-485 transmit error count byte has rolled over
K - Not Used

e. Each of these bits must be individually reset by a '1' in the corresponding bit of any subsequent Request Module Status frame, and the response frame must report the current status bits. The SCC error count bytes must not be reset. When a count rolls over (255 - 0), its corresponding roll-over flag must be set.

f. Millisecond Counter Management. The Millisecond Counter Management Frame must be used to set the value of the Millisecond Counter. The 'S' bit must return status '0' on completion or '1' on error. The 32-bit value must be loaded into the Millisecond Counter at the next 0-1 transition of the LINESYNC signal. The frames must be as follows:

Millisecond Counter Management Command

Description	msb							lsb	Byte Number
(Type Number = 50)	0	0	1	1	0	0	1	0	Byte 1
New MC Timestamp MSB	x	x	x	x	x	x	x	x	Byte 2
New MC Timestamp NMSB	x	x	x	x	x	x	x	x	Byte 3
New MC Timestamp NLSB	x	x	x	x	x	x	x	x	Byte 4
New MC Timestamp LSB	x	x	x	x	x	x	x	x	Byte 5

Millisecond Counter Management Response

Description	msb							lsb	Byte Number
(Type Number = 178)	1	0	1	1	0	0	1	0	Byte 1
Status	0	0	0	0	0	0	0	S	Byte 2

g. Configure Inputs. The Configure Inputs command frame must be used to change input configurations. The command-response frames must be as follows:

Configure Inputs Command

Description	msb							lsb	Byte Number
(Type Number = 51)	0	0	1	1	0	0	1	1	Byte 1
Number of Items (n)	n	n	n	n	n	n	n	n	Byte 2
Item # - Byte 1	E	Input Number (I0 – I59)							Byte 3(I-1)+3
Item # - Byte 2	Leading edge filter (e)								Byte 3(I-1)+4
Item # - Byte 3	Trailing edge filter (r)								Byte 3(I-1)+5

NOTE: In the case of an invalid parameter error, the entire message must be rejected.

Configure Inputs Response

Description	msb							lsb	Byte Number
(Type Number = 179)	1	0	1	1	0	0	1	1	Byte 1
Status	0	0	0	0	0	0	0	S	Byte 2

h. Block field definitions must be as follows:

E - Ignore Input Flag. "1" = do not record transition entries for this input, "0" = record transition entries for this input

e - A one-byte leading edge filter specifying the number of consecutive input samples which must be "0" before the input is considered to have entered to "0" state from "1" state (range 1 to 255, 0 = filtering disabled)

r - A one-byte trailing edge filter specifying the number of consecutive input samples which must be "1" before the input is considered to have entered to "1" state from "0" state (range 1 to 255, 0 = filtering disabled)

S - return status S = '0' on completion or '1' on error

i. Poll Raw Input Data. The Poll Raw Input Data frame must be used to poll the SIU for the current unfiltered status of all inputs. The response frame must contain 8 bytes (Inputs 0-63) of information indicating the current input status. The frames must be as follows:

Poll Raw Input Data Command

Description	msb							lsb	Byte Number
(Type Number = 52)	0	0	1	1	0	1	0	0	Byte 1

Poll Raw Input Data Response

Description	msb							lsb	Byte Number
(Type Number = 180)	1	0	1	1	0	1	0	0	Byte 1
Inputs I0 (lsb) to I7 (msb)	x	x	x	x	x	x	x	x	Byte 2
Inputs I8 to I53, I56 to I59	x	x	x	x	x	x	x	x	Bytes 3 to 9
MC Timestamp MSB	x	x	x	x	x	x	x	x	Byte 10
MC Timestamp NMSB	x	x	x	x	x	x	x	x	Byte 11
MC Timestamp NLSB	x	x	x	x	x	x	x	x	Byte 12
MC Timestamp LSB	x	x	x	x	x	x	x	x	Byte 13

j. Poll Filtered Input Data. The Poll Filtered Input Data frame must be used to poll the SIU for the current filtered status of all inputs. The response frame must contain 8 bytes (Inputs 0-63) of information indicating the current filtered status of the inputs. Raw input data must be provided in the response for inputs that are not configured for filtering. The frames must be as follows:

Poll Filter Input Data Command

Description	msb							lsb	Byte Number
(Type Number = 53)	0	0	1	1	0	1	0	1	Byte 1

Poll Filter Input Data Response

Description	msb							lsb	Byte Number
(Type Number = 181)	1	0	1	1	0	1	0	1	Byte 1
Inputs I0 (lsb) to I7 (msb)	x	x	x	x	x	x	x	x	Byte 2
Inputs I8 to I53, I56 to I59	x	x	x	x	x	x	x	x	Bytes 3 to 9
MC Timestamp MSB	x	x	x	x	x	x	x	x	Byte 10
MC Timestamp NMSB	x	x	x	x	x	x	x	x	Byte 11
MC Timestamp NLSB	x	x	x	x	x	x	x	x	Byte 12
MC Timestamp LSB	x	x	x	x	x	x	x	x	Byte 13

k. Poll Input Transition Buffer. The Poll Input Transition Buffer frame must poll the SIU for the contents of the input transition buffer. The response frame must include a three-byte information field for each of the input changes that have occurred since the last interrogation. The frames are as follows:

Poll Input Transition Buffer Command

Description	msb							lsb	Byte Number
(Type Number = 54)	0	0	1	1	0	1	1	0	Byte 1
Block Number	x	x	x	x	x	x	x	x	Byte 2

Poll Input Transition Buffer Response

Description	msb							lsb	Byte Number
(Type Number = 182)	1	0	1	1	0	1	1	0	Byte 1
Block Number	x	x	x	x	x	x	x	x	Byte 2
Number of Entries = N	x	x	x	x	x	x	x	x	Byte 3
Item #	S	Input Number (I0 – I59)							Byte 3(I-1)+4
Item # MC Timestamp NLSB	x	x	x	x	x	x	x	x	Byte 3(I-1)+5
Item # MC Timestamp LSB	x	x	x	x	x	x	x	x	Byte 3(I-1)+6
Status	0	0	0	0	C	F	E	G	Byte 3(I-1)+7
MC Timestamp MSB	x	x	x	x	x	x	x	x	Byte 3(N-1)+8
MC Timestamp NMSB	x	x	x	x	x	x	x	x	Byte 3(N-1)+9
MC Timestamp NLSB	x	x	x	x	x	x	x	x	Byte 3(N-1)+10
MC Timestamp LSB	x	x	x	x	x	x	x	x	Byte 3(N-1)+11

l. Each detected state transition for each active input is placed in the queue as it occurs. Bit definitions are as follows:

S - Indicates the state of the input after the transition, bit is 1 if the Input is ON after the transition, bit is 0 if the Input is OFF after the transition
C - Indicates the 255 entry buffer limit has been exceeded
F - Indicates the 1024 buffer limit has been exceeded
G - Indicates the requested block number is out of monotonic increment sequence
E - Same block number requested, E is set in response

m. The entries provided within the Transition Buffer Poll response must be ordered from the start of the reply as the oldest to newest. The very first access provides the oldest entry. The SIU device must initialize, upon Power Up or Reset, its last Block Number received value to 0xFF in order to facilitate suppression of the G Bit response when the ATC Controller Unit program starts and uses 0x00 as the first Block Number. Subsequent responses are subject to the old-buffer purge mechanism stated below.The ATC Controller Unit program monotonically increases the Block Number after each command issued to purge the old buffer. When the SIU Module receives this command, it must compare the associated Block Number with the Block Number of the previously received command. If it is the same, the previous buffer must be re-sent to the ATC Controller Unit and the 'E' flag set in the status response frame. If it is not equal to the previous Block Number, the old buffer must be purged and the next block of data sent. If the block number is not incremented by one, the status G bit must be set. The block number received becomes the current number (even if out of sequence). The Block Number byte sent in the response block must be the same as that received in the command block. The Block Number counter rollover (0xFF becomes 0x00) must be considered as a normal increment.

n. Set Outputs. The Set Outputs frame must be used to command the SIU to set the Outputs according to the data in the frame. If there is any error configuring the outputs, the 'E' flag in the response frame must be set to '1'. If the LINESYNC reference has been lost, the 'L' bit in the response frame must be set. Loss of LINESYNC reference must also be indicated in system status information. These command and response frames are as follows:

Set Outputs Command

Description	msb							lsb	Byte Number
(Type Number = 55)	0	0	1	1	0	1	1	1	Byte 1
Outputs O0 (lsb) to O7 (msb) Data	x	x	x	x	x	x	x	x	Byte 2
Outputs O8 to O54 Data	x	x	x	x	x	x	x	x	Bytes 3 to 8
Outputs O56 to O63 Data (reserved)	0	0	0	0	0	0	0	0	Byte 9
Outputs O0 (lsb) to O7 (msb) Control	x	x	x	x	x	x	x	x	Byte 10
Outputs O8 to O54 Control	x	x	x	x	x	x	x	x	Bytes 11 to 16
Outputs O56 to O63 Control (reserved)	0	0	0	0	0	0	0	0	Byte 17

Set Outputs Response

Description	msb							lsb	Byte Number
(Type Number = 183)	1	0	1	1	0	1	1	1	Byte 1
Status	0	0	0	0	0	0	L	E	Byte 2

o. Configure Input Tracking Functions. The Configure Input Tracking Functions frame must be used to configure the definition for an output that responds to transitions on a particular input. The maximum number of active definitions is 8. Refer to 'Tracking Functions Overview' for additional details.

p. Please note that Configure Input Tracking Functions is not intended for use with Traffic Signal Control Applications. (Authorized Engineering Information)

(1) Command and Response Frames. The command and response frames for Input Tracking Functions must be as follows:

Configure Input Tracking Functions Command

Description	msb							lsb	Byte Number
(Type Number = 56)	0	0	1	1	1	0	0	0	Byte 1
Number of Items	Number of Items								Byte 2
Item # - Byte 1	E	Output Number (O0 – O54)							Byte 2(I-1)+3
Item # - Byte 2	I	Input Number (I0 – I59)							Byte 2(I-1)+4

Number of Items: 0-16 Tracking Definitions are contained in this message.

Field Definitions:

E	'1'	-	Enable Input Tracking function for this Output
	'0'	-	Remove Input Tracking function for this Output
I	'1'	-	Output is OFF when Input is ON, ON when Input OFF
	'0'	-	Output is ON when Input is ON, OFF when Input is OFF

Output Number: 0 - Maximum Output Number for the SIU device type.
Input Number: 0 - Maximum Input Number for the SIU device type.

Configure Input Tracking Functions Response

Description	msb							lsb	Byte Number
(Type Number = 184)	1	0	1	1	1	0	0	0	Byte 1
Status	0	0	0	0	0	0	0	V	Byte 2
MC Timestamp MSB	x	x	x	x	x	x	x	x	Byte 3
MC Timestamp NMSB	x	x	x	x	x	x	x	x	Byte 4
MC Timestamp NLSB	x	x	x	x	x	x	x	x	Byte 5
MC Timestamp LSB	x	x	x	x	x	x	x	x	Byte 6

Field Definitions:

V	'1'	-	Maximum number of configurable outputs will be exceeded.
	'0'	-	No error

(2) Timestamp. The timestamp value must be sampled prior to the response frame.

(3) Output Updates. Outputs, which track inputs, must be updated no less than once per millisecond. Input to output signal propagation delay must not exceed 2 milliseconds.

(4) Tracking Functions Overview. A maximum of eight different Output numbers may be activated by specifying eight definitions.

(5) One complete definition for an Output that tracks an Input consists of two bytes containing four parameters: 1) the instruction to install or to remove the definition, 2) the Output Number, 3) the relationship of the state of the Output to the Input and 4) the Input Number.

(6) Each definition specifies the controlling Input number for that unique output number. More than one output definition may specify the same Input controlling source. [That is, the same input may be used as the control source for more than one Tracking Output.]

(7) A complete definition is called an Item in the Command Message frame. The 'Number of Items' byte specifies the quantity of complete definitions contained in the Command Frame. If the value is 0, all existing active Input Tracking definitions must be removed.

(8) The transmission of a definition may:

(a) install a new active Tracking definition.

(b) remove an existing active Tracking definition. When an Input Tracking definition is removed, the output is set according to the most recently received Set Outputs Command.

(c) convert an active output definition from Complex or Square Wave definition to Tracking. Conversion removes the existing definition and assigns the Tracking definition without a transition through the 'output is set according to the most recently received Set Outputs Command' state. The most recent state of the output remains until the new function changes it.

(d) redefine an existing Tracking definition.

(9) If a command frame to be processed by the SIU would result in having more than the maximum number (8) of definitions activated, the entire command frame must be rejected. The response V bit must be set to 1.

(10) The V bit response is based on counting the current active quantity plus the projected Enable definitions after accounting for Remove definitions and invalid Output numbers.

(11) The V bit response evaluation takes the currently active definition quantity, adds the projected Enable definitions, subtracts the Remove definitions, ignores invalid Input and Output numbers and compares the result to the Maximum Number of active Tracking definitions allowed. If the quantity of Active definitions would become greater than the Maximum Number of active Tracking definitions, or if there are more Remove definitions than existing active definitions, the V Bit must be set in the response.

(12) While processing an Enable request, an Out of Range Input number must preclude processing for that definition.

(13) The Out of Range Output and Input numbers must not affect the active definition count. No error response is returned.

(14) The rest of the message must be processed.

(15) The "Number of Items" field is valid from 0 to 16 because the longest message may contain 8 Enable and 8 Remove definitions.

(16) The Input state always comes from the Filtered Input Data source.

(17) Valid Input and Output Number Ranges:

ITS SIU device types: Inputs 0 - 53 & 56 - 59, Outputs 0 – 54

q. Configure Complex Output Functions. The Configure Complex Output Functions frame must be used to configure the definition for an output that provides a complex operation. The maximum number of active definitions is 8. Refer to 'Complex Output Functions Overview' for additional details.

(1) Please note that Configure Complex Output Functions is not intended for use with Traffic Signal Control Applications. (Authorized Engineering Information)

(2) Command and Response Frames. The command and response frames must be as follows:

Configure Complex Output Functions Command

Description	msb							lsb	Byte Number
(Type Number = 57)	0	0	1	1	1	0	0	1	Byte 1
Number of Items	Number of Items								Byte 2
Item # - Byte 1	0	Output Number (O0 – O54)							Byte 7(I-1)+3
Item # - Byte 2	Primary Duration (MSB)								Byte 7(I-1)+4
Item # - Byte 3	Primary Duration (LSB)								Byte 7(I-1)+5
Item # - Byte 4	Secondary Duration (MSB)								Byte 7(I-1)+6
Item # - Byte 5	Secondary Duration (LSB)								Byte 7(I-1)+7
Item # - Byte 6	0	Input Number (I0 – I59)							Byte 7(I-1)+8
Item # - Byte 7	P	W	G	E	J	F	R	L	Byte 7(I-1)+9

(a) Number of Items: 0-16 Complex Output Definitions are contained in this message.

(b) Output Number: 0 - Maximum Output Number for the SIU device type.

(c) Primary Duration: MSB & LSB form a 16 bit Hex numerical value 0x0000 - 0xffff.

(d) Secondary Duration: MSB & LSB form a 16 bit Hex numerical value 0x0000 - 0xffff.

(e) Input Number: 0 - Maximum Input Number for the SIU device type.

(3) Field Definitions:

P '1' -The output is configured for single-pulse operation. Once complete, the complex output function must be disabled.
'0' -The output is configured for continuous oscillation.

W '1' -It is triggered by the specified input. Triggered complex output must commence within 2 milliseconds of the associated trigger recognition.
'0' -Operation must begin within 2 milliseconds of the command receipt.

G '1' -Operation must be gated active by the specified input.
'0' -Gating is inactive.

E '1' Enable complex output function for this output
'0' Remove complex output function for this output

J '1' During primary duration, the output must be written as a logic '1'.
During secondary duration, the output must be written as a logic '0'.
'0' - During primary duration, the output must be written as a logic '0'. During secondary duration, the output must be written as a logic '1'

F '1' -The trigger or gate must be acquired subsequent to filtering the specified input. The raw input signal must be used if filtering is not enabled for the specified input.
'0' -The trigger or gate must be derived from the raw input.

R '1' -For triggered output, the output must be triggered by an ON-to-OFF transition of the specified input and must be triggered immediately upon command receipt if the input is OFF. For gated output, the output must be active while the input is OFF.
'0' -For triggered output, the output must be triggered by an OFF-to-ON transition of the specified input and must be triggered immediately upon command receipt

if the input is ON. For gated output, the output must be active while the input is ON.

L '1' - The LINESYNC based clock must be used for the time ticks.
'0' - The Millisecond Counter must be used for the time ticks.

Configure Complex Output Functions Response

Description	msb							lsb	Byte Number
(Type Number = 185)	1	0	1	1	1	0	0	1	Byte 1
Status	0	0	0	0	0	0	0	V	Byte 2
MC Timestamp (MSB)	x	x	x	x	x	x	x	x	Byte 3
MC Timestamp (NMSB)	x	x	x	x	x	x	x	x	Byte 4
MC Timestamp (NLSB)	x	x	x	x	x	x	x	x	Byte 5
MC Timestamp (LSB)	x	x	x	x	x	x	x	x	Byte 6

(4) Field Definitions:

V '1' - Maximum number of configurable outputs will be exceeded.
'0' - No error

(5) Sampling Rate. Controlling input signals must be sampled at least once per millisecond.

(6) Complex Output Functions Overview. A maximum of eight different Output numbers may be activated by specifying eight definitions.

(a) One complete definition for a Complex Output consists of seven bytes containing fourteen parameters:

1) the Output Number,
2, 3) Primary Duration: MSB & LSB form a 16 bit Hex numerical value,
4, 5) Secondary Duration: MSB & LSB form a 16 bit Hex numerical value,
6) the Input Number,
7) Bit P: One Pulse or Continuous Oscillation,
8) Bit W: Output Operation is Edge Triggered by Input or Not Triggered by Input,
9) Bit G: Output Operation is Gated by Input or is Continuous Oscillation,
10) Bit E: Enable Definition or Remove Definition,
11) Bit J: Defines Primary/Secondary Duration relationship: ON/OFF or OFF/ON,
12) Bit F: Input from Filtered or Raw Data,

13) Bit R: Selects Edge for Triggered by Input ON to OFF or OFF to ON. Bit R: Selects State for Gated to be active by Input OFF or by Input ON, 14) Linesync edges or Millisecond Counter provides tick timing.

(b) Each definition specifies the controlling Input number for that unique output number. The Input is a functional control only when the operation is specified as Triggered (W=1) or Gated (G=1). Otherwise, the Input number is ignored. More than one output definition may specify the same Input controlling source. [That is, the same input may be used as the control source for more than one Complex Output.] If both W=1 and G=1 are set in the definition, the G=1 must be used as if W=0.

(c) The primary duration is the first timed interval of a pulse or the first portion of a continuous oscillation. The first portion follows acquisition of a Trigger or Gated Input. If not Triggered or Gated, the first portion follows the activation of the definition.

(d) The secondary duration follows the Primary duration.

(e) A complete definition is called an Item in the Command Message frame.

(f) The 'Number of Items' byte specifies the quantity of complete definitions contained in the Command Frame. If the value is 0, all existing active Complex Output definitions must be removed.

(g) The transmission of a definition may:

I. install a new active Complex Output definition.

II. remove an existing active Complex Output definition. When a Complex Output definition is removed, the output is set according to the most recently received Set Outputs Command.

III. convert an active output definition from Tracking or Square Wave definition to Complex Output. Conversion removes the existing definition and assigns the Complex Output definition without a transition through the 'output is set according to the most recently received Set Outputs Command' state. The most recent state of the output remains until the new function changes it.

IV. redefine an existing Complex Output definition.

(h) If a command frame to be processed by the SIU would result in having more than the maximum number (8) definitions activated, the entire command frame must be rejected. The response V bit must be set to 1.

(i) The V bit response evaluation takes the currently active definition quantity, adds the projected Enable definitions, subtracts the Remove definitions, ignores invalid Input and Output numbers and compares the result to the maximum number of active Complex definitions allowed. If the quantity of active definitions would become greater than the maximum number of active Complex Output definitions, or if there are more Remove definitions than existing active Complex Output definitions, the V Bit must be set in the response.

(j) While processing an Enable request that requires Triggered or Gated operation, an Out of Range Input number must preclude processing for that definition.

(k) The Out of Range Output and Input numbers must not affect the active definition count. No error response is returned.

(l) The rest of the message must be processed.

(m) The "Number of Items" field is valid from 0 to 16 because the longest message may contain 8 Enable and 8 Remove definitions.

(n) The Input state comes from the Filtered or Raw Input Data source as specified by the Bit F value.

(o) Valid Input and Output Number Ranges:

(p) ITS SIU device types: Inputs 0 - 53 & 56 - 59, Outputs 0 – 54

(q) The LINESYNC based clock must used both the rising and falling edges providing a nominal 8.33 millisecond time tick.

r. Module Identification. The SIU Identification command frame must be used to request the SIU Identification value for ITS Cabinet SIUs and CMUs. Reply message must use the following addresses: ATC Controller Unit Field I/Os must respond with address 20. SIUs respond with their own address ranging from 0-14. CMUs respond with their own addresses, ranging from 15-18.

(1) The command and response frames must be shown as follows:

I/O Module Identification Command

Description	msb							lsb	Byte Number
(Type Number= 60)	0	0	1	1	1	1	0	0	Byte 1

I/O Module Identification Response

Description	msb							lsb	Byte Number
(Type Number= 188)	1	0	1	1	1	1	0	0	Byte 1
SIU I D byte	x	x	x	x	x	x	x	x	Byte 2

16. Address Select Inputs. The Address Select input bits must define the logical position of each SIU. No connection must be logical False, while a connection to Logic Ground must be a logical True. There must be sixteen unique address positions selected with a binary code, using bit 0 as least significant and bit 3 as most significant.

17. SIU/BIU Input. The SIU must contain one input that must be read directly by microprocessor. When not connected, this input must be logical False, while a connection to Ground must be a logical True.

18. Hardware Requirements.

a. Size. The SIU Module must be physically composed of a printed circuit board, 4.5 in. high by 6.5 in. long, a front panel 2.25 in. wide by 4.5 in. high with a DIN 96-pin connector on the connector end (opposite the front panel).

b. SIU Insertion and Extraction. A “U” handle must be mounted on the front panel for insertion/extraction.

c. LED Indicators. Six LED indicators must be provided on the front panel, as follows:

SIU Active	SIU Power	Serial Bus 1 TxD
Serial Bus 2 TxD	Serial Bus 1 RxD	Serial Bus 2 RxD

(1) The Serial Bus 1 indicators must be sensed on the microprocessor/controller pins. Serial Bus 2 indicators must be sensed on the Port 4 (EIA-485) signal lines. The SIU Power LED must indicate that the +24 VDC power supply is within regulation. The SIU Active LED must be controlled via SIU I/O 55.

d. Push Buttons. The SIU front panel must provide a RESET pushbutton that must provide a hardware RESET to the microprocessor/controller unit.

e. 9-position Subminiature D-type Connector. A 9-position subminiature D-type connector must be mounted on the front panel for Port 3 entry. The connector pin assignment is Pin 2- RxD, Pin 3- TxD and Pin 5- Signal Ground.

f. SIU Input Connector. The SIU Input Connection pin assignments must be as shown in drawing 4-11-8.

19. SIU Input and Output Assignments.

SIU	Set Output Command Type 55	Raw Input Data Response Type 180
I/O 0	BYTE 2 BIT 0	BYTE 2 BIT 0
I/O 1	BYTE 2 BIT 1	BYTE 2 BIT 1
I/O 2	BYTE 2 BIT 2	BYTE 2 BIT 2
I/O 3	BYTE 2 BIT 3	BYTE 2 BIT 3
I/O 4	BYTE 2 BIT 3	BYTE 2 BIT 4
I/O 5	BYTE 2 BIT 5	BYTE 2 BIT 5
I/O 6	BYTE 2 BIT 6	BYTE 2 BIT 6
I/O 7	BYTE 2 BIT 7	BYTE 2 BIT 7
I/O 8	BYTE 3 BIT 0	BYTE 3 BIT 0
I/O 9	BYTE 3 BIT 1	BYTE 3 BIT 1
I/O 10	BYTE 3 BIT 2	BYTE 3 BIT 2
I/O 11	BYTE 3 BIT 3	BYTE 3 BIT 3
I/O 12	BYTE 3 BIT 4	BYTE 3 BIT 4
I/O 13	BYTE 3 BIT 5	BYTE 3 BIT 5
I/O 14	BYTE 3 BIT 6	BYTE 3 BIT 6
I/O 15	BYTE 3 BIT 7	BYTE 3 BIT 7

SIU	Set Output Command Type 55	Raw Input Data Response Type 180
I/O 16	BYTE 4 BIT 0	BYTE 4 BIT0
I/O 17	BYTE 4 BIT 1	BYTE 4 BIT1
I/O 18	BYTE 4 BIT 2	BYTE 4 BIT2
I/O 19	BYTE 4 BIT 3	BYTE 4 BIT3
I/O 20	BYTE 4 BIT 4	BYTE 4 BIT4
I/O 21	BYTE 4 BIT 5	BYTE 4 BIT5
I/O 22	BYTE 4 BIT 6	BYTE 4 BIT6
I/O 23	BYTE 4 BIT 7	BYTE 4 BIT7
I/O 24	BYTE 5 BIT0	BYTE 5 BIT 0
I/O 25	BYTE 5 BIT1	BYTE 5 BIT 1
I/O 26	BYTE 5 BIT2	BYTE 5 BIT 2
I/O 27	BYTE 5 BIT3	BYTE 5 BIT 3
I/O 28	BYTE 5 BIT4	BYTE 5 BIT 4
I/O 29	BYTE 5 BIT5	BYTE 5 BIT 5
I/O 30	BYTE 5 BIT6	BYTE 5 BIT 6
I/O 31	BYTE 5 BIT7	BYTE 5 BIT 7
I/O 32	BYTE 6 BIT0	BYTE 6 BIT 0
I/O 33	BYTE 6 BIT1	BYTE 6 BIT 1
I/O 34	BYTE 6 BIT2	BYTE 6 BIT 2
I/O 35	BYTE 6 BIT3	BYTE 6 BIT 3
I/O 36	BYTE 6 BIT4	BYTE 6 BIT 4
I/O 37	BYTE 6 BIT5	BYTE 6 BIT 5
I/O 38	BYTE 6 BIT6	BYTE 6 BIT 6
I/O 39	BYTE 6 BIT7	BYTE 6 BIT 7
I/O 40	BYTE 6 BIT0	BYTE 6 BIT 0
I/O 41	BYTE 7 BIT1	BYTE 7 BIT 1
I/O 42	BYTE 7 BIT2	BYTE 7 BIT 2
I/O 43	BYTE 7 BIT3	BYTE 7 BIT 3
I/O 44	BYTE 7 BIT4	BYTE 7 BIT 4
I/O 45	BYTE 7 BIT5	BYTE 7 BIT 5
I/O 46	BYTE 7 BIT6	BYTE 7 BIT 6
I/O 47	BYTE 7 BIT7	BYTE 7 BIT 7
I/O 48	BYTE 8 BIT0	BYTE 8 BIT 0
I/O 49	BYTE 8 BIT1	BYTE 8 BIT 1

SIU	Set Output Command Type 55	Raw Input Data Response Type 180
I/O 50	BYTE 8 BIT2	BYTE 8 BIT 2
I/O 51	BYTE 8 BIT3	BYTE 8 BIT 3
I/O 52	BYTE 8 BIT4	BYTE 8 BIT 4
I/O 53	BYTE 8 BIT5	BYTE 8 BIT 5
Active LED (O54)	BYTE 8 BIT6	
Opto Input 1 (I56)		BYTE 9 BIT 0
Opto Input 2 (I57)		BYTE 9 BIT 1
Opto Input 3 (I58)		BYTE 9 BIT 2
Opto Input 4 (I59)		BYTE 9 BIT 3
A000		BYTE 9 BIT 4
A001		BYTE 9 BIT 5
A002		BYTE 9 BIT 6
A003		BYTE 9 BIT 7

A000 to A003 must be the address of the SIU.

20. Block Diagrams.

a. SIU Structure. Each SIU must contain 54 Input/Outputs and each must be connected as follows:

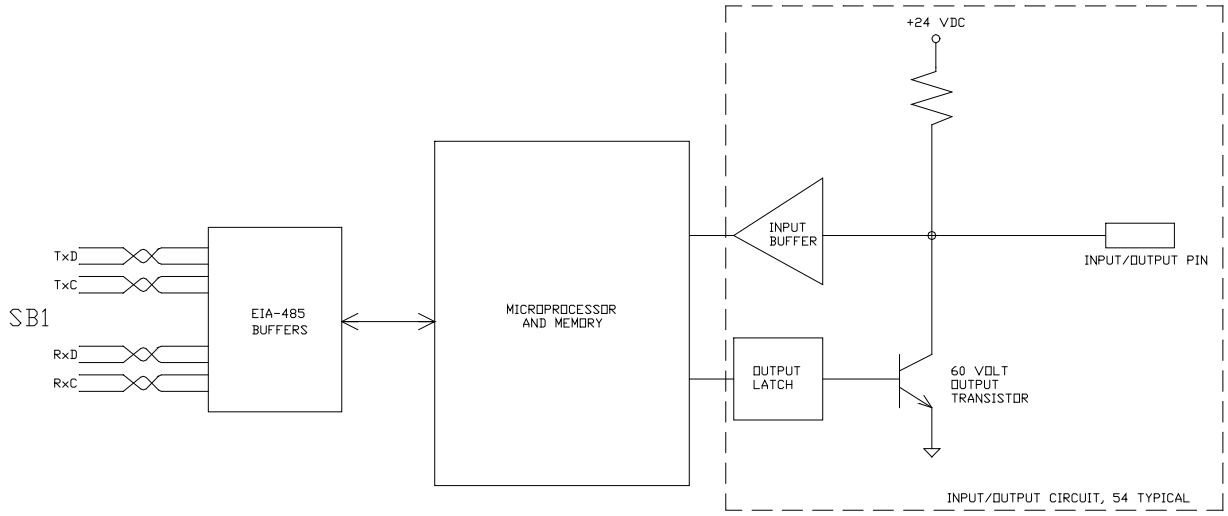


Figure 3
SIU Input/Output Connections.

b. When the SIU is powered, all outputs must be initialized OFF and fifty-four inputs must be available. Without jumpers or firmware changes, the Controller software must be able to turn ON any of the fifty-four outputs. Each output must be able to be read back as an input in order to check integrity.

c. Existing CALTRANS-style Detectors.

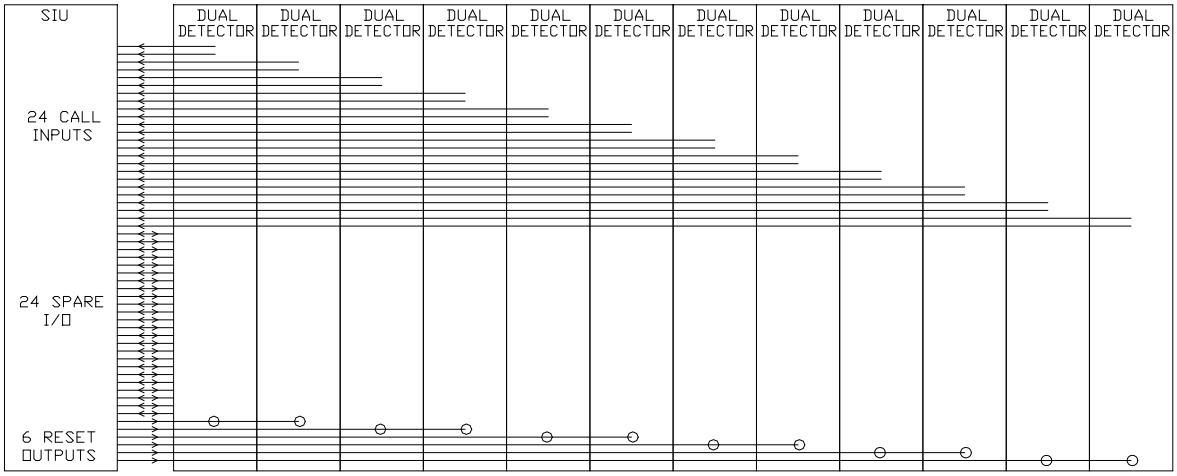


Figure 4
Legacy CALTRANS-style Detector Inputs/Outputs.

d. In Figure 5, twelve legacy CALTRANS-style detectors may be installed in the Input Assembly. The twenty-four CALLS must be read by twenty-four SIU inputs, while detectors must be able to be reset by six SIU outputs, two detectors at a time.

e. Existing NEMA-style Detectors.

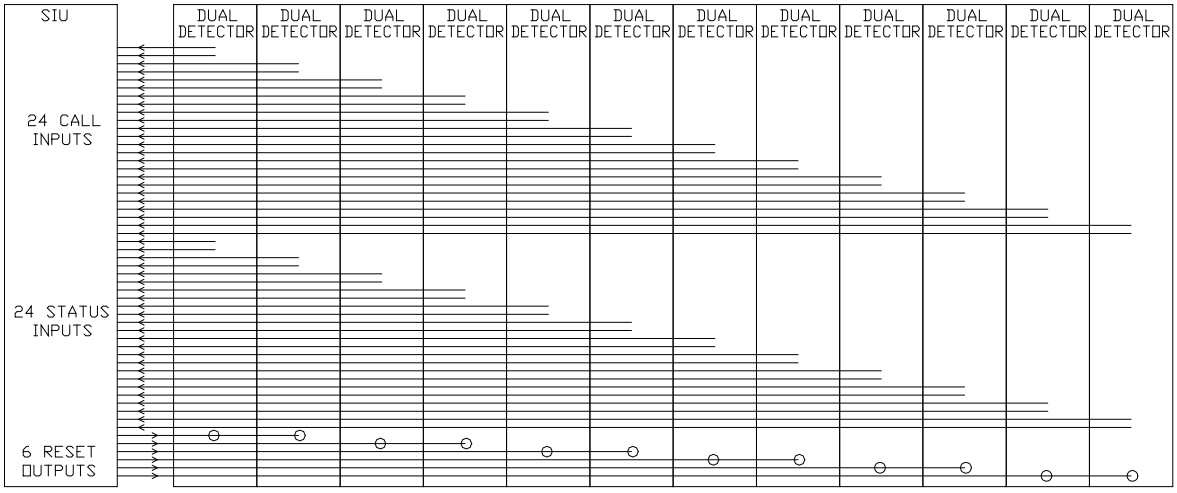


Figure 5
Legacy NEMA-style Detector Inputs/Outputs.

f. In Figure 6, twelve legacy NEMA detectors may be installed in the Input Assembly. The twenty-four CALLS must be read by twenty-four SIU inputs, while the twenty-four STATUS must be read by another twenty-four SIU inputs. The detectors must be able to be reset by six SIU outputs, two detectors at a time, same as NEMA.

g. Existing Detectors with Serial Ports.

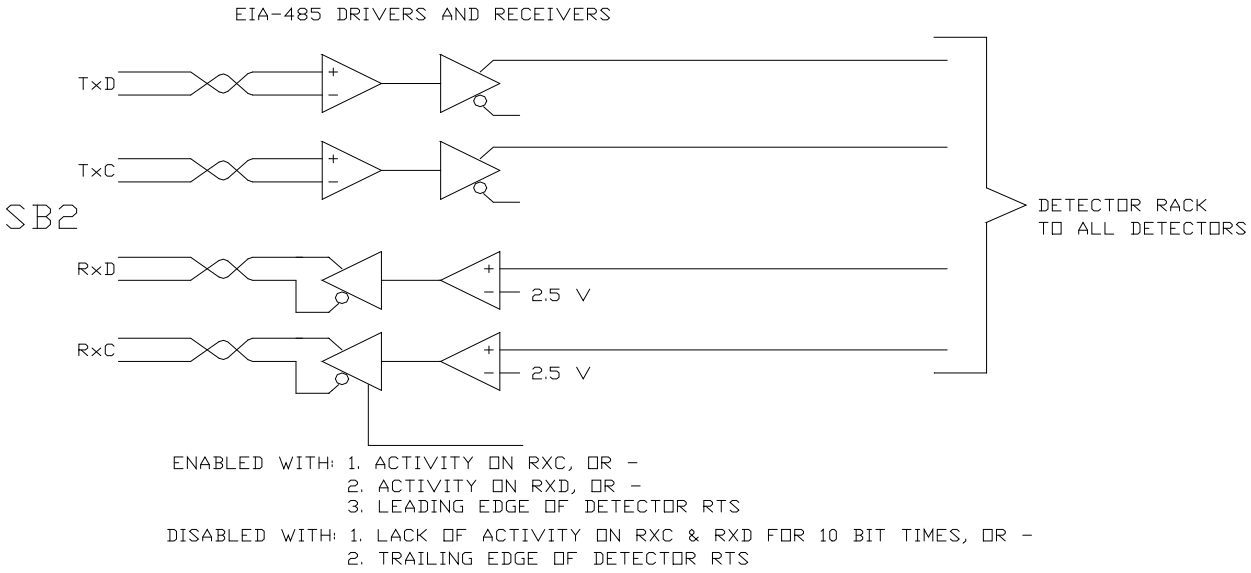


Figure 6
Legacy Detectors with Serial Ports Input/Output Connections

h. Circuitry shown in Figure 7 must be included in each SIU, providing a direct serial connection from the controller to each individual serial detector. This serial connection must be in addition to all of the NEMA CALL and STATUS lines shown in Figure 6.

i. Future Advanced Detectors.

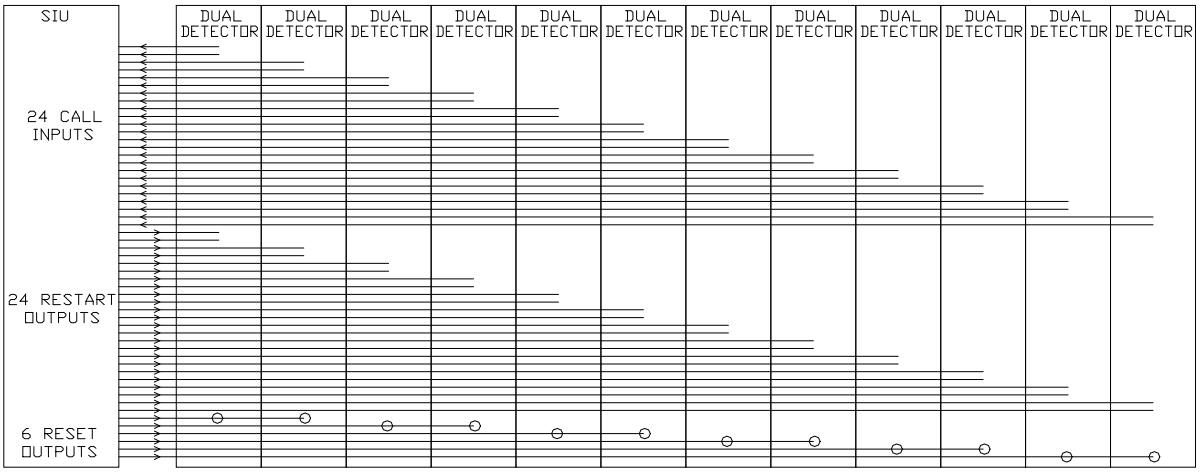


Figure 7
Future Advanced Detector Inputs/Outputs.

j. Status information must be retrieved from each detector via Serial Bus 2 as described in Figure 7, eliminating the need for the NEMA STATUS inputs. The NEMA STATUS inputs must become individual RESTART outputs from the SIU. The RESET and RESTART outputs differ as follows. RESET must be connected directly to the microprocessor RESET pin of each detector, generating a "hard" reset, used as a last resort to recover stalled detectors. RESTART must be a "soft" signal to the detector to clear all tuning and programming for that individual detector channel, without affecting others.

k. Switch Packs.

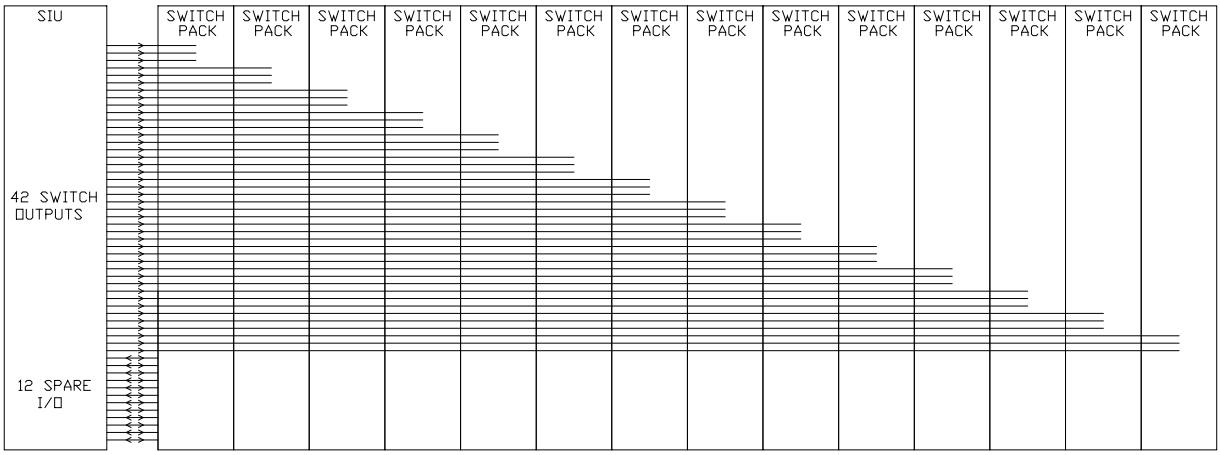


Figure 8
Switch Pack Outputs.

l. Figure 8, 42 SIU outputs must be used to control fourteen Switch Packs, with enough outputs remaining to control four more. Each output must be able to be read back by the controller.

H. Cabinet Details.

Table of Contents

Model 200 Switchpack & 204 Flasher Units	Figure 9
Model 212 Cabinet Monitor Unit (CMU)	Figure 10
Model 214 Auxiliary Monitor (AMU)	Figure 11
Model 216 ITS Cabinet Power Supply Unit	Figure 12
Model 216 EP Cabinet External Power Supply	Figure 13
Model 218 Serial Interface Unit (SIU)	Figure 14
Transfer Relay Wiring and Outline Dimension	Figure 15
Detector Sensor Units and Isolators	Figure 16

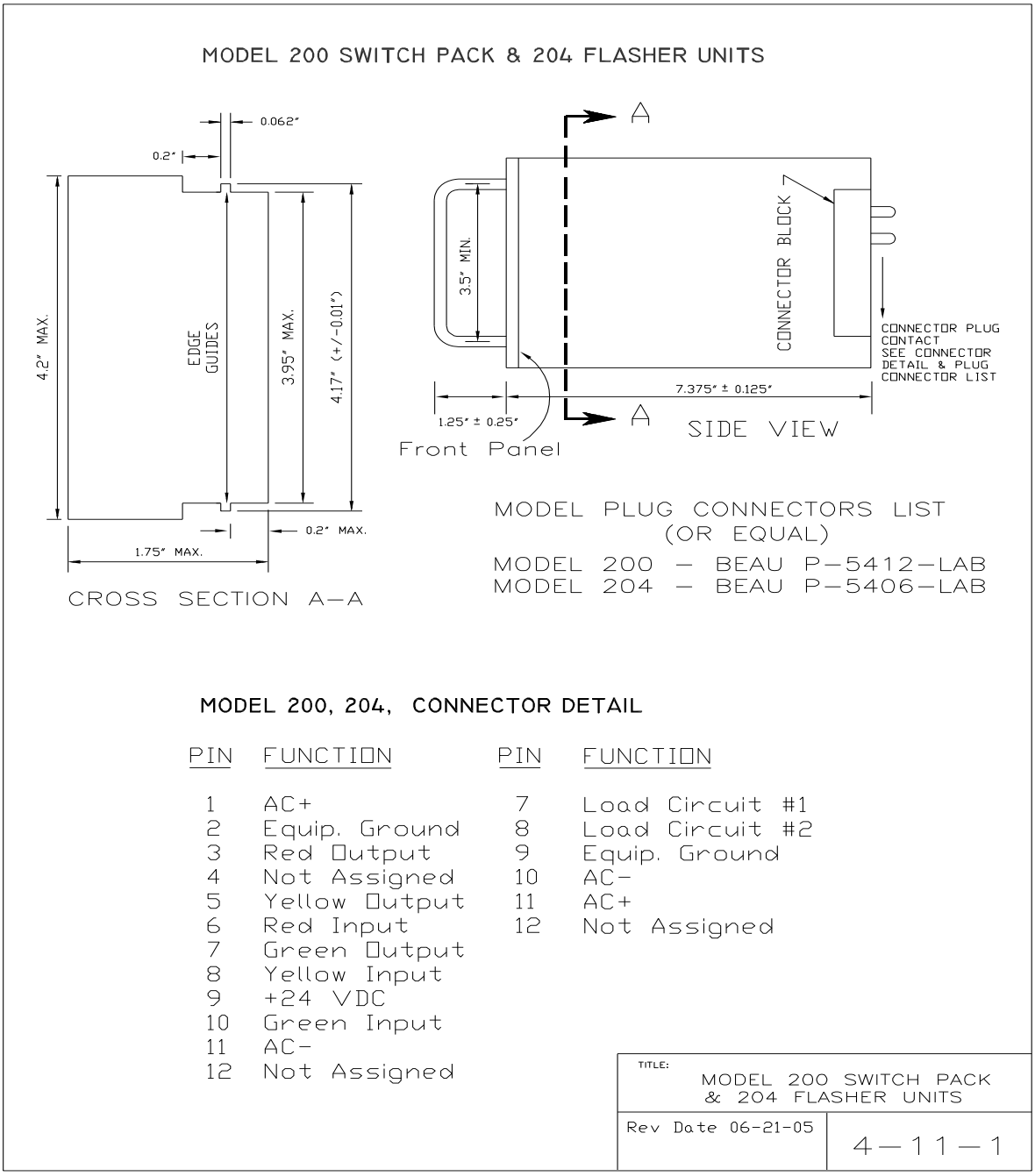
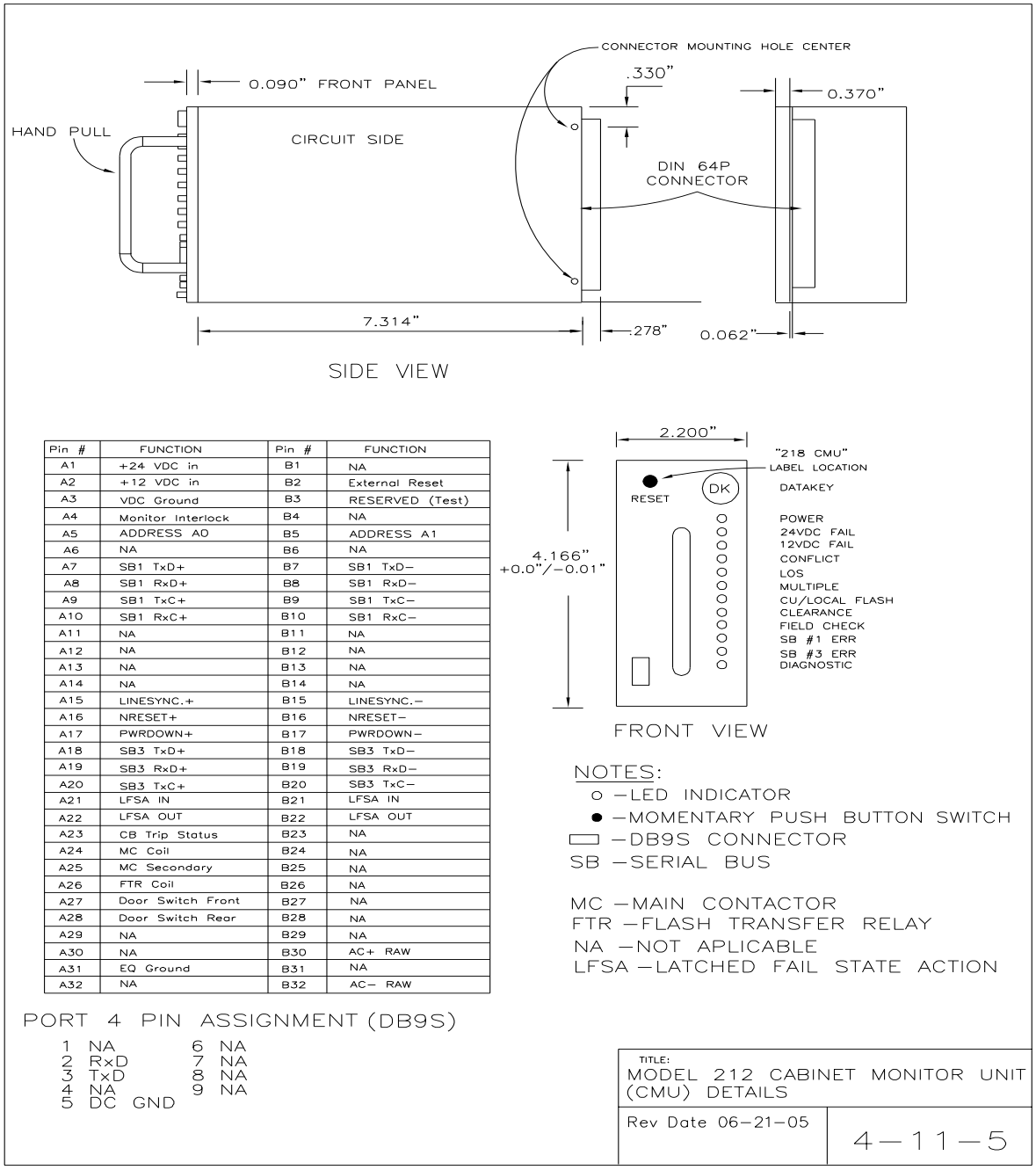


Figure 9
Model 200 Switchpack & 204 Flasher Units



Pin #	FUNCTION	Pin #	FUNCTION
A1	+24 VDC in	B1	NA
A2	+12 VDC in	B2	External Reset
A3	VDC Ground	B3	RESERVED (Test)
A4	Monitor Interlock	B4	NA
A5	ADDRESS A0	B5	ADDRESS A1
A6	NA	B6	NA
A7	SB1 TxD+	B7	SB1 TxD−
A8	SB1 RxD+	B8	SB1 RxD−
A9	SB1 TxC+	B9	SB1 TxC−
A10	SB1 RxC+	B10	SB1 RxC−
A11	NA	B11	NA
A12	NA	B12	NA
A13	NA	B13	NA
A14	NA	B14	NA
A15	LINESYNC.+	B15	LINESYNC.−
A16	NRESET+	B16	NRESET−
A17	PWRDOWN+	B17	PWRDOWN−
A18	SB3 TxD+	B18	SB3 TxD−
A19	SB3 RxD+	B19	SB3 RxD−
A20	SB3 TxC+	B20	SB3 TxC−
A21	LFSA IN	B21	LFSA IN
A22	LFSA OUT	B22	LFSA OUT
A23	CB Trip Status	B23	NA
A24	MC Coil	B24	NA
A25	MC Secondary	B25	NA
A26	FTR Coil	B26	NA
A27	Door Switch Front	B27	NA
A28	Door Switch Rear	B28	NA
A29	NA	B29	NA
A30	NA	B30	AC+ RAW
A31	EQ Ground	B31	NA
A32	NA	B32	AC− RAW

NOTES:
- o −LED INDICATOR
- ● −MOMENTARY PUSH BUTTON SWITCH
- ▭ −DB9S CONNECTOR
- SB −SERIAL BUS

MC −MAIN CONTACTOR
FTR −FLASH TRANSFER RELAY
NA −NOT APLICABLE
LFSA −LATCHED FAIL STATE ACTION

PORT 4 PIN ASSIGNMENT (DB9S)

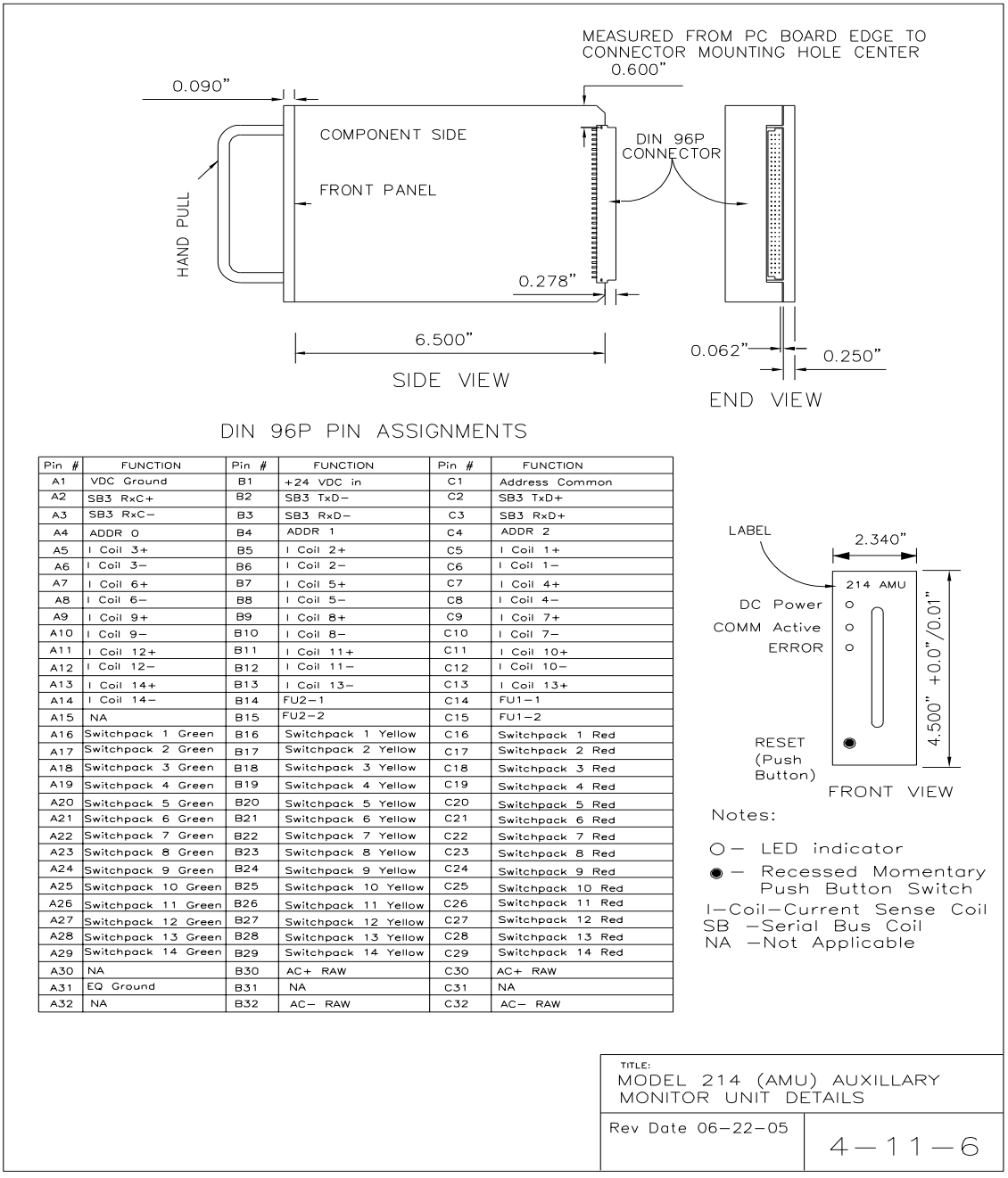
1 NA	6 NA
2 RxD	7 NA
3 TxD	8 NA
4 NA	9 NA
5 DC GND	

TITLE: MODEL 212 CABINET MONITOR UNIT (CMU) DETAILS

Rev Date 06−21−05

4−11−5

Figure 10
Model 212 Cabinet Monitor Unit (CMU)



DIN 96P PIN ASSIGNMENTS

Pin #	FUNCTION	Pin #	FUNCTION	Pin #	FUNCTION
A1	VDC Ground	B1	+24 VDC in	C1	Address Common
A2	SB3 RxC+	B2	SB3 TxD−	C2	SB3 TxD+
A3	SB3 RxC−	B3	SB3 RxD−	C3	SB3 RxD+
A4	ADDR 0	B4	ADDR 1	C4	ADDR 2
A5	I Coil 3+	B5	I Coil 2+	C5	I Coil 1+
A6	I Coil 3−	B6	I Coil 2−	C6	I Coil 1−
A7	I Coil 6+	B7	I Coil 5+	C7	I Coil 4+
A8	I Coil 6−	B8	I Coil 5−	C8	I Coil 4−
A9	I Coil 9+	B9	I Coil 8+	C9	I Coil 7+
A10	I Coil 9−	B10	I Coil 8−	C10	I Coil 7−
A11	I Coil 12+	B11	I Coil 11+	C11	I Coil 10+
A12	I Coil 12−	B12	I Coil 11−	C12	I Coil 10−
A13	I Coil 14+	B13	I Coil 13−	C13	I Coil 13+
A14	I Coil 14−	B14	FU2−1	C14	FU1−1
A15	NA	B15	FU2−2	C15	FU1−2
A16	Switchpack 1 Green	B16	Switchpack 1 Yellow	C16	Switchpack 1 Red
A17	Switchpack 2 Green	B17	Switchpack 2 Yellow	C17	Switchpack 2 Red
A18	Switchpack 3 Green	B18	Switchpack 3 Yellow	C18	Switchpack 3 Red
A19	Switchpack 4 Green	B19	Switchpack 4 Yellow	C19	Switchpack 4 Red
A20	Switchpack 5 Green	B20	Switchpack 5 Yellow	C20	Switchpack 5 Red
A21	Switchpack 6 Green	B21	Switchpack 6 Yellow	C21	Switchpack 6 Red
A22	Switchpack 7 Green	B22	Switchpack 7 Yellow	C22	Switchpack 7 Red
A23	Switchpack 8 Green	B23	Switchpack 8 Yellow	C23	Switchpack 8 Red
A24	Switchpack 9 Green	B24	Switchpack 9 Yellow	C24	Switchpack 9 Red
A25	Switchpack 10 Green	B25	Switchpack 10 Yellow	C25	Switchpack 10 Red
A26	Switchpack 11 Green	B26	Switchpack 11 Yellow	C26	Switchpack 11 Red
A27	Switchpack 12 Green	B27	Switchpack 12 Yellow	C27	Switchpack 12 Red
A28	Switchpack 13 Green	B28	Switchpack 13 Yellow	C28	Switchpack 13 Red
A29	Switchpack 14 Green	B29	Switchpack 14 Yellow	C29	Switchpack 14 Red
A30	NA	B30	AC+ RAW	C30	AC+ RAW
A31	EQ Ground	B31	NA	C31	NA
A32	NA	B32	AC− RAW	C32	AC− RAW

Notes:

○ − LED indicator

◉ − Recessed Momentary Push Button Switch

I−Coil−Current Sense Coil
SB −Serial Bus Coil
NA −Not Applicable

TITLE:
MODEL 214 (AMU) AUXILLARY MONITOR UNIT DETAILS

Rev Date 06−22−05

4−11−6

Figure 11
Model 214 Auxiliary Monitor (AMU)

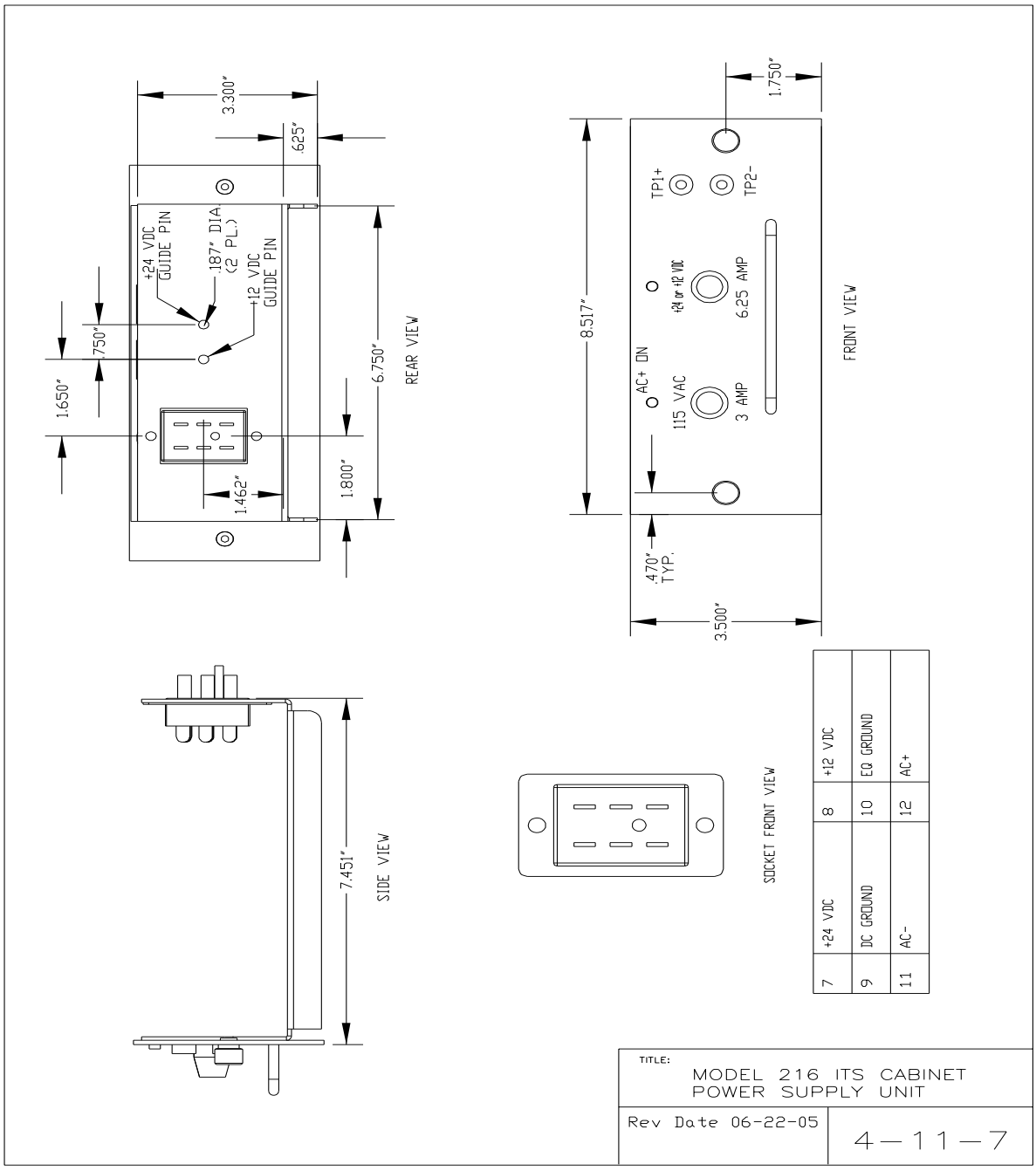


Figure 12
Model 216 ITS Cabinet Power Supply Unit

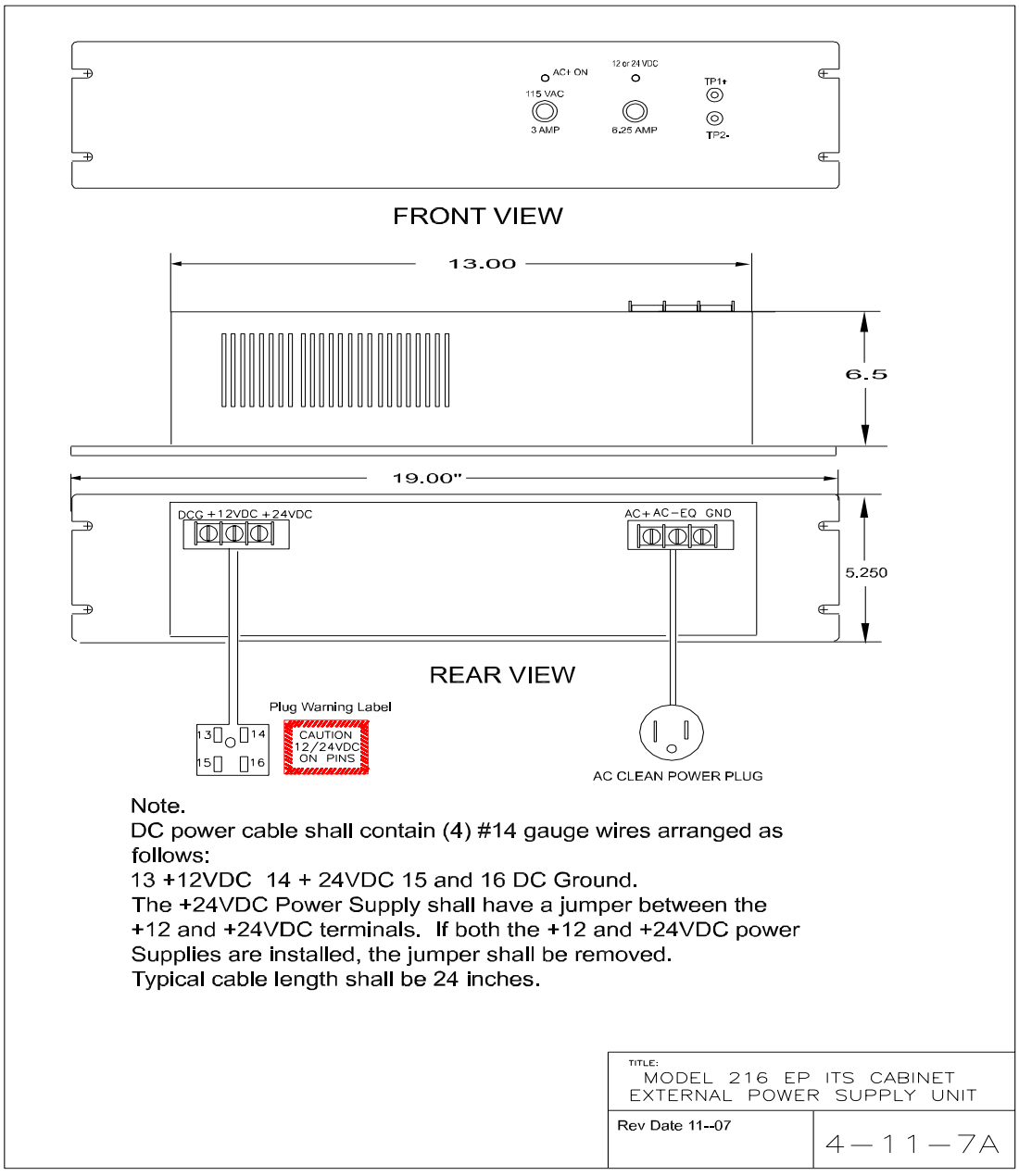
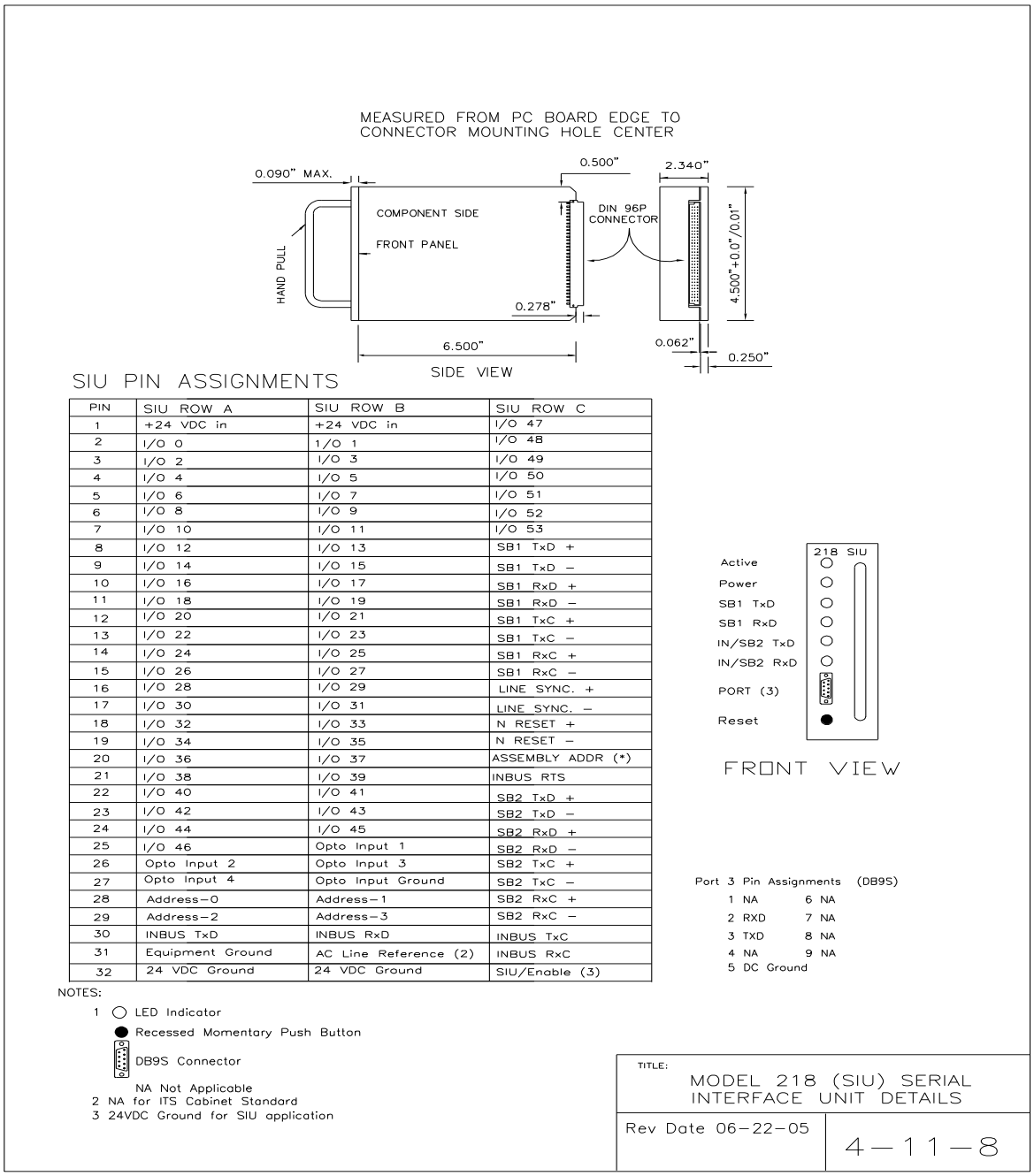


Figure 13
Model 216 EP Cabinet External Power Supply



SIU PIN ASSIGNMENTS

PIN	SIU ROW A	SIU ROW B	SIU ROW C
1	+24 VDC in	+24 VDC in	I/O 47
2	I/O 0	I/O 1	I/O 48
3	I/O 2	I/O 3	I/O 49
4	I/O 4	I/O 5	I/O 50
5	I/O 6	I/O 7	I/O 51
6	I/O 8	I/O 9	I/O 52
7	I/O 10	I/O 11	I/O 53
8	I/O 12	I/O 13	SB1 TxD +
9	I/O 14	I/O 15	SB1 TxD −
10	I/O 16	I/O 17	SB1 RxD +
11	I/O 18	I/O 19	SB1 RxD −
12	I/O 20	I/O 21	SB1 TxC +
13	I/O 22	I/O 23	SB1 TxC −
14	I/O 24	I/O 25	SB1 RxC +
15	I/O 26	I/O 27	SB1 RxC −
16	I/O 28	I/O 29	LINE SYNC. +
17	I/O 30	I/O 31	LINE SYNC. −
18	I/O 32	I/O 33	N RESET +
19	I/O 34	I/O 35	N RESET −
20	I/O 36	I/O 37	ASSEMBLY ADDR (*)
21	I/O 38	I/O 39	INBUS RTS
22	I/O 40	I/O 41	SB2 TxD +
23	I/O 42	I/O 43	SB2 TxD −
24	I/O 44	I/O 45	SB2 RxD +
25	I/O 46	Opto Input 1	SB2 RxD −
26	Opto Input 2	Opto Input 3	SB2 TxC +
27	Opto Input 4	Opto Input Ground	SB2 TxC −
28	Address−0	Address−1	SB2 RxC +
29	Address−2	Address−3	SB2 RxC −
30	INBUS TxD	INBUS RxD	INBUS TxC
31	Equipment Ground	AC Line Reference (2)	INBUS RxC
32	24 VDC Ground	24 VDC Ground	SIU/Enable (3)

FRONT VIEW

Port 3 Pin Assignments (DB9S)

1	NA	6	NA
2	RXD	7	NA
3	TXD	8	NA
4	NA	9	NA
5	DC Ground		

NOTES:
1 ○ LED Indicator
● Recessed Momentary Push Button
DB9S Connector
NA Not Applicable
2 NA for ITS Cabinet Standard
3 24VDC Ground for SIU application

TITLE:
MODEL 218 (SIU) SERIAL INTERFACE UNIT DETAILS

Rev Date 06−22−05

4−11−8

Figure 14
Model 218 Serial Interface Unit (SIU)

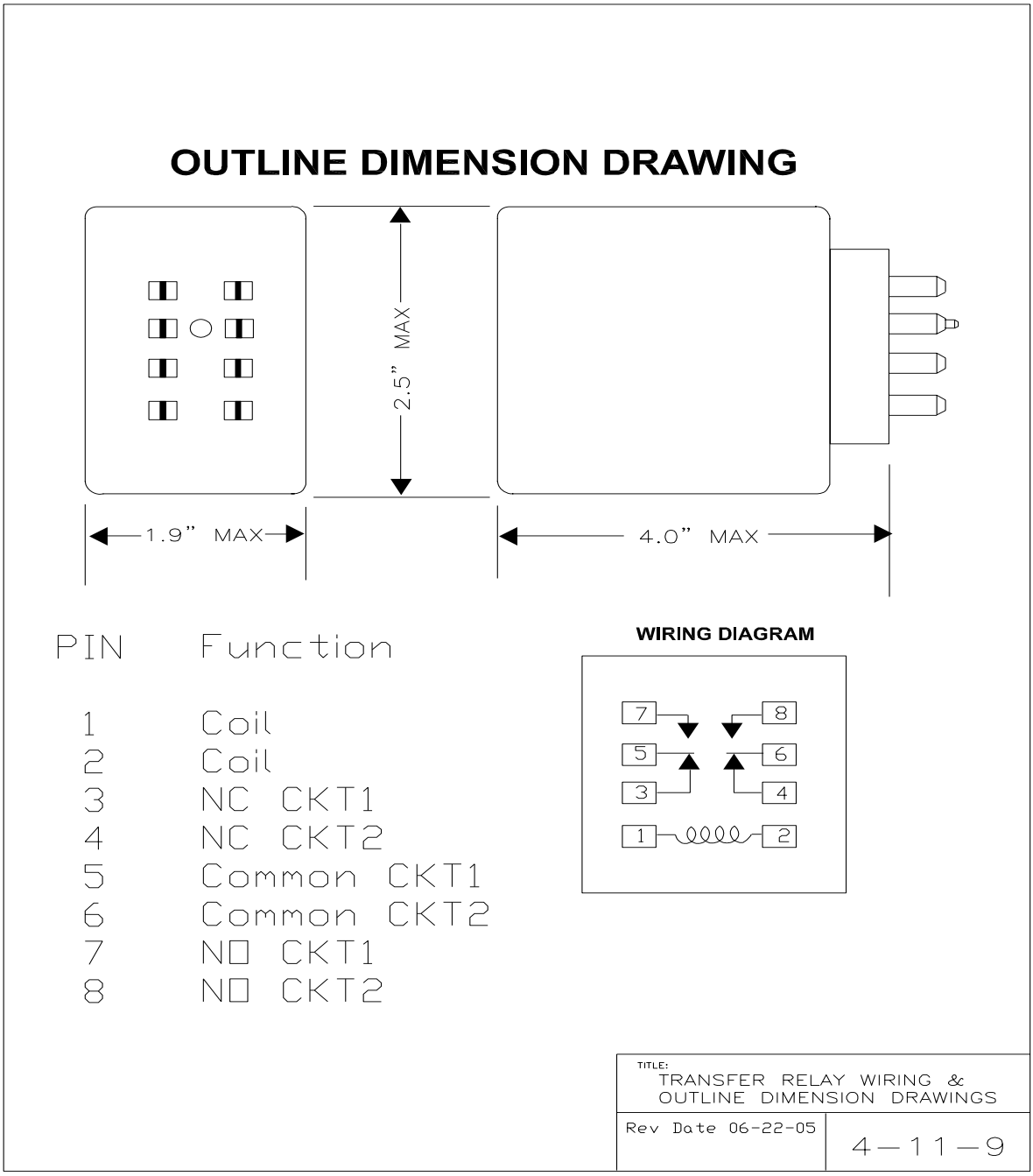


Figure 15
Transfer Relay Wiring and Outline Dimension

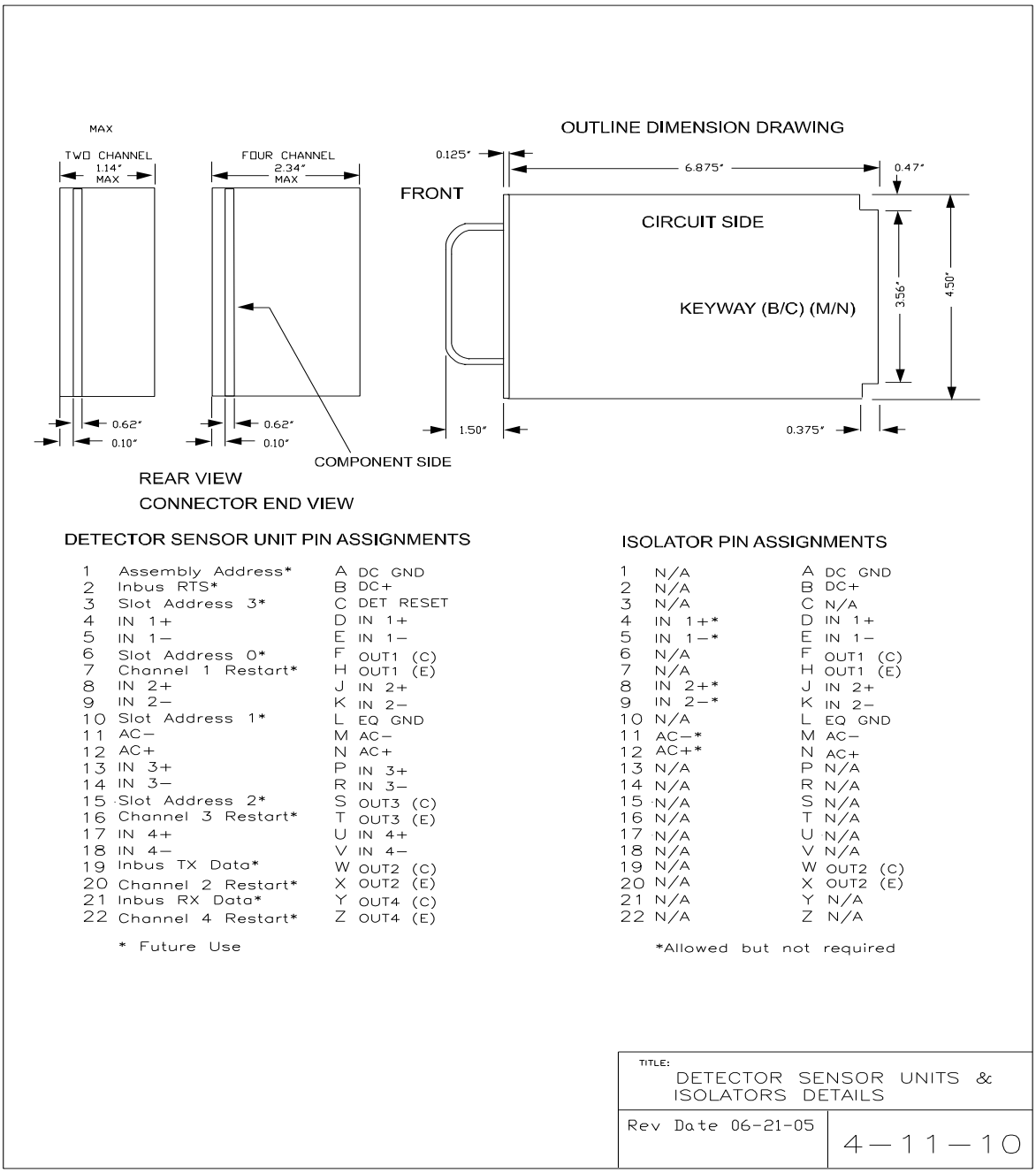


Figure 16
Detector Sensor Units and Isolators

2.11 DETECTOR SENSOR UNITS, ELEMENTS AND ISOLATORS

A. General Requirements.

1. The sensor and isolator channels must be operationally independent from each other.

2. Each sensor unit or AC isolator channel must draw no more than 100 milliamperes from the +24 VDC cabinet power supply and must be insensitive to 700 millivolts RMS ripple on the incoming +24 VDC line.

3. The sensor unit or isolator front panel must be provided with a hand pull to facilitate insertion and removal from the Input Assembly.

4. All control switches, gain dials and channel indicators must be mounted on the front panel. Each sensor unit or isolator channel must have an indicator to provide visual indication of detector or incoming signal.

5. Each sensor unit or isolator channel output must be an opto-isolated NPN Open Collector capable of sinking 50 milliamperes at 30 VDC. The output must be compatible with the controller unit inputs.

6. A valid channel input must cause a channel Ground True Output to the controller unit of a minimum 100 milliseconds in duration. An onboard physical switching mechanism must be provided to disable this feature when the mechanism is in an OPEN position. Said switching mechanism must eliminate the minimum timing requirement.

7. The output transistor must switch from OFF to ON state or ON to OFF state in 20 microseconds or less.

8. Onboard protection must be provided to enable the sensor unit or isolator to comply with ANSI/IEEE C62.41 (100 Kilohertz Ring Wave and the EFT Burst) at voltages and currents specified at “Location Category A1” (i.e. up to 2.0 Kilovolts, 0.07 Kiloampheres for the 100 Kilohertz Ring Wave) and at “Test Severity” level I (i.e. up to 1.0 Kilovolts, open-circuit) for the EFT Burst.

9. Detector Sensor Units and Isolators must have a front panel mounted test switch for each channel to simulate valid input. The test switch must be a single-pole double-throw, three position CONTROL test switch: The position assignment must be UP = Constant ON; MIDDLE = Normal Operation; and DOWN = Momentary ON.

B. Model 222 & 224 Loop Detector Sensor Unit.

1. General Requirements.

a. The sensor unit channel must produce an output signal when a vehicle passes over or remains over loop wires embedded in the roadway. The method of detection must be based upon a design that renders the output signal when a metallic mass (vehicle) enters the detection zone causing a change of 0.02% minimum decrease in inductance of the circuit measured at the input terminals of the sensor unit.

b. An open loop must cause the sensor unit channel to output a signal indicating a non-detect situation.

c. Each sensor unit channel must be capable of detecting all types of licensed motor vehicles when connected to the loop configuration/lead-in requirements.

d. The sensor unit must comply with all performance requirements when connected to an inductance (loop plus lead-in) from 50 to 700 micro Henries with a Q-parameter as low as 5 at the sensor unit operating frequency.

e. Loop inputs to each channel must be transformer isolated.

f. Each individual channel must have a minimum of 4 switch selectable operating frequencies.

g. The sensor unit channel tuning circuits must be automatic and must be so designed that drift caused by environmental changes or changes in applied power must not cause an actuation.

h. A switch or switch position must be provided on the front panel to disable each channel output.

2. Mode Selection Requirements. Each sensor unit channel must have PULSE and PRESENCE selectable modes.

a. Pulse Mode.

(1) In the PULSE MODE, each new vehicle presence within the detection zone must initiate a sensor unit channel output pulse of 125 milliseconds (+/-25 milliseconds) in duration.

(2) Should a vehicle remain in a portion of the detection zone for a period in excess of 2 seconds, the sensor unit channel must automatically “tune out” the presence of said vehicle. The sensor unit channel must then be capable of detecting another vehicle entering the same detection zone. The recovery time to full sensitivity between the first vehicle pulse and channel capability to detect another vehicle must be 3 seconds maximum.

b. Presence Mode.

(1) In the PRESENCE MODE, the sensor unit channel must recover to normal sensitivity within 1 second after termination of vehicle presence in the detection zone regardless of the duration of the presence.

(2) The channel sensitivity settings must provide presence detection of a vehicle in the detection zone for a specified time period and inductance change(s). The conditions are as follows:

	MINIMUM TIME DURATION IN MINUTES	DETECTOR INPUT INDUCTANCE CHANGE
SETTING 6	3	0.02% or more
	10	0.06% or more
SETTING 2	4	1.00% or more

3. Sensitivity.

a. This section and included subsections contain example inductive loop detector configurations with which Loop Detector Sensor Units must properly function. Reference is made to California Standard Plan ES-5A & B Loop Configurations described in the California Department of Transportation Standard Plans. The configurations described herein are meant to be representative examples of inductive loop detector configurations.

(1) Single Type A, B, Q or Round Loop with a 250 foot lead-in cable.

(2) Single Type A, B, Q or Round Loop with a 1000 foot lead-in cable.

(3) 4 Type A, B, or Q Loops connected in series/parallel with a 250 foot lead-in cable.

(4) 4 Type A, B, Q or Round Loops connected in series with a 1000 foot lead-in cable.

(5) One 50 foot Type C Loop with a 250 foot lead-in cable.

b. Each sensor unit channel must be equipped with 7 selectable sensitivity setting(s) in presence and pulse modes to accomplish the following under operational and environmental requirements of this specification:

(1) Each sensor unit channel must respond while in Setting 2 to a nominal change in inductance between 0.15% to 0.4% (median sensitivity of 0.32%) while connected to the loop configurations described in this specification.

(2) Each sensor unit channel must respond while in Setting 6 to an inductance of 0.02% while connected to the loop configurations described in this specification.

(3) All sensitivity settings must not differ +/-40% from the nominal value chosen.

(4) Each sensor unit channel must not detect vehicles, moving or stopped, at distances of 3 feet or more from any loop perimeter, in all configurations listed in this specification.

4. Response Time. Response time of the sensor unit channel for Sensitivity Setting 2 must be less than 5 +/-1 millisecond at an approximate loop frequency of 40 Kilohertz. That is, for any decreased inductive change that exceeds its sensitivity threshold, the channel must output a ground true logic level within 5 millisecond (+/-1 millisecond). When such change is removed, the output must become an open circuit within 5 millisecond (+/-1 millisecond).

5. Beginning of Normal Operation. The sensor unit channels must begin normal operation within 2 seconds after the application of power or after a reset signal of 30 microseconds.

6. Tracking Rate. The sensor unit must be capable of compensating or tracking for an environmental change up to 0.001% change in inductance per second.

7. Tracking Range.

   a. The sensor unit must be capable of normal operation as the input inductance is changed from +/-5.0% from the quiescent tuning point regardless of internal circuit drift.

   b. The sensor unit must be capable of normal operation as the input resistance is changed from +/-0.5% from the quiescent tuning point regardless of internal circuit drift.

8. Temperature Change. The operation of the sensor unit must not be affected by changes in the inductance and/or capacitance of the loop caused by environmental changes, with the rate of temperature change not exceeding 1 degree C per 3 minutes. The opening or closing of the controller cabinet door with a temperature differential of up to 18 degrees C between the inside and outside air must not affect the proper operation of the sensor unit.

C. Magnetic Detector Requirements.

1. The Model 232 Two-Channel Magnetic Detector Sensor Unit must provide 2 channels of detection. When resident in an energized cabinet Input Assembly, and each channel connected to its associated Model 231 Magnetic Detector Sensing Element(s), the channel must produce a continuous output signal to the controller unit when a voltage is induced in the sensing element by a vehicle passing over the sensing element.

2. Each channel must detect vehicles passing within 6 feet of the Model 231 Sensing Element with 1000 feet of lead-in cable, at all speeds between 3 and 80 miles per hour.

3. A single control knob for adjusting the sensitivity of each channel must be mounted on the front panel and must be readily adjustable without the use of tools.

4. A momentary switch or switch position must be provided to place a call on each channel, on an individual basis.

D. Model 242 Two-Channel DC Isolator.

1. General Requirements.

a. The Model 242 Two-Channel DC Isolator must contain 2 isolation channels which provide isolation between electrical contacts external to the module and the controller unit input. The method of isolation must be based upon a design which must provide reliable operation.

b. The isolator must have an internal power supply supplying 20 VDC (+/-4 VDC) to the field input side of the isolation channels. The isolator must not draw more than 2.5 Watts of AC power. No current must be drawn from the cabinet power supply.

c. A channel contact closure input of 5 milliseconds or less must not cause an output (ground true) to the controller. An input of 25 milliseconds or greater must cause an output to the controller. An input of duration between 5 and 25 milliseconds may or may not cause an output to the controller. The channel circuitry must be able to react to a new input closure within 25 milliseconds of an input opening.

d. Each isolation channel field input must be turned ON (TRUE) when a contact closure causes an input voltage of less than 8 VDC, and must be turned OFF (FALSE) when the contact opening causes the input voltage to exceed 12 VDC. Each input must deliver no less than 15 milliamperes, nor more than 40 milliamperes, to an electrical contact closure or short from the power supply.

E. Model 252 Two-Channel AC Isolator.

1. General Requirements.

a. The Model 252 Two-Channel AC Isolator must contain 2 isolation channels which provide isolation between external 120 VAC input circuits and the controller unit input circuits. The method of isolation must be based upon a design that provides reliable operation.

b. A channel input voltage "Von" of 80 VAC (+/-5 VAC) applied for a minimum duration of 120 milliseconds (+/-10 milliseconds) must cause an output (Ground True) to the controller unit.

c. A channel input voltage "Voff" (Von minus 10 VAC) applied for a minimum duration of 120 milliseconds (+/-10 milliseconds) must cause an output (Ground False) to the controller unit.

d. A two-post jumper must be provided to select inverted output states for Von and Voff. When in CLOSED position (Grounded), Von must cause a Ground False output. An indicator must be provided on the front panel labeled 'RR" which must indicate a Voff input, Ground True output.

e. The input impedance of each channel must be between 6,000 - 15,000 Ohms at 60 Hertz.

f. The minimum isolation must be 1000 Megohms between the input and output terminals at 500 AC applied voltage.

2.12 CABINET SYSTEM REQUIREMENTS

A. General.

1. The Intelligent Transportation System (ITS) Serial Interconnected Cabinet Family is a group of cabinets designed to fulfill a variety of applications. This chapter describes the functional and physical requirements of said cabinets.

2. There are common parts to all cabinets, such as Modular Bus and Power Assemblies, ATC Controller Unit, Power Distribution Assembly (PDA ITS), Input and Output Assemblies and Service Assemblies.

3. The ATC Controller Unit is serially connected to the Cabinet via two serial synchronous ports located at the Field I/O C12 Connector or the CPU-1B C13 Connector (Serial Bus 1 only). These two communication links use EIA-485 Drivers/Receivers and Synchronous Data Link Control (SDLC) Protocol to interface with Serial Bus #1 and #2.

B. Cabinet Model Number and Consistency.

1. The ITS Cabinets must consist of a package of items needed to carry out a specific Application. Cabinet Versions provided here are EXAMPLES of possible cabinet configurations. A Product Implementation Conformance Statement is provided as an Annex to this standard:

a. Cabinet Traffic Signal Application - Series 340

340 - 4 Door Cabinet with “P” Base Ground Mount
342 - 2 Door Cabinet with “170” Base Ground Mount
346 - 2 Door Cabinet with ”170” Base, Adaptor Mount

b. Cabinet Traffic Management Application - Series 350

354 - 2 Door Cabinet with “170” Base Ground Mount
356 - 2 Door Cabinet with “170” Base Adaptor Mount

Table 2
Example Cabinet Configurations

	Package Items	340	342	346	Drawings
1	Housing #1 /Cage #1	-	1	-	6-5-4
2	Housing #2 /Cage #2	-	-	1	6-5-4
3	Housing #3 (2) Cage #1	1	-	-	6-5-4
4	"J" Panel Cage #1	4	2	-	6-5-8
5	"J" Panel Cage #2	-	-	2	6-5-9
6	Service Panel Assembly w/ AC/EG Bus	1	1	1	6-5-11
7	Raw/Clean AC Power Assembly 2 socket	1	1	1	6-5-15A
8	Raw/Clean AC Power Assembly 4 socket	-	-	-	6-5-15
9	Raw/Clean AC Power Extension	-	-	-	6-5-15
10	AC Clean Module Assembly	1	-	-	6-5-14
11	DC Power/ COMM Assembly	2	1	-	6-5-17
12	DC Power/ COMM Extension	-	-	-	6-5-17
13	Cabinet Shelf Assembly	-	-	-	6-5-10
14	Drawer Assembly	2	1	1	6-5-10
15	Input Assembly**	3	2	1	6-5-35/38
16	Service Assembly***	1	1	1	Figure 62,63
17	Six Pack Output Assembly**	1	1	-	6-5-23/28
18	Fourteen Pack Output Assembly**	1	1	1	6-5-23/28
19	PDA5 IP w 12 and 24V DC Power Supplies	-	-	-	6-5-19
20	PDA 5 EP with rack mount power supply	1	1	1	6-5-19A
21	Rack Mount 24V Power Supply	1	1	1	4-11-7A
22	Rack Mount 12V Power Supply	1	-	-	4-11-7A
23	Fiber Optic Termination Panel	1	1	1	6-5-42
24	Input Terminal Panel (Optional 342*)	-	*	-	6-5-13
25	Manual Advance Pushbutton Cable	1	1	1	6-5-32
26	Field Input Panel with Mounting Brackets	2	-	-	FIGURE 21A, 21I
27	Field Output Panel with Mounting Brackets	2	-	-	FIGURE 21E, 21I

**Field Wire Support Bracket required with each Assembly
***Service Assembly to be rack mounted below output file(s)

C. Special Equipment and Materials

1. Provide each major assembly with the following:

a. 14 Pack Output Assembly:

(14) Model 200 Switch Pack Units
(6) Model 205 Flash Transfer Relay Unit (FTRs) (these relays must be designed for continuous operation in the energized position)

(12) Red Flash Program Blocks
(4) White Flash Program Blocks
(1) Type 218 Serial Interface Unit
(1) Type 214 Auxiliary Monitor Unit
(1) Serial Bus 3 cable
(1) Control Serial Bus (SB1/SB2) Cable
(1) Address Block (Output Assembly)

b. 6 Pack Output Assembly:

(6) Model 200 Switch Pack Units
(3) Model 205 Flash Transfer Relay Unit (FTRs) (these relays must be designed for continuous operation in the energized position)
(6) Red Flash Program Blocks
(2) White Flash Program Blocks
(1) Type 218 Serial Interface Unit
(1) Type 214 Auxiliary Monitor Unit
(1) Serial Bus 3 cable
(1) Control Serial Bus (SB1/SB2) Cable
(1) Address Block (Output Assembly)

c. Input Assembly Number One (1):

(4) Type 222 – Loop Detector Sensors Unit
(2) Type 242 Two Channel DC Isolator Units
(2) Type 252 Two Channel AC Isolator Units
(1) Type 218 Serial Interface Unit
(1) Address Block (Input Assembly)
(1) Control Serial Bus (SB1/SB2) Cable

d. Input Assembly Number Two (2):

(4) Type 222 – Loop Detector Sensors Unit
(2) Type 242 Two Channel DC Isolator Units
(1) Type 218 Serial Interface Unit
(1) Address Block (Input Assembly)
(1) Control Serial Bus (SB1/SB2) Cable

e. Input Assembly Number Three (3):

(1) Type 218 Serial Interface Unit
(1) Address Block (Input Assembly)
(1) Control Serial Bus (SB1/SB2) Cable

f. Power Distribution Assembly must be PDA #5 EP with:

(1) Rack Mountable Model 216-24 Power Supply (pins 13 and 14 jumpered at supply terminal for single unit assembly)

(2) Model 204 Flasher Units
(1) Model 212 Cabinet Monitor Unit w/ 2 program keys
(1) Address Block (CMU)
(1) CC Harness
(1) Serial bus 3 Cable
(1) DC Power Harness (DCP)
(1) Control Serial Bus (SB1/SB2) Cable

g. Power Distribution Assembly must be PDA #5 IP with:

(1) Model 216-24 Power Supply
(1) Model 216-12 Power Supply
(2) Model 204 Flasher Units
(1) Model 212 Cabinet Monitor Unit w/ 2 program keys
(1) Address Block (CMU)
(1) CC Harness
(1) Serial bus 3 Cable
(1) DC Power Harness (DCP)
(1) Control Serial Bus (SB1/SB2) Cable

h. Service Panel Assembly:

(1) EDCO SHA-1250, or approved equal

i. Service Assembly:

(3) Type 218 Serial Interface Units
(3) Type 214 Auxiliary Monitor Units
(1) Model 212 Cabinet Monitor Unit

j. Field Wire Support Brackets.

(1) Cage 1 units require one deep support bracket for each Input and Output Assembly if field panels are not supplied.

(2) Cage 2 Units require one shallow support for each Input and Output Assembly.

k. Hardwire Copper Interface

(1) Cabinets shall be wired to accept and implement 120 volt hardwire interconnect systems.

(2) Standard color sequence for wires in positions 1-8 shall be:

White/Blue/Red/Green/Yellow/Black/White Black/Blue Black

(3) Install two (2) 8-position slider link blocks labeled SB1, 1-8 and SB2, 1-8 rated (250V / 20 amps) on the J-Panel.

(4) Install one (1) 8-position fuse block labeled FB, 1-8 rated (250V / 20 amps) with 8-3amp AGU fuses (250V) on the J-Panel adjacent to SB1 and SB2.

(5) Input file connections will be performed in the field.

(6) Install #12 AWG jumpers between line side of FB1 to line side of SB1 corresponding terminals 1 through 8. Jumper wires shall be identified according to the standard color sequence.

(7) All labels shall be machine printed, clearly readable, and of material that shall resist fading, cracking, discoloration, or detaching with age.

l. Series 340 Cabinet (Housing 3) must be provided with the following:

(1) Two (2) Field Input Termination Panels in accordance with Drawings and mounted at the bottom of the rack. They must be attached to the rack with an angle bracket and each panel attached to the angle bracket with captive thumb-screws. A total of twenty four (24) EDCO MRA–6lC–6.

(2) Two (2) Field Output Termination Panels in accordance with Drawings and be mounted at the bottom of the rack. They must be attached to the rack with an angle bracket and each panel attached to the angle bracket with captive thumb-screws as shown in the drawings.

D. Cabinet Cage Configuration Drawings.

Model 340 Cage 1 (Dual) Assembly Requirements	Figure 17
Model 340 Cage 1 Input w/ Controller Drawer Assy (Dual) Assy Reqmnt	Figure 18
Model 340 Cage 1 Outputs (Dual) Assembly Requirements	Figure 19
Model 340 Cage 1 Outputs w/ Controller Drawer Assy (Dual) Assy Reqmnts	Figure 20
Model 340 Cages (Dual) Cable Assembly Requirements	Figure 21
Field Input Panel	Figure 21A
Input Assembly Assignment to Field Panels	Figure 21B
Field Input Panel #1 Terminal and Labeling	Figure 21C
Field Input Panel #2 Terminal and Labeling	Figure 21D
Field Output Panel	Figure 21E
14 and 6 Pack Serial Output Assembly Wiring Assignment	Figure 21F
Field Output Wiring Diagram Output Files Phases 1 Thru 7	Figure 21G
Field Output Wiring Diagram Output Files Phases 8 Thru 14	Figure 21H
Termination Angle Brackets	Figure 21I
Model 342 Cage 1 Assembly Requirements	Figure 22
Cage 2 Assembly – Modified Drawer Loc.	Figure 23
Model 354 Cage 1 Assembly Requirements	Figure 24
Model 356 Cage 2 Assembly Requirements	Figure 25

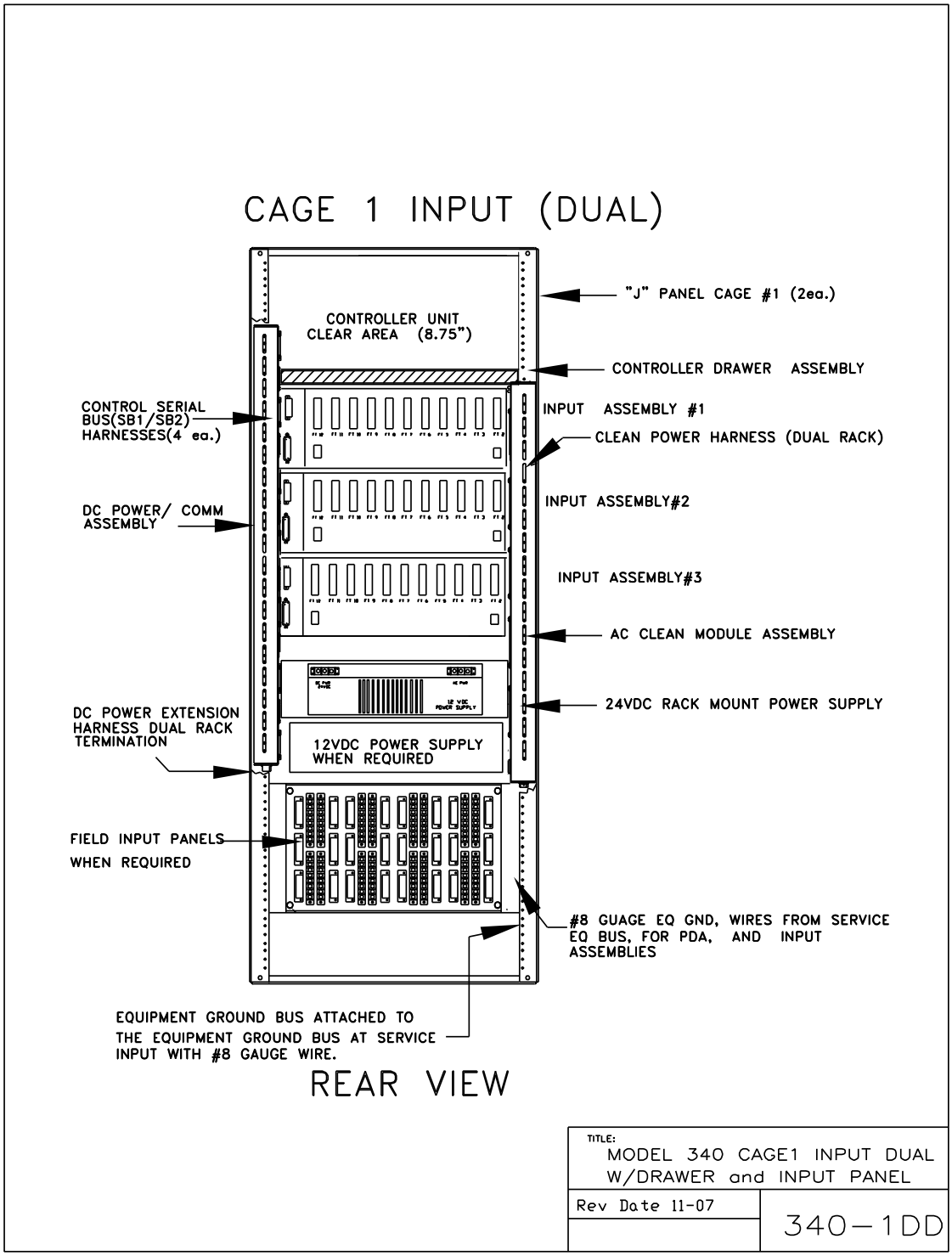


Figure 17
Model 340 Cage 1 (Dual) Assembly Requirements

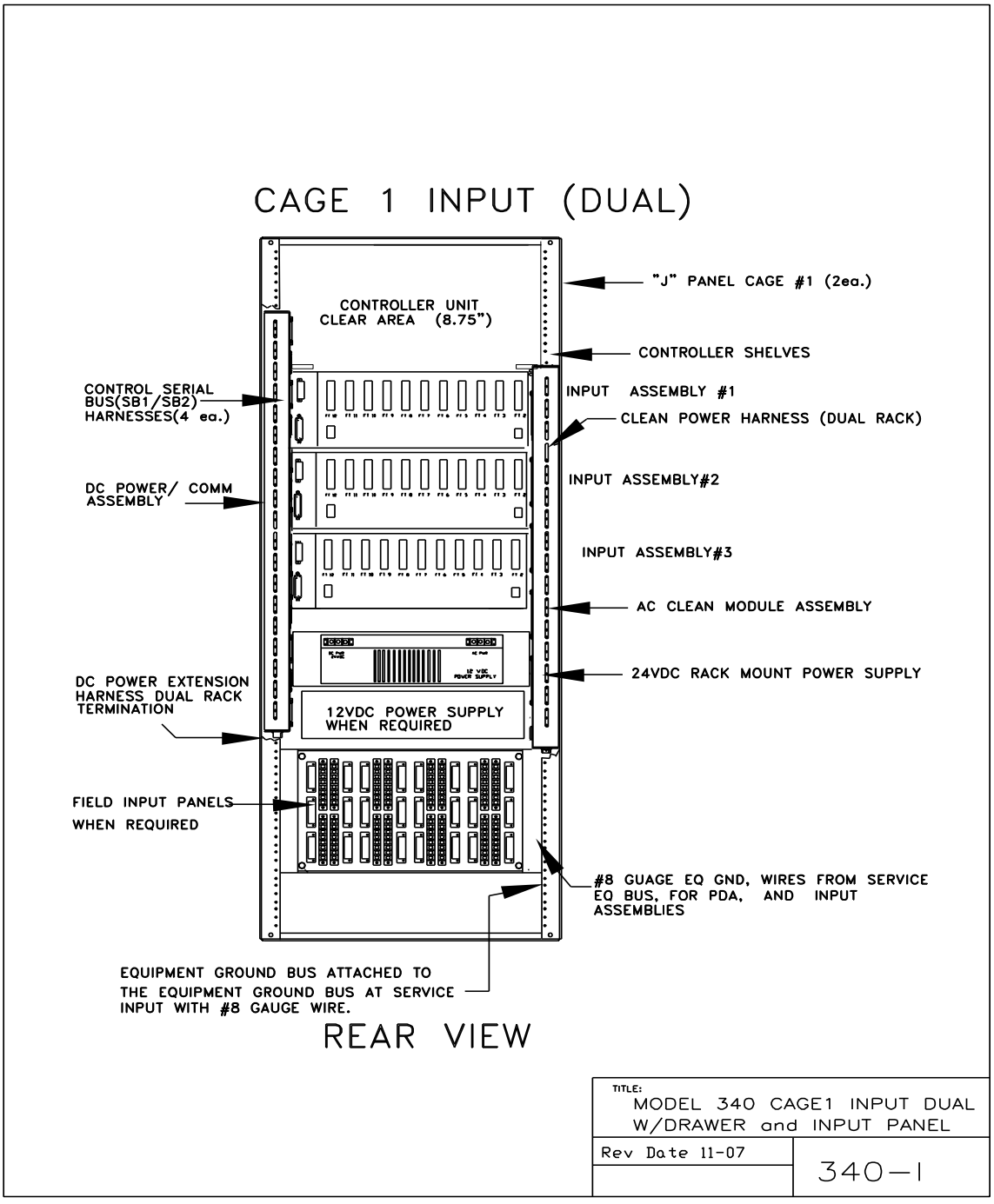


Figure 18
Model 340 Cage 1 Input w/ Controller Drawer Assy (Dual) Assy Requirements

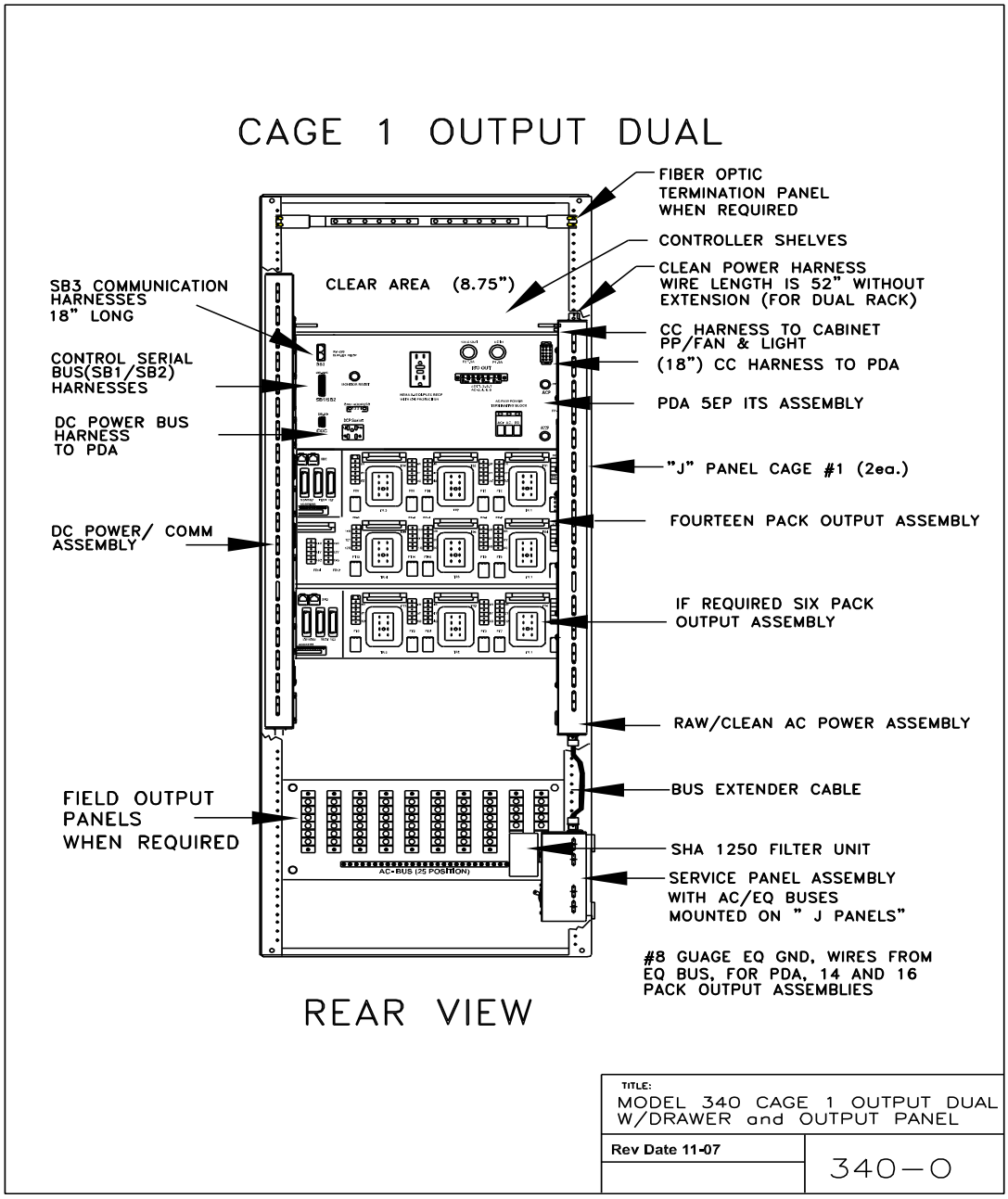


Figure 19
Model 340 Cage 1 Outputs (Dual) Assembly Requirements

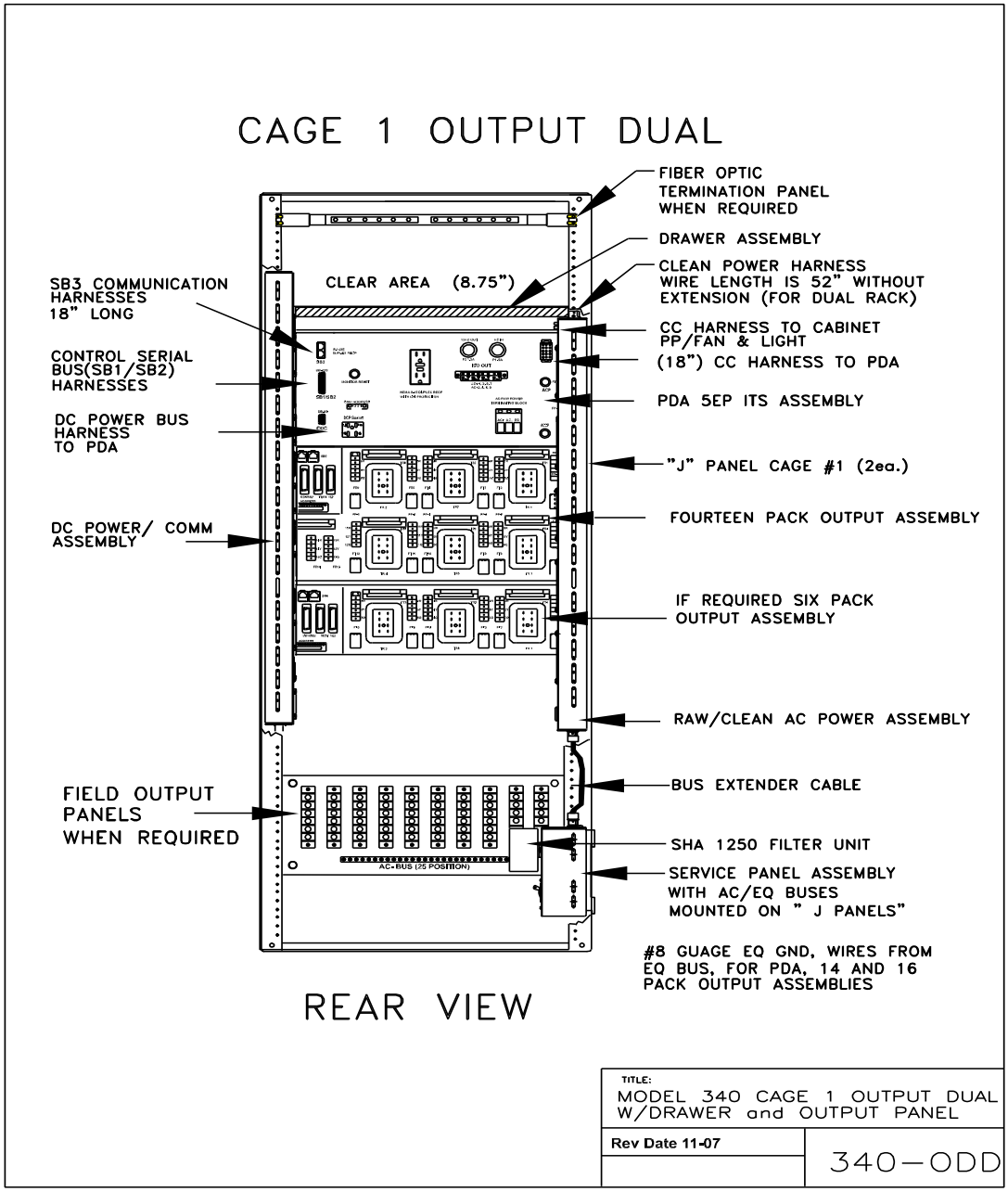


Figure 20
Model 340 Cage 1 Outputs w/ Controller Drawer Assy (Dual) Assy Requirements

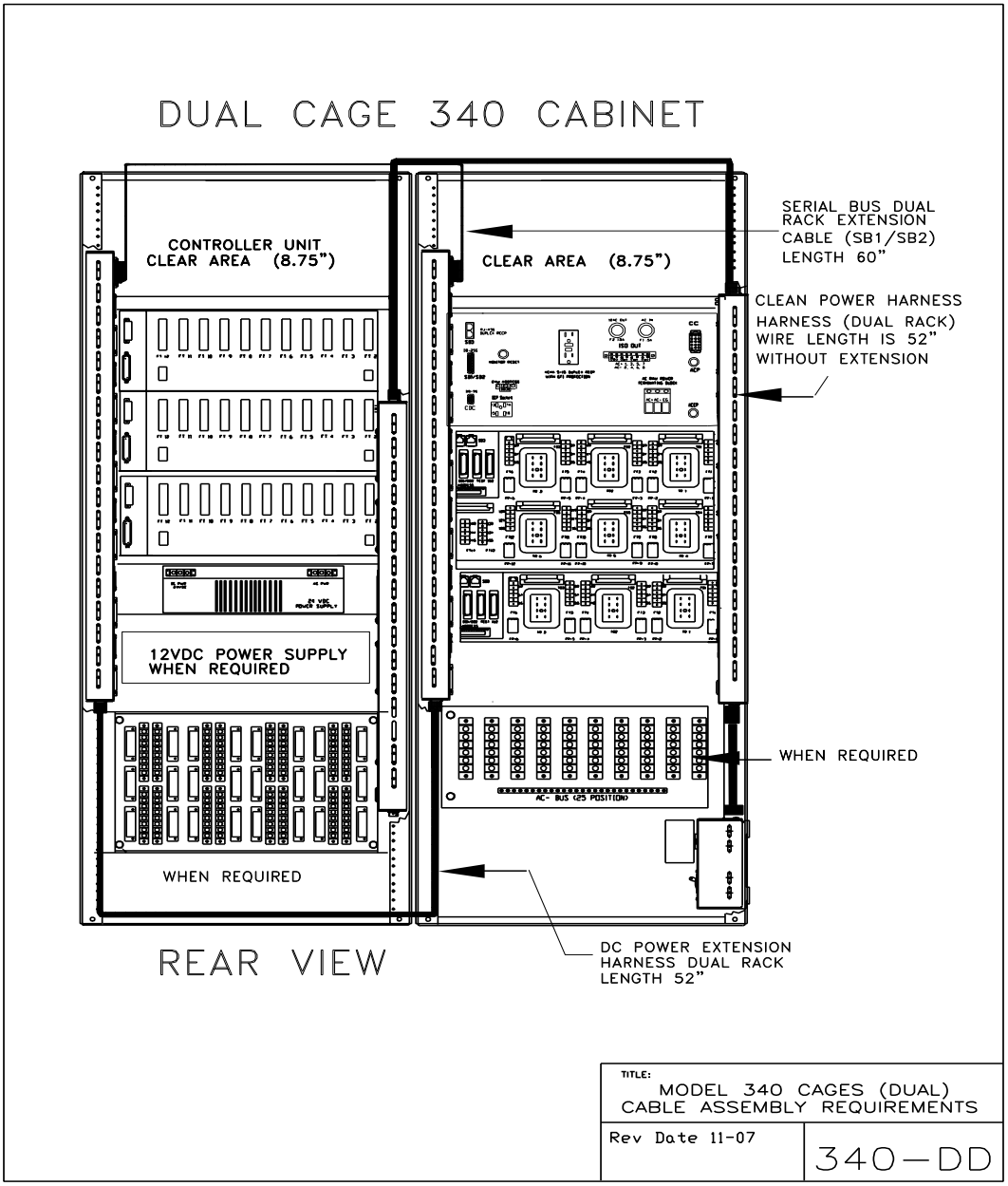


Figure 21
Model 340 Cages (Dual) Cable Assembly Requirements

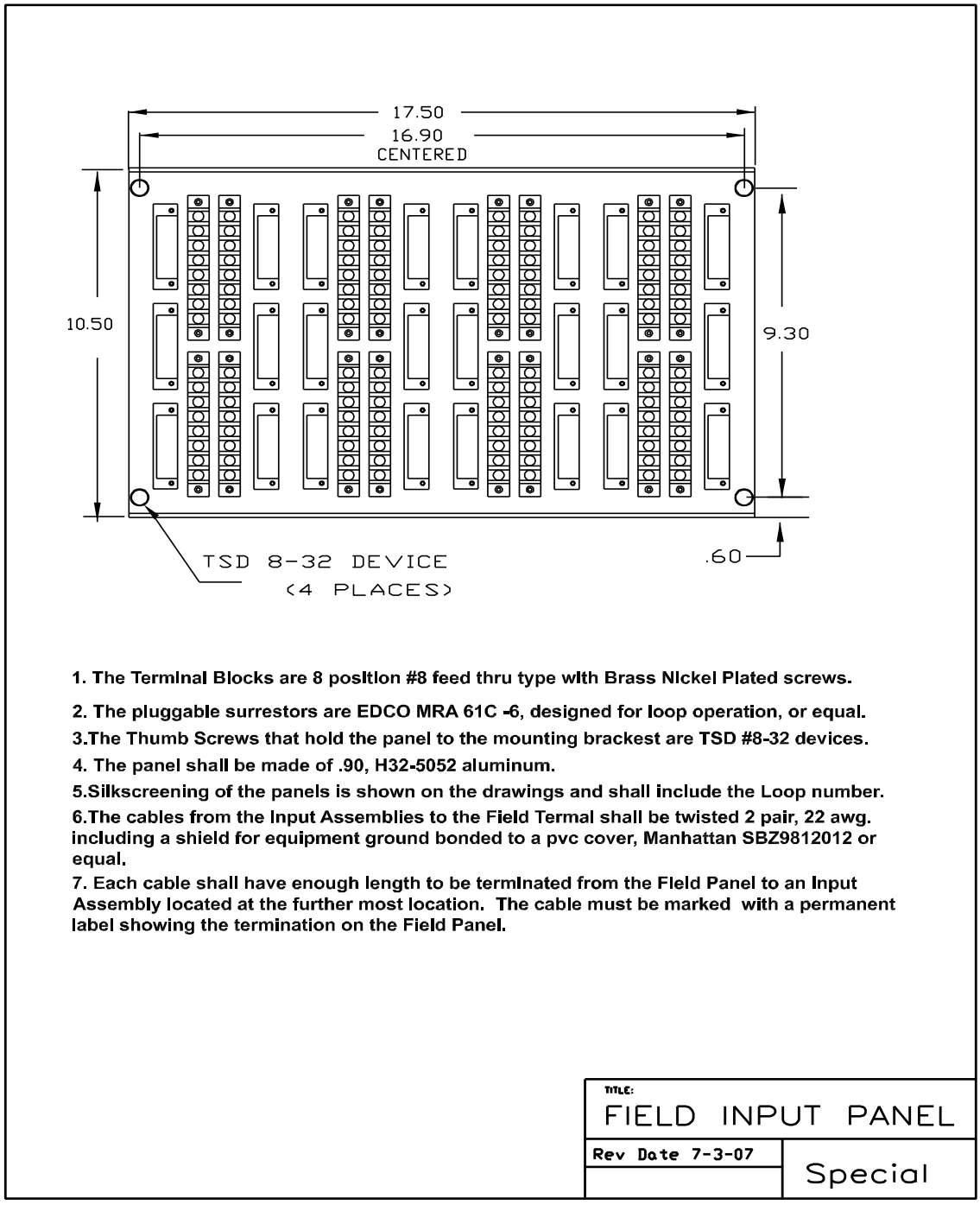


Figure 21A
Field Input Panel

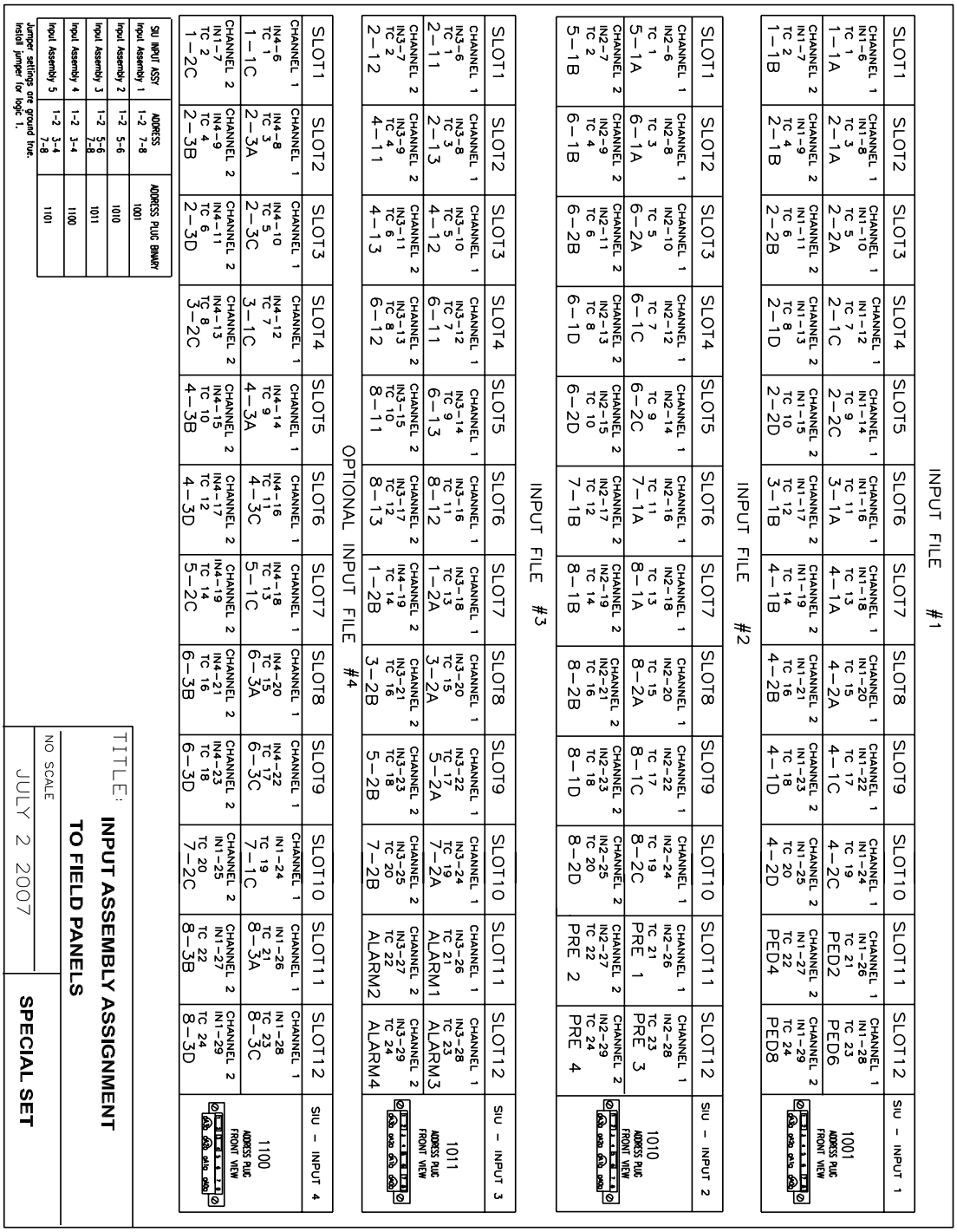


Figure 21B
Input Assembly Assignment to Field Panels

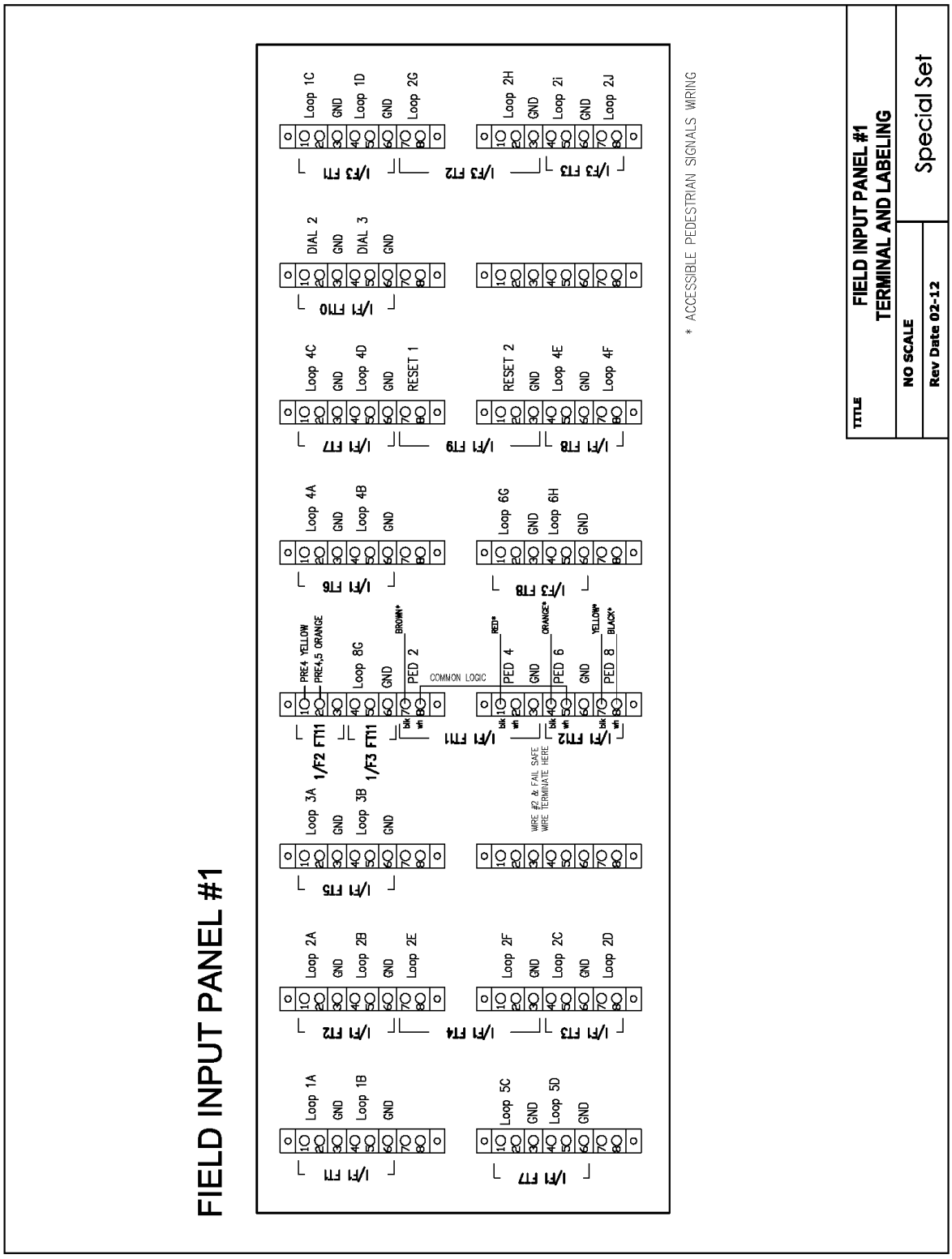


Figure 21C
Field Input Panel #1 Terminal and Labeling

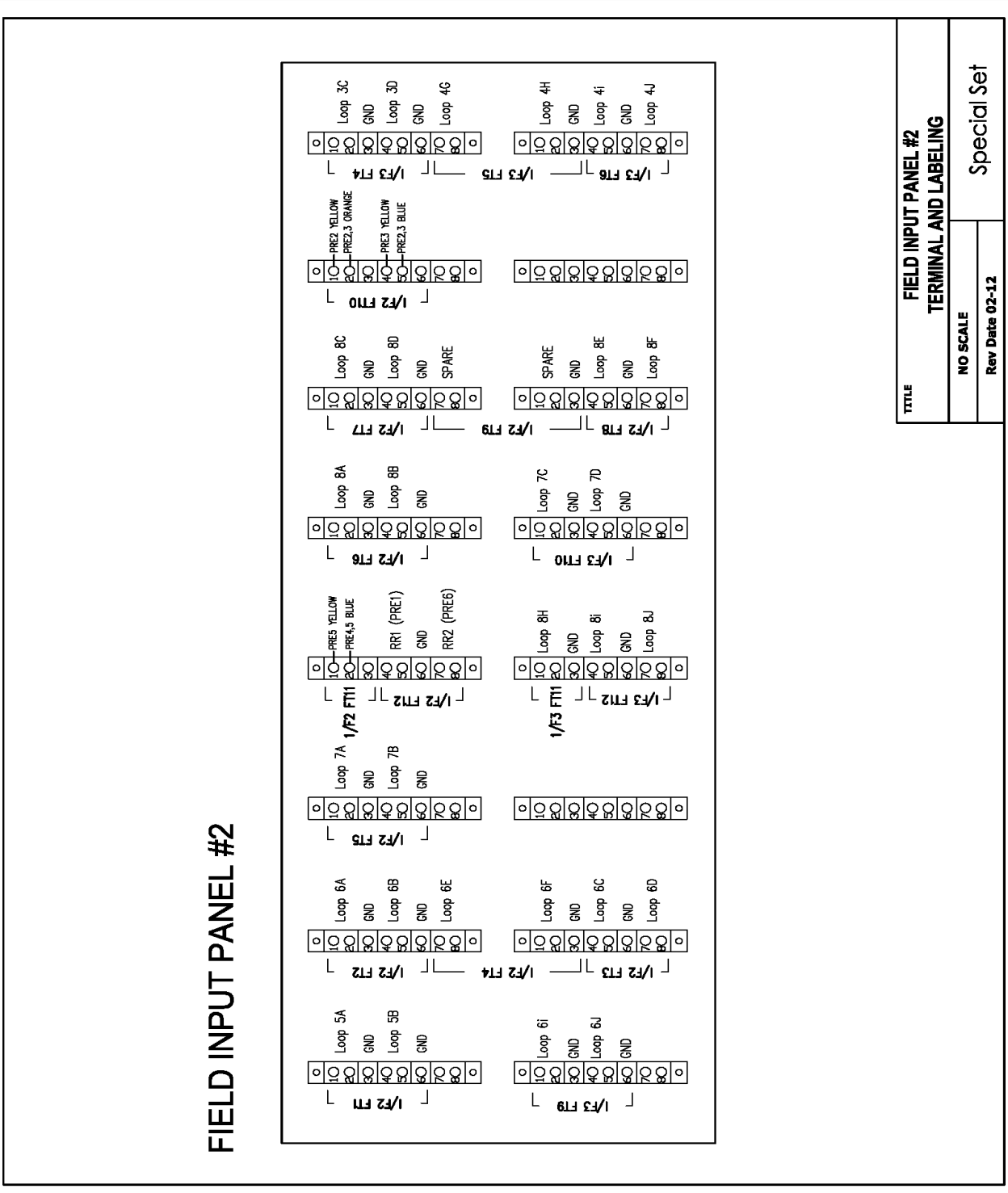


Figure 21D
Field Input Panel #2 Terminal and Labeling

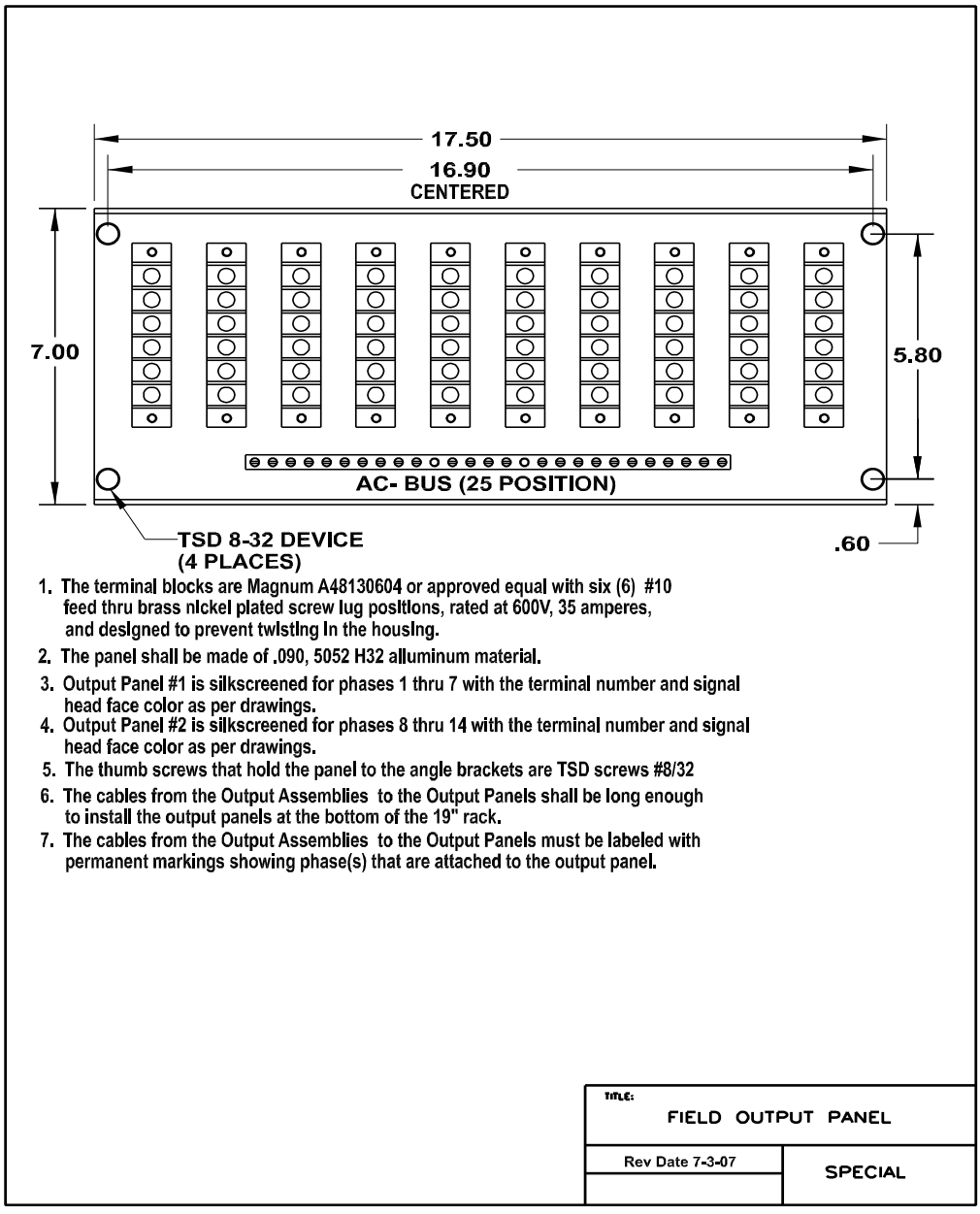
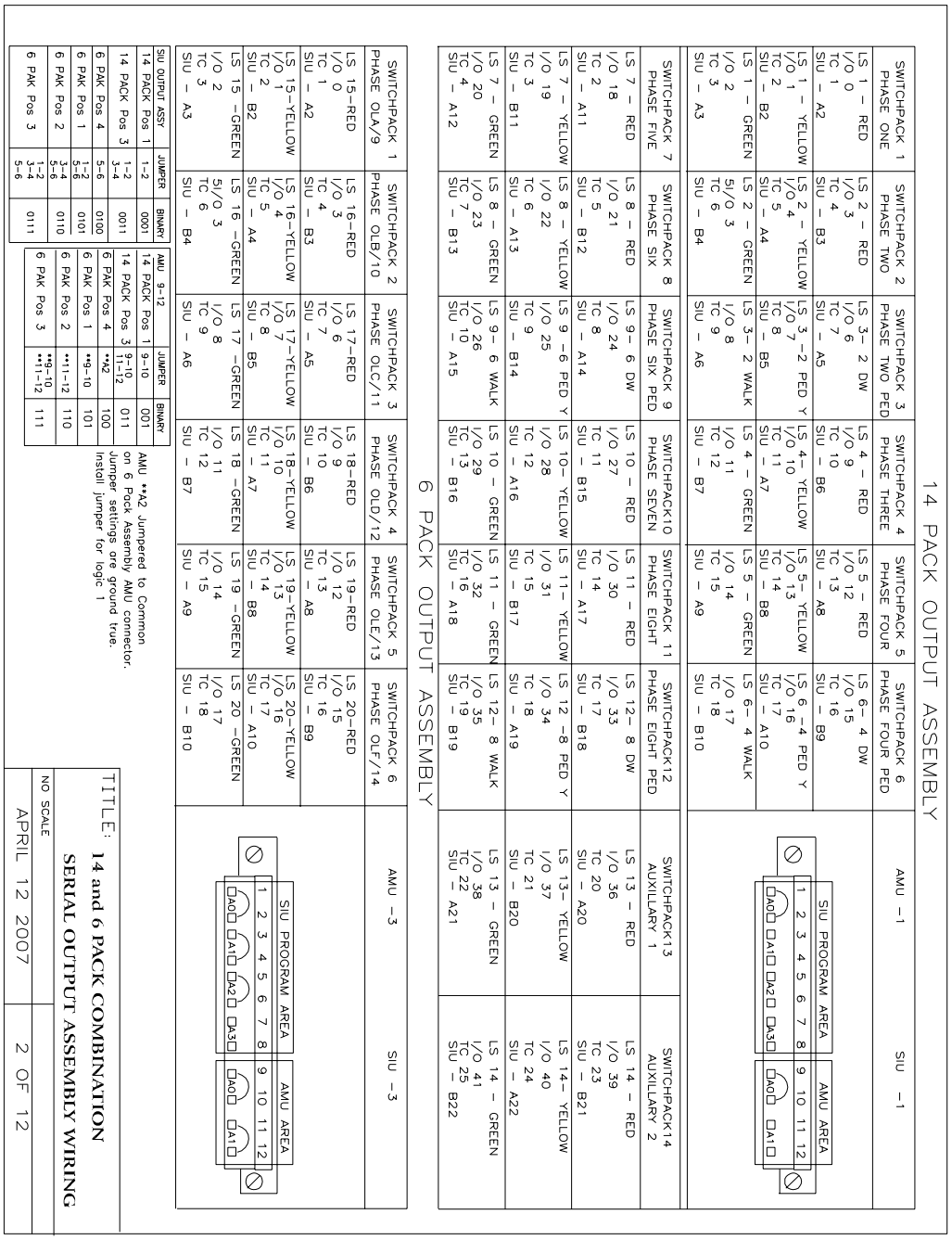


Figure 21E
Field Output Panel



SIU OUTPUT ASSY	JUMPER	BINARY
14 PACK Pos 1	1–2	0001
14 PACK Pos 3	1–2 3–4	0011
14 PACK Pos 4	5–6	0100
6 PAK Pos 1	1–2 5–6	0101
6 PAK Pos 2	3–4 5–6	0110
6 PAK Pos 3	1–2 3–4 5–6	0111

AMU 9–12	JUMPER	BINARY
14 PACK Pos 1	9–10	001
14 PACK Pos 3	9–10 11–12	011
14 PACK Pos 4	**A2	100
6 PAK Pos 1	**9–10	101
6 PAK Pos 2	**11–12	110
6 PAK Pos 3	**9–10 **11–12	111

AMU **A2 Jumpered to Common on 6 Pack Assembly AMU connector.
Jumper settings are ground true.
Install jumper for logic 1

TITLE: **14 and 6 PACK COMBINATION SERIAL OUTPUT ASSEMBLY WIRING**

NO SCALE | APRIL 12 2007 | 2 OF 12

Figure 21F
14 and 6 Pack Serial Output Assembly Wiring Assignment

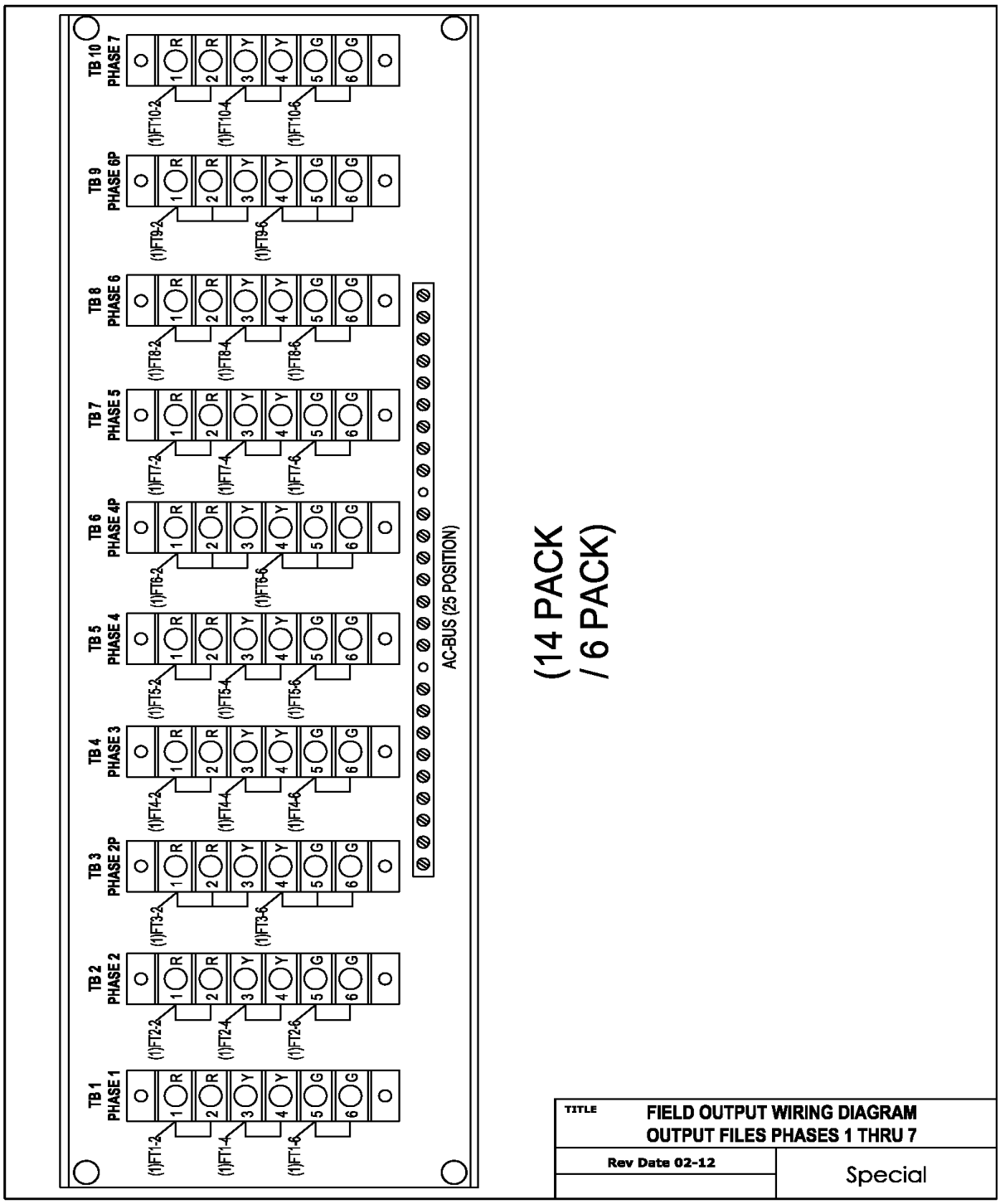


Figure 21G
Field Output Wiring Diagram Output Files Phases 1 Thru 7

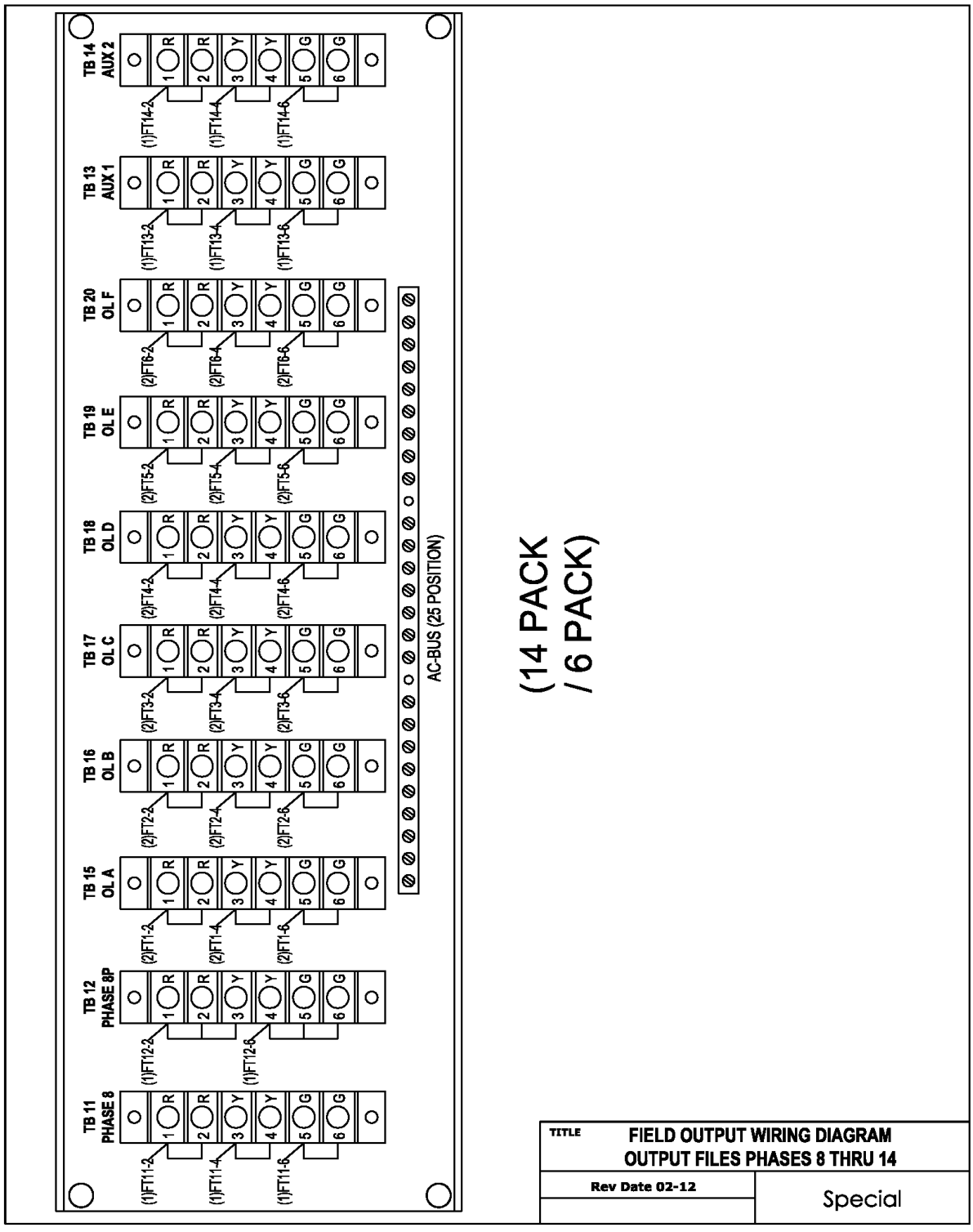


Figure 21H
Field Output Wiring Diagram Output Files Phases 8 Thru 14

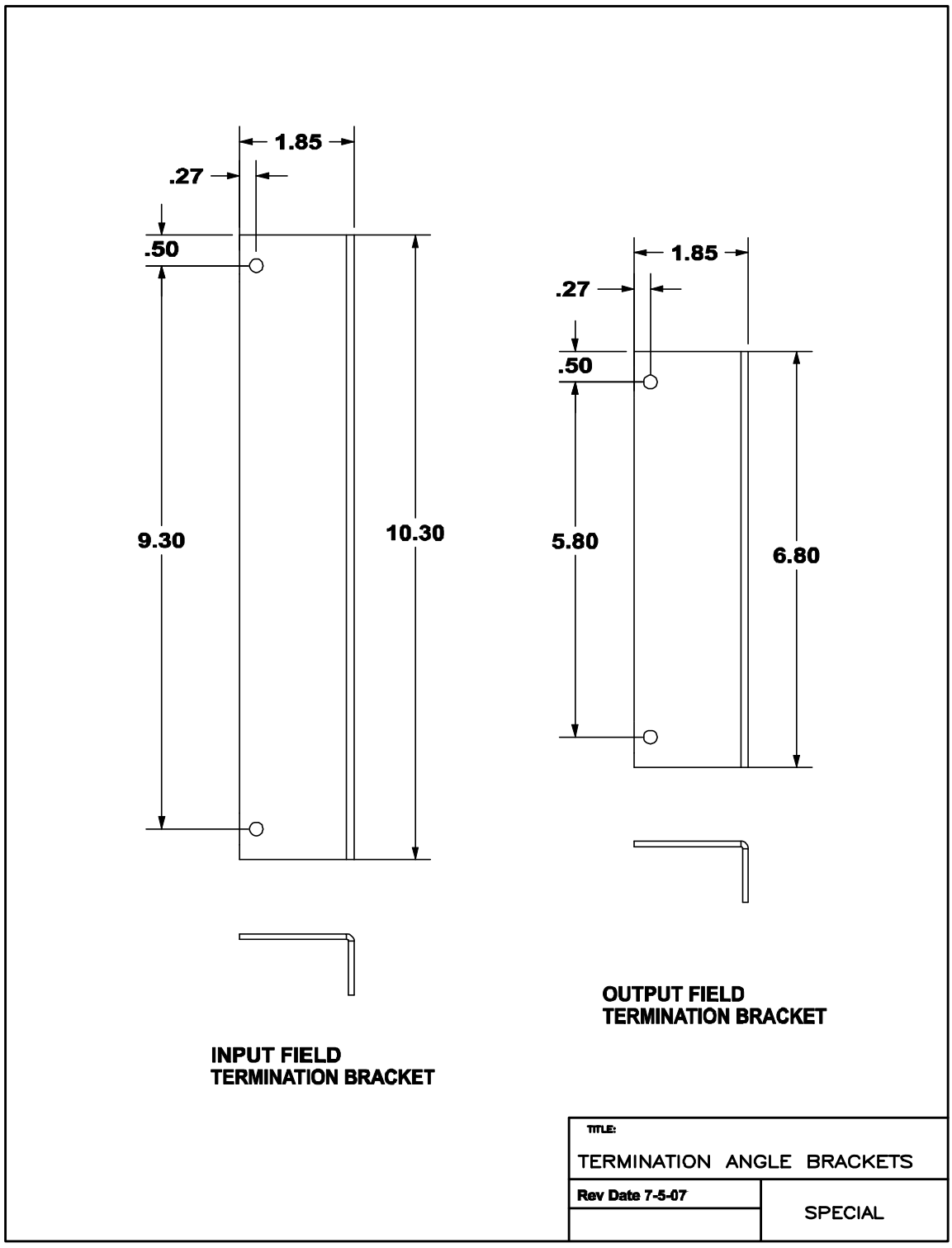


Figure 21I
Termination Angle Brackets

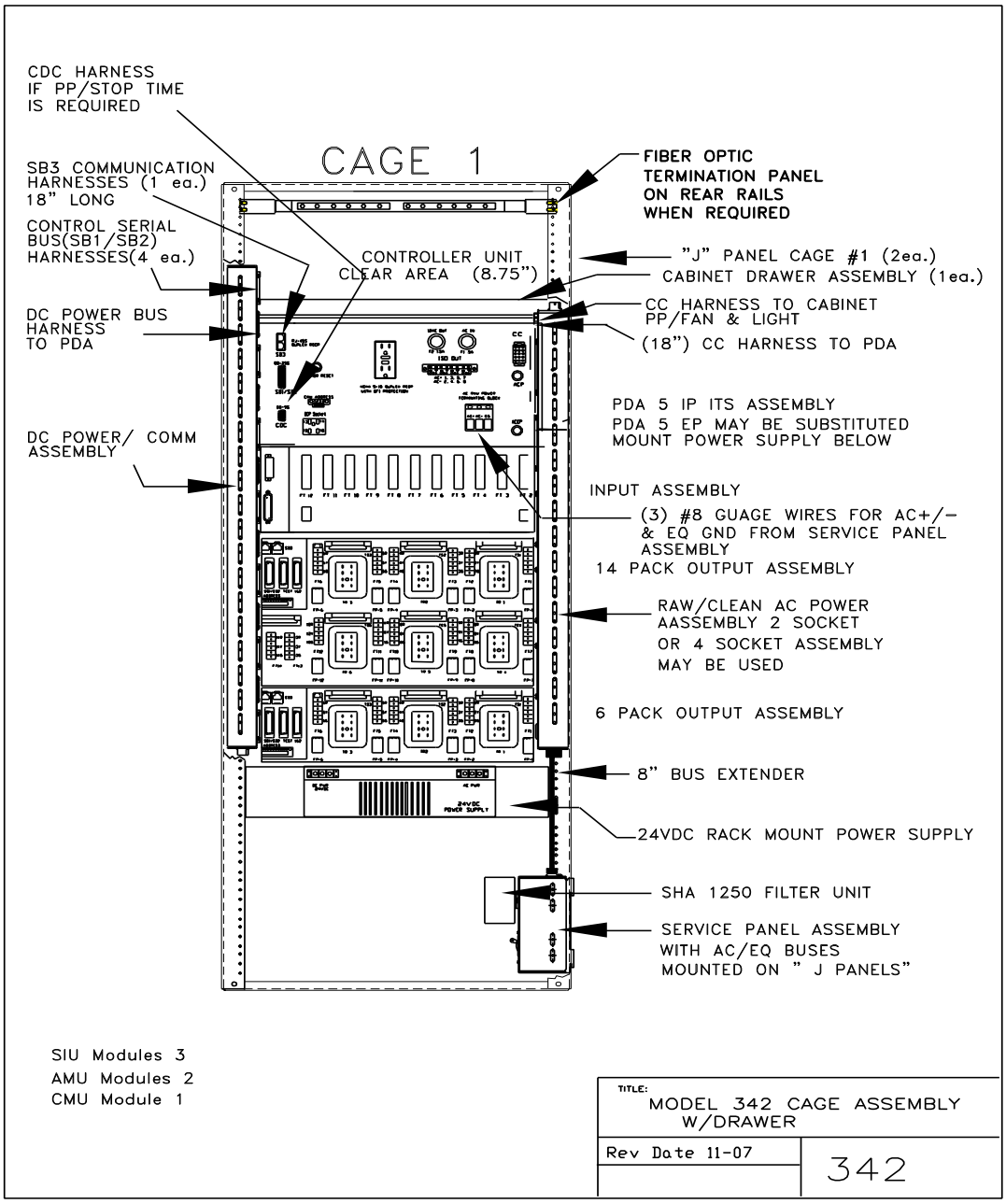


Figure 22
Model 342 Cage 1 Assembly Requirements

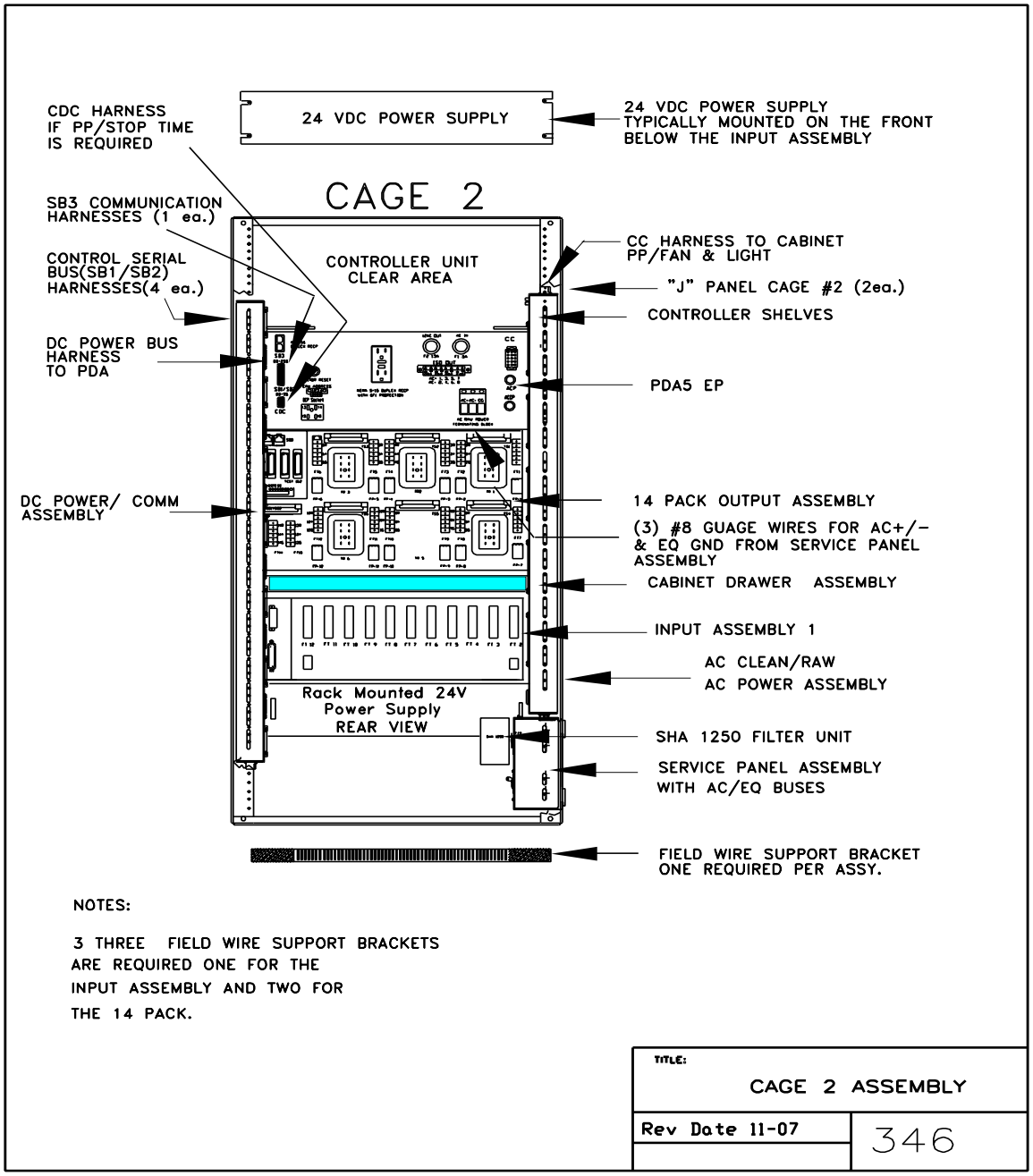


Figure 23
Cage 2 Assembly – Modified Drawer Loc.

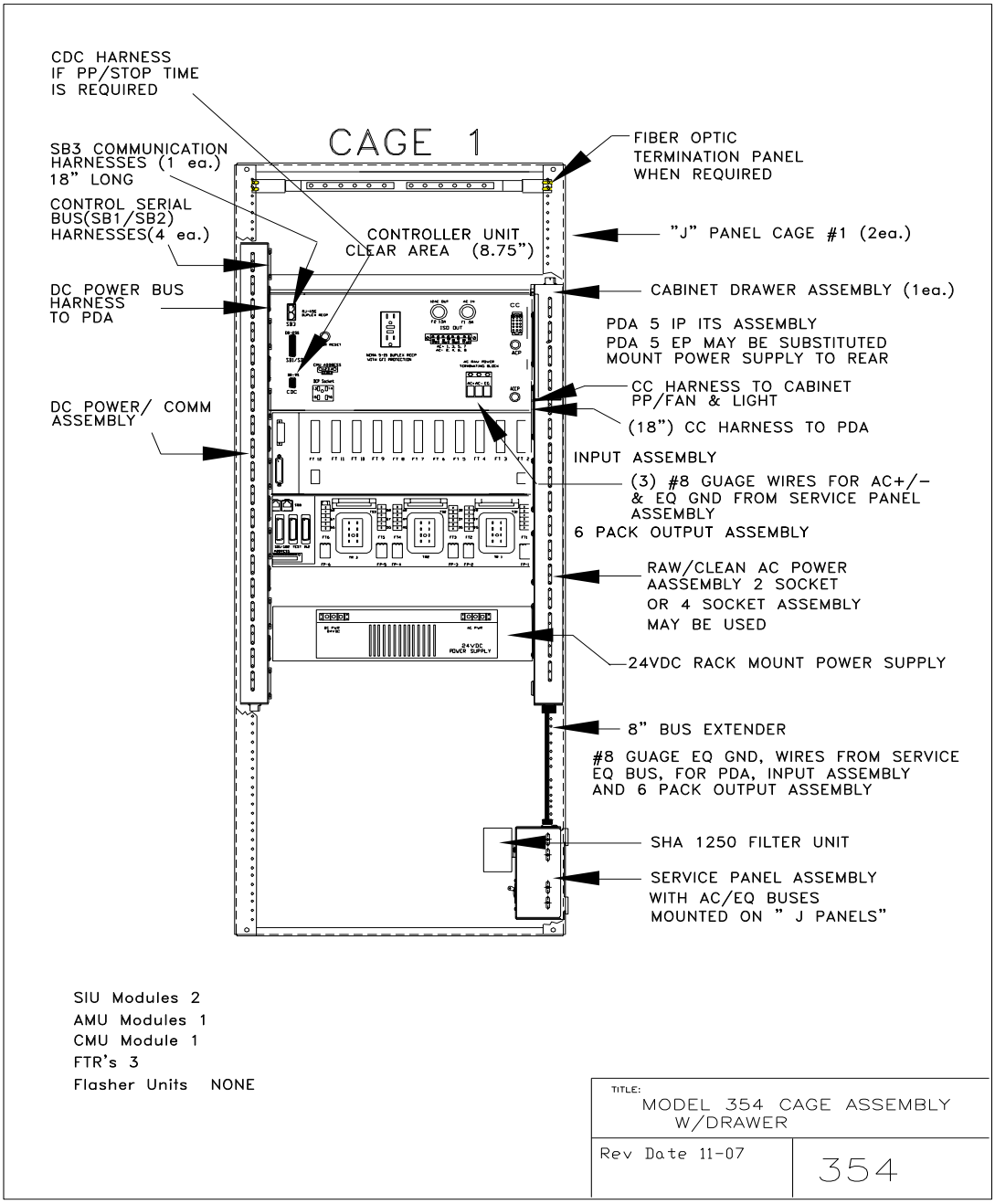


Figure 24
Model 354 Cage 1 Assembly Requirements

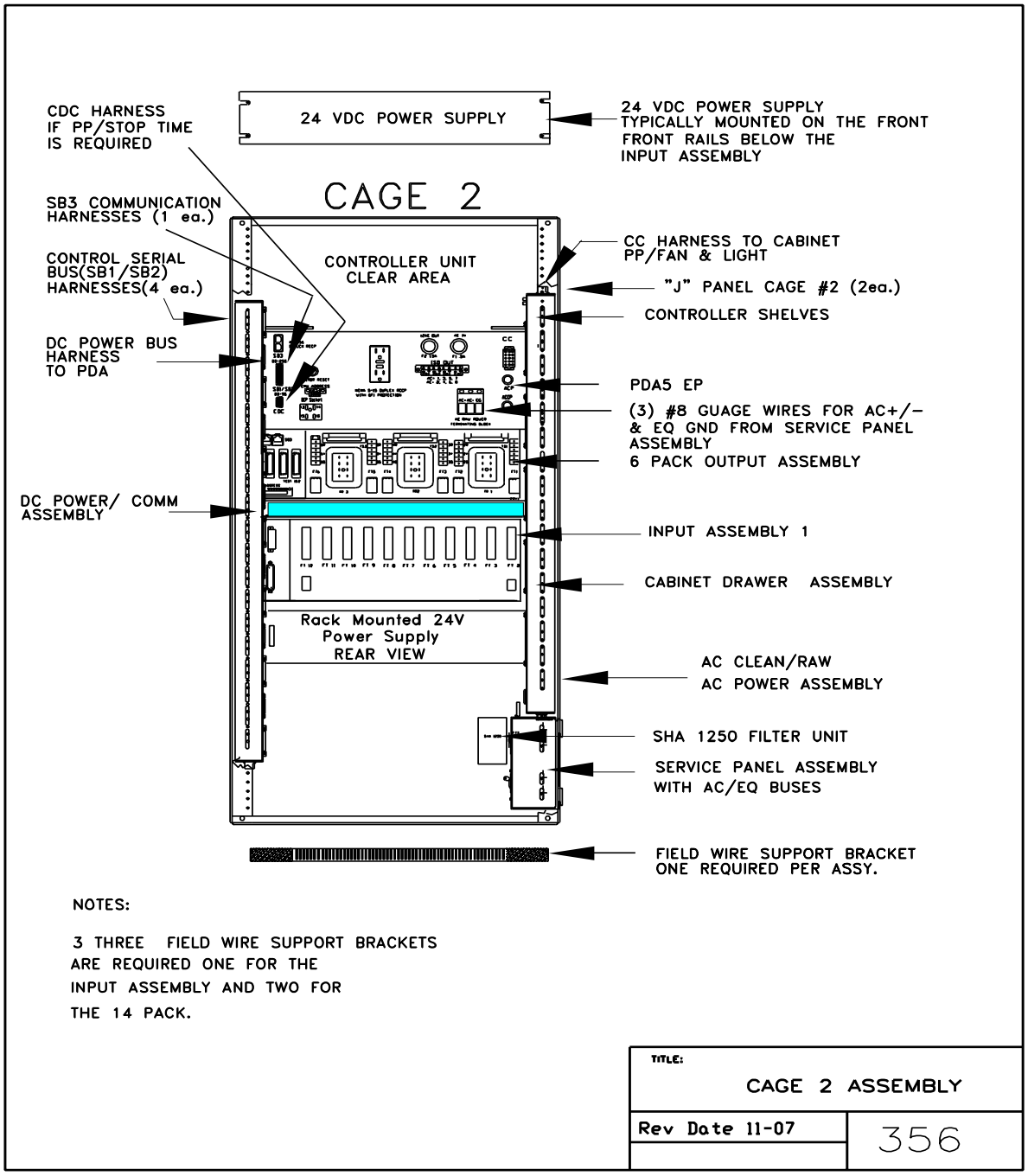


Figure 25
Model 356 Cage 2 Assembly Requirements

E. Serial Bus # 1 System.

1. Serial Bus #1 must function as a distributed real-time cabinet control and communications bus. The Bus Commands are generated in the ATC Controller Unit. They must be passed to the assembly Model 218 SIU Units and Model 212 CMU Monitor Unit using EIA 485 COMM/SDLC Protocol Frame Address/Message Packets. The SIU Units must read the Address Connector for Assembly Address Number. The CMU must read the Address Connector of the PDA. The AMU units must read address information as part of the Output Assembly address connector.

2. The following Address Frame numbers must be assigned to the assemblies and monitor as:

Address	SYSTEM ASSEMBLY / UNIT	ADDRESS										
		SIU								AMU		
		A7	A6	A5	A4	A3	A2	A1	A0	A2	A1	A0
0	Reserved									0	0	0
1	14 Pack in position 1	0	0	0	0	0	0	0	1	0	0	1
2	Reserved											
3	14 Pack in position 3	0	0	0	0	0	0	1	1	0	1	1
4	6 Pack in position 4	0	0	0	0	0	1	0	0	1*	0	0
5	6 Pack in position 1	0	0	0	0	0	1	0	1	1*	0	1
6	6 Pack in position 2	0	0	0	0	0	1	1	0	1*	1	0
7	6 Pack in position 3	0	0	0	0	0	1	1	1	1*	1	1
8	Reserved											
9	Input #1	0	0	0	0	1	0	0	1			
10	Input #2	0	0	0	0	1	0	1	0			
11	Input #3	0	0	0	0	1	0	1	1			
11	Input #4	0	0	0	0	1	1	0	0			
13	Input #5	0	0	0	0	1	1	0	1			
14	Reserved											
15	CMU #1	0	0	0	0	1	1	1	1			
16	CMU #2	0	0	0	1	0	0	0	0			
17	CMU #3	0	0	0	1	0	0	0	1			
18	CMU #4	0	0	0	1	0	0	1	0			

Address	SYSTEM ASSEMBLY / UNIT	ADDRESS										
		SIU								AMU		
		A7	A6	A5	A4	A3	A2	A1	A0	A2	A1	A0
19	CPU	0	0	0	1	0	0	1	1			
20	FIO 2A or 8	0	0	0	1	0	1	0	0			
21to 254	Reserved											
255	Broadcast All	1	1	1	1	1	1	1	1			

*A2 Jumpered on Assembly

3. If the Command Address Frame matches the Unit, the Unit must read the message for processing and response. The Message First Byte must be the message name. The Unit must set the Response Packet First Byte to Command Message plus 128 and the appropriate data.

F. Serial Bus #2 System.

1. Serial Bus #2 must be dedicated to gathering preprocessed data from the Cabinet Smart Input Devices resident in the input assemblies. This serial bus must be for off-line use in operations with the ATC Controller Unit controlling data collection. Serial Bus #2 must be designed to operate Asynchronous EIA 485 lines at selected data rates up to 19,200 bits per second. See section on SIU Port 2 Operation for communication, interface and message protocol.

2. Typical Command/Response Messages must use similar message format as Serial Bus #1, collecting Operational Status, Detection Speed reports, Occupancy reports, Counts, etc.

G. Cabinet Control/Emergency Override System (CCEOS).

1. System Description. The Control and Emergency Override System is composed of the Police Panel Switches, Door Switches, ITS Power Distribution Assembly with resident Cabinet Monitor Unit, Serial Bus #1, Modular Bus Assemblies and cables, and the Output Assemblies with Transfer Relays Program Block Connectors and AMU Units. The purpose of the Emergency Override system is to transfer control from the ATC Controller Unit to the Cabinet Monitoring System. The Emergency Override system may also be manually controlled by switches either on the ITS PDA Assembly or Police Panel. The action taken depends upon the application. The Transfer Relays in the Output Assemblies, when de-energized, must transfer from Switch Pack Control to the EOS control. When the Cabinet is in the SIGNALS OFF condition the Main Contactor must be OFF and the FTR's are energized. If the intersection is FLASH Mode when in the Ramp Metering application, the display is NO INDICATION or BLANK Mode.

2. Cabinet Monitoring System. The Cabinet Monitoring System must use two serial Bus systems for the interface; Serial Bus #1, links the ATC Controller Unit via a Serial Bus Harness to the DC Power/Communications Assembly. A Serial Bus Harness plugged into the DC Power/Communications Assembly must connect to the 212 Cabinet Monitor Unit with application serial memory key resident in the PDA ITS.

3. Serial Bus #3 Harnesses must provide the interconnection between the Output Assembly's 214 Auxiliary Monitor Units and the CMU. The Bus Harnesses must be daisy chained between the Output Assemblies and the PDA ITS. See sections CMU and AMU sections for operations, functions, protocol, Message frames and bit rate.

H. Housings.

1. Housing Package. The housings must include, but not be limited to, the following:

   a. Enclosure & Doors

   b. Gasketing

   c. Lifting Eyes & External Bolt Heads

   d. Door Latches & Locks

   e. Ventilation

   f. Cage Supports & Mounting

   g. Door Hinges & Catches

   h. Police Panel

   i. Aluminum Surfaces

   j. Light fixtures

2. Housing Construction. The housing must be rainproof. It must have front and rear doors, each equipped with a lock and handle. The enclosure top must be crowned to prevent standing water. The aluminum surface must be either coated with a Mill Finish or Anti-Graffiti Paint.

a. Material Thickness. The enclosure, doors, lifting eyes, gasket channels, police panel door, spacer supports and all supports welded to the enclosure and doors must be fabricated of 0.125 in. minimum thickness aluminum sheet. The filter shell, filter trough, fan support and police panel enclosure must be fabricated of 0.080 in. minimum thickness aluminum sheet. The spacer supports must have the option to use 0.059 in. minimum stainless steel sheet.

b. Welds. All exterior seams for enclosure and doors must be continuously welded and must be smooth. All edges must be filled to a radius of 0.03125 in. minimum. Exterior cabinet welds must be done by gas Tungsten arc TIG process only. ER5356 aluminum alloy bare welding electrodes conforming to AWS A5.10 requirements must be used for welding on aluminum. Procedures, welders and welding operators must conform to the requirements and practices in AWS B3.0 and C5.6 for aluminum. Internal cabinet welds must be done by gas metal arc MIG or gas Tungsten arc TIG Process.

c. Aluminum Surface Protection. ALUMINUM SURFACE PROTECTION must be either MILL FINISH or ANTI-GRAFFITI Paint.

(1) Anti – Graffiti Paint. The aluminum surface must be cleaned, etched and rinsed. The cleaning and etching procedure must be to immerse in inhabited alkaline cleaner at 71 degrees C for five minutes (Oakite 61A, Diversey 909 or equivalent in mix of the 6 to 8 ounces per gallon to distilled water). Rinse in cold water. Etch in a sodium solution at 66 degrees C for 5 minutes 90.5 ounce sodium fluoride plus 5 ounces of sodium hydroxide mix per gallon to distilled water. Rinse in cold water. Desmut in a 50% by volume nitric acid solution at 20 degrees C for 2 minutes. Rinse in cold water. Dry surfaces by preheating in an oven for 15 minutes at 400 degrees F. Remove and coat the surfaces using TCI Wheel Silver # 9811- 0110 with a minimum film build of not more than 2 mils total thickness. Place back into preheated oven for 10 minutes minimum at 360 degrees F to gel the base coat. Remove and coat the surfaces using TCI Anti-graffiti Clear # 9810-0231. Place back into oven and fully cure at 380 degrees F for 40 minutes.

d. Enclosure Door Frames and Door Seals. The enclosure door frames must be double flanged out on all four sides and must have strikers to hold tension on, and form a firm seal between, the door gasketing and the frame. The dimension between the door edge and the enclosure external surface when the door is closed and locked must be 0.156 in. (+/-0.08 in.).

3. Gasketing. Gasketing must be provided on all door openings and must be dust-tight. Gaskets must be 0.25 in. minimum thickness closed cell neoprene or silicone (BOYD R- 108480 or equal) and must be permanently bonded to the metal. A gasket top and side channels must be provided to support the top gasket on the door to prevent gasket gravitational fatigue.

4. Cage Mounting Supports. Cage mounting supports must be provided on either side, level with the bottom edge of the door opening, for horizontal support and bolt attachment; side cage supports provided for the bracket cage supports; and bracket cage support attachments.

5. Lifting Eyes and Exterior Bolt Heads. The housing must be provided with 2 lifting eyes for placing the cabinet on its foundation. Each eye opening must have a minimum diameter of 0.75 in.. Each eye must be able to support the weight load of 1000 lbs. All bolt heads must be tamperproof type.

6. Door Latches and Locks. The latching handles must have provision for padlocking in the closed position. Each handle must be 0.75 in. minimum diameter stainless steel with a minimum of 0.50 in. shank. The padlocking attachment must be placed at 4 in. from the handle shank center. An additional 4 in. minimum gripping length must be provided.

    a. Latch/Lock Mechanism. The latching mechanism must be a three-point draw roller type. The pushrods must be turned edgewise at the outward supports and have a cross section of 0.25 in. thick by 0.75 in. wide minimum. Rollers must have a minimum diameter of 0.875 in. with nylon wheels and steel ball bearings. When the door is closed and latched, the door must be locked. The lock and lock support must be rigidly mounted on the door. The lock must be mounted in the upper quadrant, above the handle when in it's full open position. In the locked position, the bolt throw must extend a minimum of 0.25 in. (+/-0.03125 in.) into the latch cam area. A seal must be provided to prevent dust or water entry through the lock opening.

    b. Lock and Keys. The locks must be Corbin 2 type. One key must be supplied with each lock. The keys must be removable in the locked position only. The locks must have rectangular, spacing loaded bolts. The bolt must have a 0.281 in. throw and must be 0.75 in. wide by 0.375 in. thick. Tolerance is 0.035 in.. A swing away cover must be placed over the key entrance to protect the lock mechanism.

    c. Cam. The center latch cam must be fabricated of a minimum thickness of 0.188 in. aluminum, or 11 gauge steel. The bolt surface must horizontally cover the cam thickness. The cam must be structured to only allow the door to open when the handle is moved toward the center of the door.

7. Housing Ventilation. Housing Ventilation must including intake, exhaust, filtration, and continuous running fan assembly, or a thermostat controlled fan.

    a. Intake & Filter. The louvered vent depth must be a maximum of 0.25 in.. A removable and reusable air filter must be housed behind the door vents. The filter filtration area must cover the vent opening area. A filter shell must be provided that fits over the filter providing mechanical support for the filter. This shell must be louvered to direct the incoming air downward. The shell sides and top must be bent over a minimum of 0.25 in. to house the filter. The filter resident in its shell must be held firmly in place with a bottom trough and spring loaded upper clamp. No incoming air must bypass the filter. The bottom filter trough must be formed into a waterproof sump with drain holes to the outside housing. The filter must be 16 in. wide by 12 in. high by 0.875 in. thick. The filter must be an ECO-AIR Product E35S or equal. The intake (including filter with shell) and exhaust areas must pass a minimum of 60 cubic feet of air per minute for Housing #1; 120 cubic feet of air per minute for Housing #3; and 26 cubic feet of air per minute for Housing #2.

    b. Fan. Each electric fan must be equipped with ball or roller bearings and must have a minimum capacity of 100 cubic feet of free air delivery per minute. The fan must be mounted within the housing and protected with a finger guard.

8. Hinges. Stainless Steel hinges (Two-bolts per leaf) must be provided to bolt the enclosure to the doors. Housing #1 & Housing #3 must have four hinges per door and Housing #2 must have three hinges per door. Each hinge must be 3-1/2 in. minimum length and have a fixed pin. The pin ends must be welded to hinge and ground smooth. The pins and bolts must be covered by the door edge and not accessible when the door is closed. A ground strap between the door and the main cabinet housing must be required when 120 VAC components are mounted on the door.

9. Door Catches. Front and rear doors must be provided with catches to hold the door open at both 90 and 165 (+/-10 degrees). The catch minimum diameter must be 0.375 in. aluminum rods. The catches must be capable of holding the door open at 90 degrees in a 60 mph wind acting at an angle perpendicular to the plane of the door.

10. Police Panel. A police panel assembly must be provided to allow the limited control access. The panel door must be equipped with a lock and master police key. The front and back of the panel must be enclosed with a rigid metal covering so that no parts having live voltage are exposed. The panel assembly must have a drain to prevent water from collecting within the assembly. The drain must be channeled to the outside. The series 35X Cabinets must have one switch provided and labeled "SIGNALS ON - OFF ". The series 34X Cabinets must have one switch labeled "FLASH/AUTO". The MANUAL CONTROL ENABLE ON-OFF switch and a receptacle for the INTERVAL ADVANCE cord must be provided. A 12 VAC transformer must be provided in advance of the INTERVAL ADVANCE receptacle. An INTERVAL ADVANCE cord, six feet in length, must be provided.

11. Housing Lighting. Fluorescent light fixtures must be provided inside the top portion of the housing. The fluorescent fixtures must be suitable for use in the housing environment when placed in the field. The fixtures must utilize an F15T5-CW fluorescent lamp. A minimum of four (4) fixtures will be provided for 340 housings, and a minimum of two (2) fixtures will be provided for all other housings.

I. Rack Cage. A Standard Rack Cage must be installed inside the housing for mounting of the ATC Controller Unit and cabinet assemblies. The EIA rack portion of the cage must consist of four continuous, adjustable equipment mounting angles. The mounting angle nominal thickness must be 11 gauge plated steel. The mounting angles must be tapped with 10-32 threads with EIA universal spacing. The mounting angle must comply with standard EIA-310-B and must be supported at the top and bottom by either welded or bolted support angles to form a cage. The mounting angles must provide holes to mount the “J” panels.

1. Clearance Between Rails. Clearance between rails for mounting assemblies must be 17.75 in..

2. Cage Connection. The cage must be bolted to the cabinet at 4 points via the housing cage supports and 4 points via associated spacer brackets (top and bottom).

3. Cage Location. The cage(s) must be centered within the cabinet door opening(s).

J. Cabinet Assemblies.

1. General.

a. Cabinet Assemblies. The cabinet assemblies must be completely removable from or installable in the cabinet cage without removing any other equipment and using only a Standard Slotted or Phillips Screwdriver.

b. Visible and Accessible Devices. All fuses, circuit breakers, switches (except Police Panel Switches and Fan Fuse) and indicators must be readily visible and accessible when the cabinet front door is open.

c. Labels and Marker Strips. All equipment in the cabinet must be clearly and permanently labeled. The marker strips must be made of material that can be easily and legibly written on using a pencil or ballpoint pen. Marker strips must be located immediately below the item they are to identify and must be clearly visible with the items installed.

d. Resistor/Capacitor Suppression. Suppression must be provided at all relay sockets (across relay coil), except for the Transfer Relays (TR) in the output assemblies where one suppression device may be common for all.

e. PDA, Output and Input Assemblies. PDA, Output and Input Assemblies Depth must include terminal sockets, plug-in units and strain relief bar (Field Wire Support Bracket). The Width must be 17.5 in. maximum including side screws. The maximum Depth, including connectors, must not exceed 14.0 in. The assembly housing top and bottom must be slotted for vertical ventilation. Assembly Thickness - Side ends must be fabricated of 0.080 in. minimum thickness aluminum sheet. All other surfaces must be fabricated of 0.0625 in. minimum thickness aluminum sheet. The aluminum metal surface must be treated with clear chromate.

f. Connector Sockets. Flasher and Switch Pack Unit sockets must be mounted with their front face 7.50 in. from the assembly front panel.

g. Nylon Guides. Guides (top and bottom) must be provided for assembly Plug-in units (Power Supply Units guide on bottom only). The guides must begin 0.50 in. from the assembly front panel face.

2. "J" Panel Assemblies. The "J" Panels must be mirror images of each other when mounted in the cabinet cage. They must be bolted to the cage with the matching shelf unit bolted to the panel. Two ten position minimum AC- Raw & Equipment Ground Copper Bus Bars must be provided on the lower right position of the J Panel when viewed from the rear door for interconnect to the Service Panel and provide the termination of AC- Raw and Equipment Ground wiring within the Cage and Cabinet.

a. Input Termination Panel Assembly. An optional Input Termination Panel must be provided that uses ten twelve-position terminal blocks and 4 copper bus bars. Eight of the twelve position terminal blocks and the four copper bus bars must be used for termination of field inputs. Two of the twelve position terminal blocks must be used for termination of the CDC interface. Input transient protection devices may be used for input termination. Terminal blocks one through four provide termination for Input Assembly #1 and terminal blocks five through eight provide termination for Input Assembly #2. A ground lug must be provided on the panel assembly to terminate an 8 AWG green wire that is attached to the Equipment Ground copper bus bar on the "J" panel assembly. The Input Termination Panel must be mounted on the left side of the Rack Assembly, when viewing from the rear.

3. Cabinet Shelf Assemblies. A Shelf Assembly must be provided unless otherwise called out in the contract special provisions. One alternative is a shelf/drawer assembly.

4. Service Panel Assembly.

a. General Requirements. A Service Panel Assembly must be provided. The assembly must function as the entry point for AC Power to the cabinet including main and secondary circuit breakers, cabinet transient and voltage surge protection, clean power filtering, Raw and Clean AC Power Source.

b. Location. The assembly must be located on the lower right J Panel when viewed from the back door.

c. Service Terminal Block. The terminals of the Block must be labeled AC+, AC- and EG and must be covered with a clear insulating material to prevent inadvertent contact. The Terminating Lugs must be large enough to accommodate # 2 conductors.

d. AC+ Raw, AC- Raw and Equipment Ground Bus Termination. This assembly must provide two 8 in. #8 gauge wire extensions for AC-Raw and Equipment Ground, for attachment to the AC- and Ground busses mounted on the "J" panel.

e. The DC Ground and Equipment Ground Bus must be electrically isolated by 500 Megohms when tested at 250 VDC.

f. The AC- copper terminal bus must not be grounded to the cabinet or connected to logic ground. Nylon screws with a minimum diameter of 0.25 in. or nylon spacers must be used for securing the bus to the J Panel.

5. Raw/Clean AC Power Assembly. This Assembly must be provided in each cabinet. It must provide Six Clean AC Power Receptacles for assemblies and cabinet units; Raw AC Power to the Output Assemblies; and both logic and power to the Fan and Light system, door opening circuitry and logic interface (all via CCIN and CCOUT Connectors).

    a. Raw/Clean AC Power Extension. The Extension must provide a minimum of five additional NEMA 5-15 receptacles with harness plug connector for plugging into the main assembly. The extension may be an option in Housing #1, and must be required in Cage 2 of the Housing #3.

6. DC Power/Communications Assembly. This assembly must function as the DC Power bus, providing Six VDC BEAU S5404-SB Receptacles and communications interface between the ATC Controller Unit and other assemblies. This assembly must interface with ATC Controller Unit Logic Lines (Power Down, NRESET and LINESYNC) and Seven System Serial Bus signals via DB-25S Connectors.

    a. DC Power/Communications Extension. The Extension must provide additional Serial Bus Connectors and DC Receptacles. The extension may be an option.

    b. Terminator Unit. A Serial Bus #1 and #2 Terminator Unit must be provided and plugged into the DC POWER / COMMUNICATIONS ASSEMBLY DB 25S End Connector. The Terminator Unit must provide a 150 ohm termination resistor between the RxD+ and RxD-, the TxD+ and TxD-, the RxC+ and RxC-, and the TxC+ and TxC- pairs for both Serial Bus #1 and Serial Bus #2.

        (1) The Terminator Unit must also provide 1K ohm DC bias resistors from +5VDC ISO to the RxD+, the RxC+, the TxD+, and the TxC+ of both Serial Bus #1 and Serial Bus #2. The Terminator Unit must provide 1K ohm DC bias resistors from ISO GND to the RxD-, the RxC-, the TxD-, and the TxC- of both Serial Bus #1 and Serial Bus #2.

7. Power Distribution Assembly ITS.

    a. The Power Distribution Assembly ITS is an EIA-310B rack mounted assembly that provides for the protection and distribution of AC power and DC power. The following must be included:

        (1) Logic control circuits, including a Main Contactor for control of the load circuits;

        (2) Fault sensing field Circuit Breakers, eight for Traffic applications and four for Traffic Management systems.

(3) Production and distribution of DC power, using +12VDC and 24VDC pluggable power supplies.

(4) A resident Cabinet Monitor Unit (CMU).

(5) Maintenance service, consisting of a circuit breaker in line with GFI equipment power receptacles.

(6) Two Model 204 Flasher Units, protected by a ganged two pole 20 A Circuit Breaker when operating in a Traffic Signal application.

(7) A 25 Pin D Socket must be provided for communication with the ATC Controller Unit. This Socket must be mated with an 18in. Communications Cable. This Cable must be attached to the Assembly by slotted 4:40 screws. See Serial Bus Harnesses Detail 6-5-39.

(8) A four position Address Socket and plug must be provided to provide addressing to the CMU.

b. A CDC Connector must be provided on the rear panel of the Output Assembly for isolated signal outputs from the police panel. The CDC Socket is a 9 Pin "D" connector that contains the Manual Control Enable, Stop Time, Interval Advance, and Manual Flash switch signals. The Manual Control Enable and Manual Flash switch signals must be a 120 VAC signal in series with a 27K Ohm resistor. The Interval Advance and Stop Time switch signals must be 12 VAC signals from a transformer located in the PDA. The secondary output of the 12 VAC transformer must be tied to AC- RAW. CDC pin 5 Common must be referenced to AC- RAW. CDC pins 8 must provide an interface for the external reset signal and 9 must provide an interface for DC Ground.

c. The PDA must be provided with eight field load circuit breakers and two Model 204 Flasher Units with ganged circuit beaker protection. The Load Circuit Breakers located on the PDA that are used to control the Output Assembly Model 200 Switch Pack Units must have auxiliary switches. The auxiliary switches must "open" when the load breaker has tripped and the system will transfer the power from the Main Contactor to the Flash or Blank condition.

d. The Amperage Rating of breakers must be shown on the face of the breaker or handle. Breaker function must be labeled below the breakers on the front panel. Ganged Circuit Breakers must be assembled by the circuit breaker manufacturer and certified that their circuit breakers must gang trip.

e. The maintenance equipment circuit must include a 15-Ampere Circuit Breaker in line with GFCI receptacles on both the front and back of the assembly. The back receptacle must be the first with GFCI Protection device as defined in the National Electrical Code. Circuit interruption must occur on 6 milliamperes of ground fault-current and must not occur less than 4 milliamperes of ground-fault current. The front receptacle must be attached to the load side of the GFCI device.

f. The AUTO/FLASH Switch when placed in FLASH position must de-energize the Main Contactor and the Transfer Relays (TR) Coils. When the switch is placed in the AUTO position must energize the Main Contactor and the TR Coils. The switch must be a SPST Control Switch.

g. The DC Power must be brought to the back panel using a BEAU S5404-SB Receptacle. An 18 in. DC Power (DCP) Harness, with sheath, consisting of 4 #18 cables, with a BEAU P5404-LAB Connector on each end, must be provided with the Assembly. The harness must be plugged in to an adjacent plug on the DC/COMM Assembly. See detail 6-5-40 of this specification.

h. Three 36 in. minimum length #8 gauge wires, one black for AC+, one white for AC- and one green or green/yellow for Equipment Ground, must be attached to the rear of the assembly at the AC Raw Power Terminating Block. The cables must be routed between the Service Panel Assembly AC+ terminal, the AC-Bus and the Equipment Ground Bus.

(1) The PDA Assembly must have a resident 18 in. ACP Harness with sheath and strain relief. The other end must contain a BEAU P5412-CCE connector. This harness must be plugged into the P1 connector on the Raw/Clean AC Power Assembly. The ACP harness must provide Flasher input and AC power to the Switch Packs.

(2) An 18 in. long CC Harness must be provided with sheath and strain relief. When plugged into the Raw/Clean AC Power Assembly (CC IN) this harness must provide AC Raw voltage and control logic between the ITS PDA Assembly and the Police Panel control switches.

(3) An 18 in. long ACCP power cord with strain relief and a NEMA 5-15 plug must provide AC Clean power to the PDA ITS Assembly when plugged into the Raw/Clean Power Assembly.

i. A capacitive load of 1 microFarad at 400 VAC must be provided across each Flasher Unit Output.

8. Input Assembly.

   a. The Input Assembly must be an EIA-310B rack mounted assembly providing twelve slots of 22/44 pin PCB sockets. A Model 218 Serial Interface Unit (SIU) must be provided in its location mated to a DIN 96-Pin Connector. The SIU must provide interface and control between the ATC Controller Unit and the input units via System Serial Bus #1 and #2. See Section Model 218 SIU for System Operation and Interface. A 25 Pin D Socket must be provided for communication with the ATC Controller Unit. This Socket must be mated with an 18 in. Communications Cable. This Cable must be attached to the Assembly by slotted 4:40 screws. See Serial Bus Harnesses Detail.

   b. The input assembly must be wired to accept Model 222 and 224 ILD Sensor Units, Model 232 Magnetic Sensor Unit, Model 242 and 252 Isolator Units and Slot mounted NEMA Detectors. Each slot connector is a PCB 22/44 Pin Socket type wired for 2 and 4 channel devices. The F and W Unit Output pins must provide the 24 Inputs to the SIU Channel 1 (Serial Bus #1). In addition, NEMA Status inputs must be provided on pins 7 and 20. INBUS must be provided on pin 19 and 21 with four slots address lines matching NEMA pin outs.

   c. The SIU Unit must provide 6 detector RESET Outputs, one for every two slots and should the NEMA Status not be required, a RESTART Output from the SIU to the sensor units as a soft reset per channel via pins 7-20. See Input Assembly Wiring Diagram 6-5-37.

   d. The INBUS must interface with the SIU Channel 2 to provide communications between “Smart Input Units” and Serial Bus #2. The SIU functions as a hardware driver interface only between the ATC Controller Unit and Input Units installed in the Input Assembly. See Type 218 SIU section 4.

   e. A 25 Pin DB Connector must be provided on the left assembly side (rear panel) to interface the assembly (SIU) to the DC/COMM Assembly Serial Bus #1 and #2. A 32 Pin DB (Socket) must be provided for the Test Function. For Test Connector wiring, see Input Wiring Diagrams 6-5-37.

   f. Four special function Inputs must be provided via 9-position subminiature D-type connector to the SIU. These are electrically isolated and may handle 12V DC/AC inputs and are referenced to a separate isolated ground. Note: In the ITS Cabinet interface wiring 120 VAC inputs must be routed to the Isolated SIU inputs through a 27K Ohm, 1 watt, resistor located in the PDA ITS Assembly.

   g. The assembly height must be 5.25 in. (3 U).

h. An 18 in. harness cable, with strain relief and sheath and terminated with a BEAU S5404-SB connector, must be supplied for interconnect of +24/+12VDC power.

i. Pins D, E, J, K, and L on each PCB Connector slot must be routed to their associated field terminal, i.e. FT1-12 Additionally, an Equipment Ground Lug must be provided on the back panel for termination of a #8 AWG conductor.

j. Each Input Assembly must contain a 4-bit address code plug and socket. The Input Assembly address must be provided by a plug with jumpers installed to produce a binary code 1, 2, 4, and 8. The address receptacle must be installed on the back panel of the Input Assembly, Ground True Logic must be used with Ground True equaling Logic "1". See instructions on Input Assembly Connectors detail 6-5-38.

k. Securing PDB Connectors. All connectors mounted on the PCB must be mechanically secured to the chassis or frame of the unit or assembly.

9. Output Assembly.

a. The Output Assembly must be an EIA-310B rack mounted assembly delivered in six Switch Pack or fourteen Switch Pack configurations. This assembly may provide eighteen load circuits or forty-two load circuits. Either configuration is designed to interface with a plug in Model 200 Switch Pack Unit. The SIU must be provided resident in its connector to provide interface and control. In addition, a Model 214 AMU Unit must be provided in its connector to sense voltage and current for the CMU. A 25 Pin D Socket must be provided for communication with the ATC Controller Unit. This Socket must be mated with an 18 in. Communications Cable. This Cable must be attached to the Assembly by slotted 4:40 screws. See Serial Bus Harnesses Detail 6-5-39.

b. The Model 205 relay units and Program Blocks must be provided to select control and color state of the Emergency Override State (red, yellow, or no indication output). The programming connectors must be Molex Type 1375 or equal. The relay units and program blocks must be mounted on the rear of the Output Assembly. Program Block Pins must be crimped and soldered. The Model 205 transfer relays must be accessible on the rear of the Output Assembly without the use of tools.

c. An Address Plug and Socket must be provided on Output Assembly for defining the Serial Bus #1 and #3 addressing. See 6/14 Pack Output Assembly Connectors Detail.

d. Transformers must be provided on the incoming AC source for each Switch Pack to measure the load current. See AMU Current Sensing.

e. Field Termination must be provided on the rear panel of the assembly consisting of six-position sockets and plugs.

f. Transient suppression must be provided at the field terminals, for the protection of the Switch Packs, on rear panel of the assembly consisting of three nine-position sockets and plugs for a 6 Pack Output Assembly. A 14 Pack Output Assembly requires seven nine-position sockets and plugs. Each socket must provide protection for two Switch Packs. Protection devices must be terminated to Equipment Ground.

g. A Serial Bus #1 DB25 female connector must be provided on the upper left rear panel of the Output Assembly for serial interconnection to the DC Power/Communication Assembly. This Socket must be mated with an 18 in. Communications Cable. This Cable must be attached to the Assembly by slotted 4:40 screws. See Serial Bus Harnesses Detail.

h. A CDC Connector must be provided on the rear panel of the Output Assembly for signal interconnection to the unit. The CDC Socket is a 9 Pin "D" connector. These inputs are electrically isolated and may handle 120 VAC signals when wired to the PDA ITS Assembly and 12 VAC inputs that are referenced to a separate isolated ground. This Cable must be attached to the Assembly by slotted 4:40 screws.

i. Two RJ-11S Connectors must be provided on the rear panel of the Output Assembly for signal interconnection of Serial Bus #3.

j. An Equipment Ground Lug must be provided on the rear panel for termination of a #8 green wire.

k. The 6-Pack Output Assembly height must be 5.25 in. (3 U) and the 14-Pack Output Assembly must be 10-1/2 in.

10. Cabinet Harnesses. Cabinet Harnesses are supplied with each cabinet configuration. See Serial Bus and DCP Harness Details.

11. Fiber Optic Termination Panel. A Fiber Optic Termination Panel shall be supplied with each cabinet configuration. See Fiber Optic Termination Panel Details.

12. The Service Assembly must be an EIA-310B rack mounted assembly providing seven slots of sockets. Three (3) Model 218 Serial Interface Units (SIU) must be provided in their locations mated to DIN 96S-Pin Connectors. Three (3) Model 214 Auxiliary Monitor Unit (AMU) must be provided in their locations mated to DIN 96S-Pin Connectors. One (1) Model 212 Cabinet Monitor Unit (CMU) must be provided in its location mated to a DIN 64S Connector.

K. Cabinet Details.

Cabinet Housings # 1 and # 2	Figure 26
Cabinet Housing # 3 – Detail 1	Figure 27
Cabinet Housing # 3 – Detail 2	Figure 28
Cabinet Cages # 1 and # 2	Figure 29
Cabinet Cage to Housing # 1 and # 2 Supports	Figure 30
Cabinet Cage to Housing # 3 Supports	Figure 31
Cabinet Housing # 2/Adapters and Shipping Pallet	Figure 32
"J" Panels – Cage 1	Figure 33
"J" Panels – Cage 2	Figure 34
Controller Shelf/Drawer Support Assembly	Figure 35
Service Panel Assembly Cage 1 and 2	Figure 36
Service Panel Assembly Schematic	Figure 37
Input Termination Panel Housing #1	Figure 38
AC Clean Module Assembly and Harness	Figure 39
Raw/Clean AC Power Assembly and Extension 4 Socket	Figure 40
Raw/Clean AC Power Assembly and Extension 2 Socket	Figure 41
Raw/Clean AC Power Assembly Wiring Diagram 4 Socket	Figure 42
Raw/Clean AC Power Assembly Wiring Diagram 2 Socket	Figure 43
DC Power/Communications Assembly and Extension	Figure 44
DC Power/Communications Assembly Wiring Diagram	Figure 45
PDA 5 IP ITS – Front View	Figure 46
PDA 5 EP ITS – Front View	Figure 47
PDA 5 IP/EP ITS – Rear View	Figure 48
PDA 5 IP ITS/Cabinet – Wiring Diagram	Figure 49
PDA 5 EP ITS/Cabinet – Wiring Diagram	Figure 50
PDA 5 IP/EP ITS – Connectors	Figure 51
6/14 Pack Output Assembly – Front View	Figure 52
6/14 Pack Output Assembly – Rear Views	Figure 53
6/14 Pack Output Assembly – Wiring Diagram	Figure 54
6 Pack O/A – CB/Flasher Diagram and Assignment Note	Figure 55
14 Pack O/A – CB/Flasher Diagram	Figure 56
6/14 Pack Output Assembly Connectors	Figure 57
AMU to Output Assembly Interconnect	Figure 58
Serial Bus #1 and #2 Terminator Unit	Figure 59
Bus Assembly and Shelve Attachment Detail	Figure 60
CDC Harness/Manual Advance Push Button Cable	Figure 61
Service Assembly 1	Figure 62
Service Assembly 2	Figure 63

Input Assembly – Front View	Figure 64
Input Assembly – Rear View	Figure 65
Input Assembly – Wiring Diagram	Figure 66
Input Assembly – Connectors	Figure 67
Serial Bus Harness	Figure 68
DC Power/Police Panel Harnesses	Figure 69
Field Wire Support Bracket/Transient Protector Assembly	Figure 70
Fiber Optic Termination Panel	Figure 71
Police Panel and CC Schematic (CMU Bypass)	Figure 72
Police Panel and CC Schematic General	Figure 73

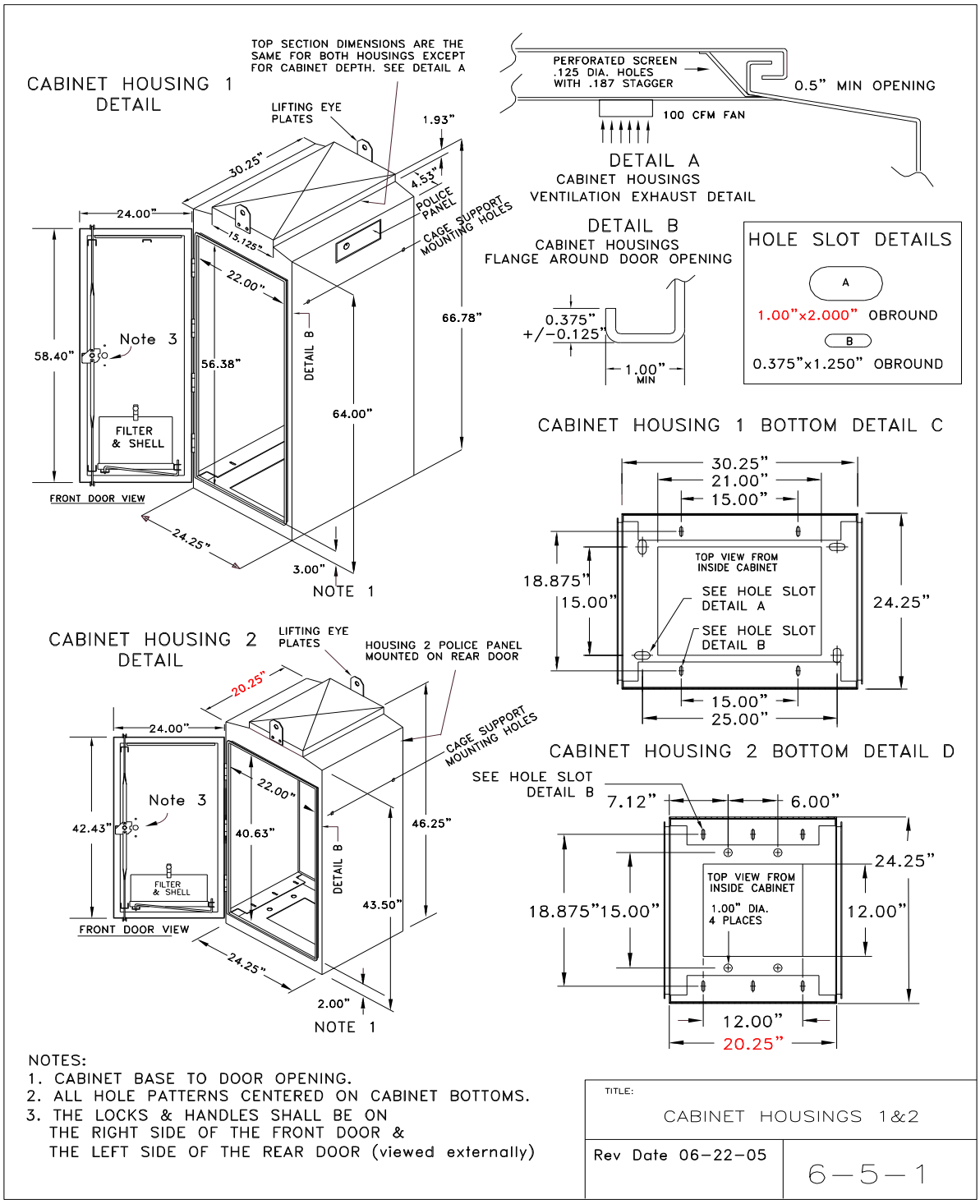


Figure 26
Cabinet Housings # 1 and # 2

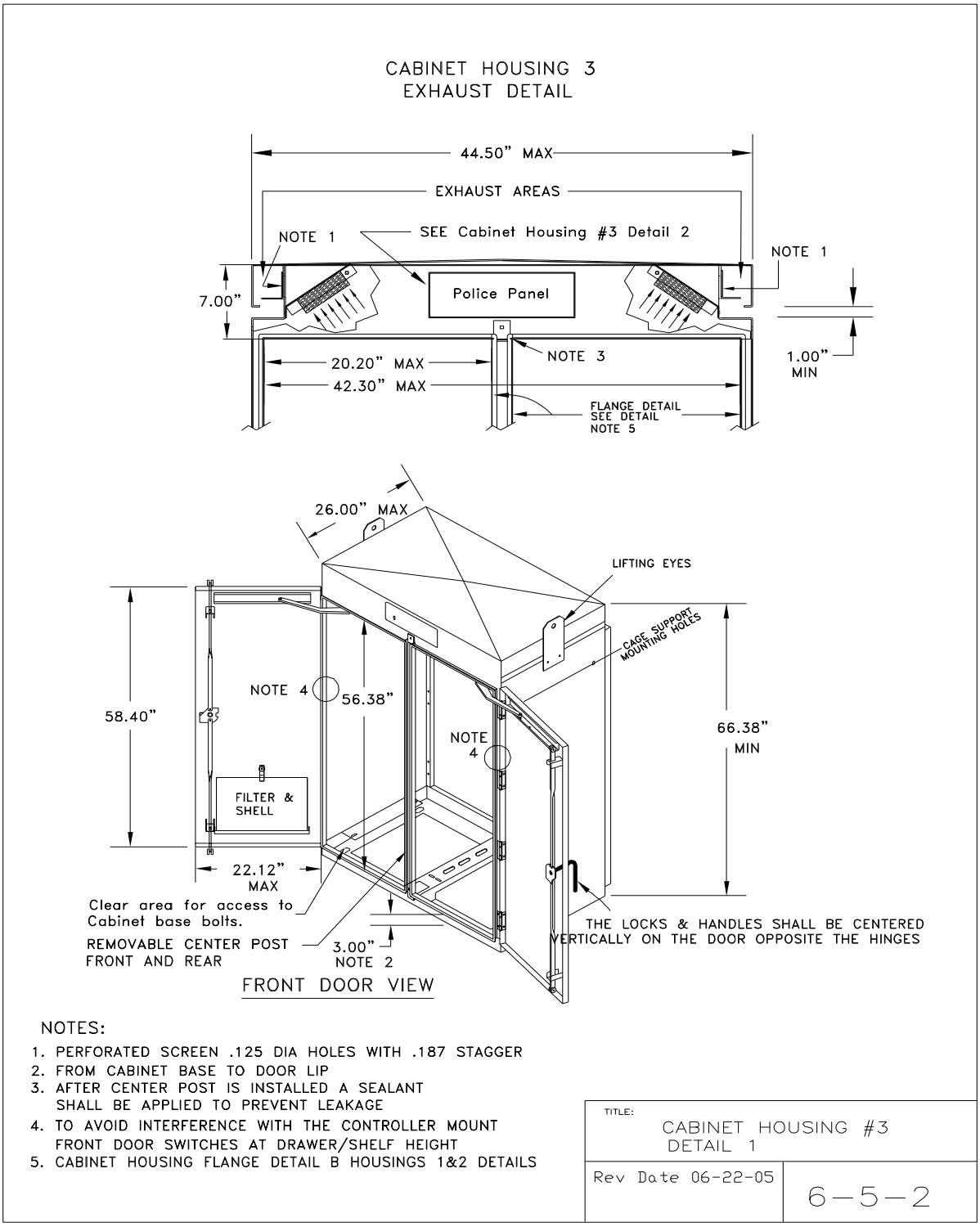


Figure 27
Cabinet Housing # 3 – Detail 1

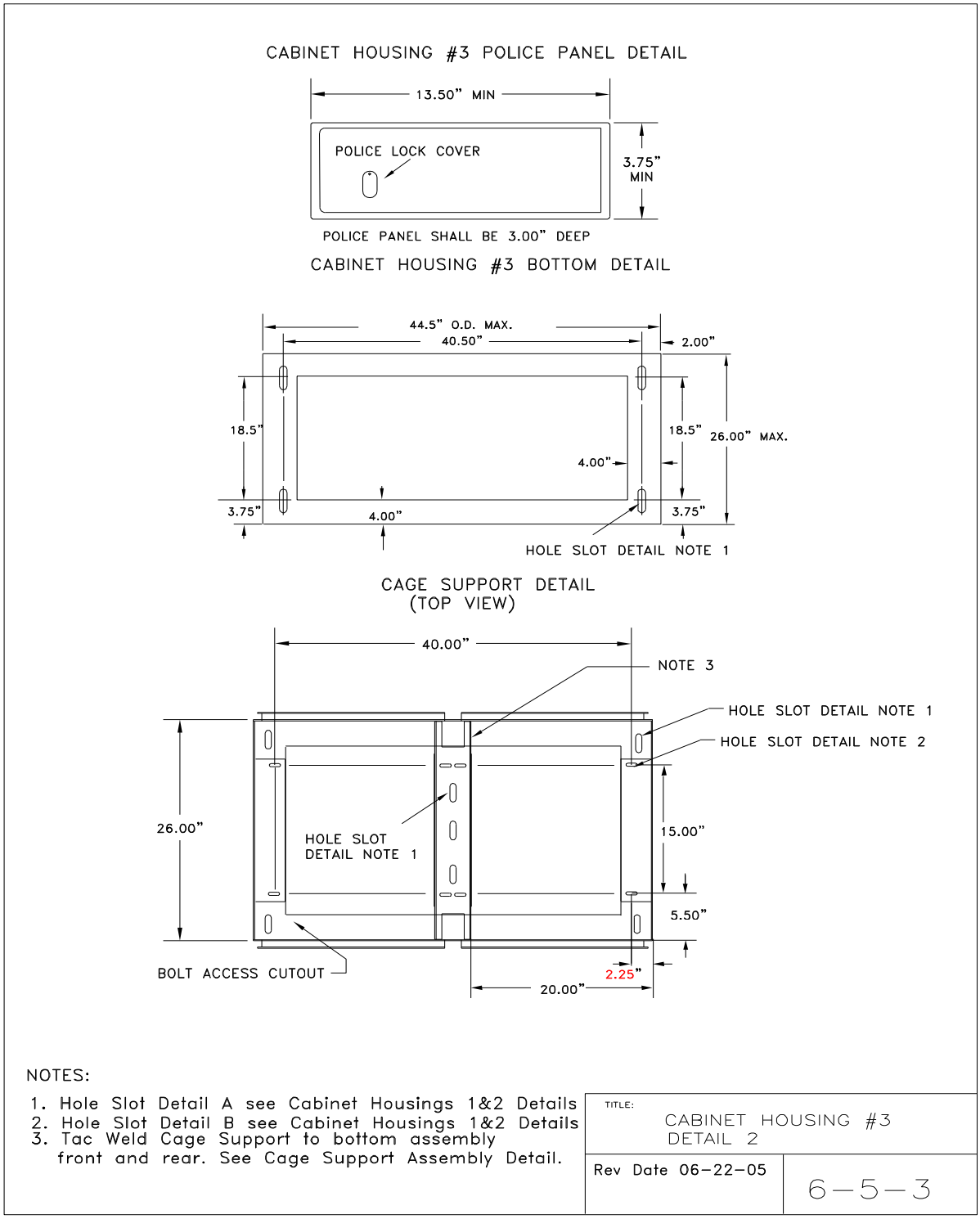


Figure 28
Cabinet Housing # 3 – Detail 2

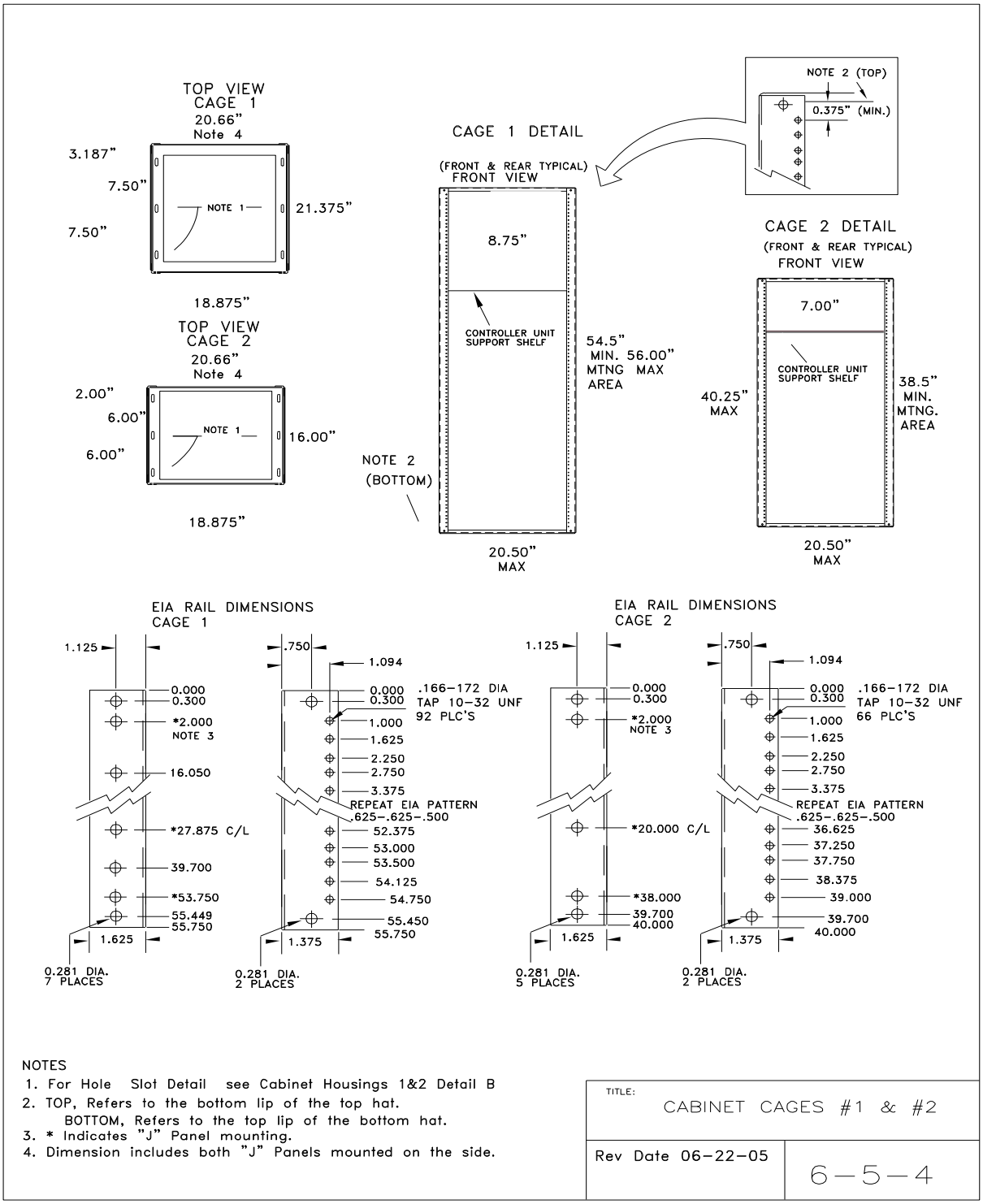


Figure 29
Cabinet Cages # 1 and # 2

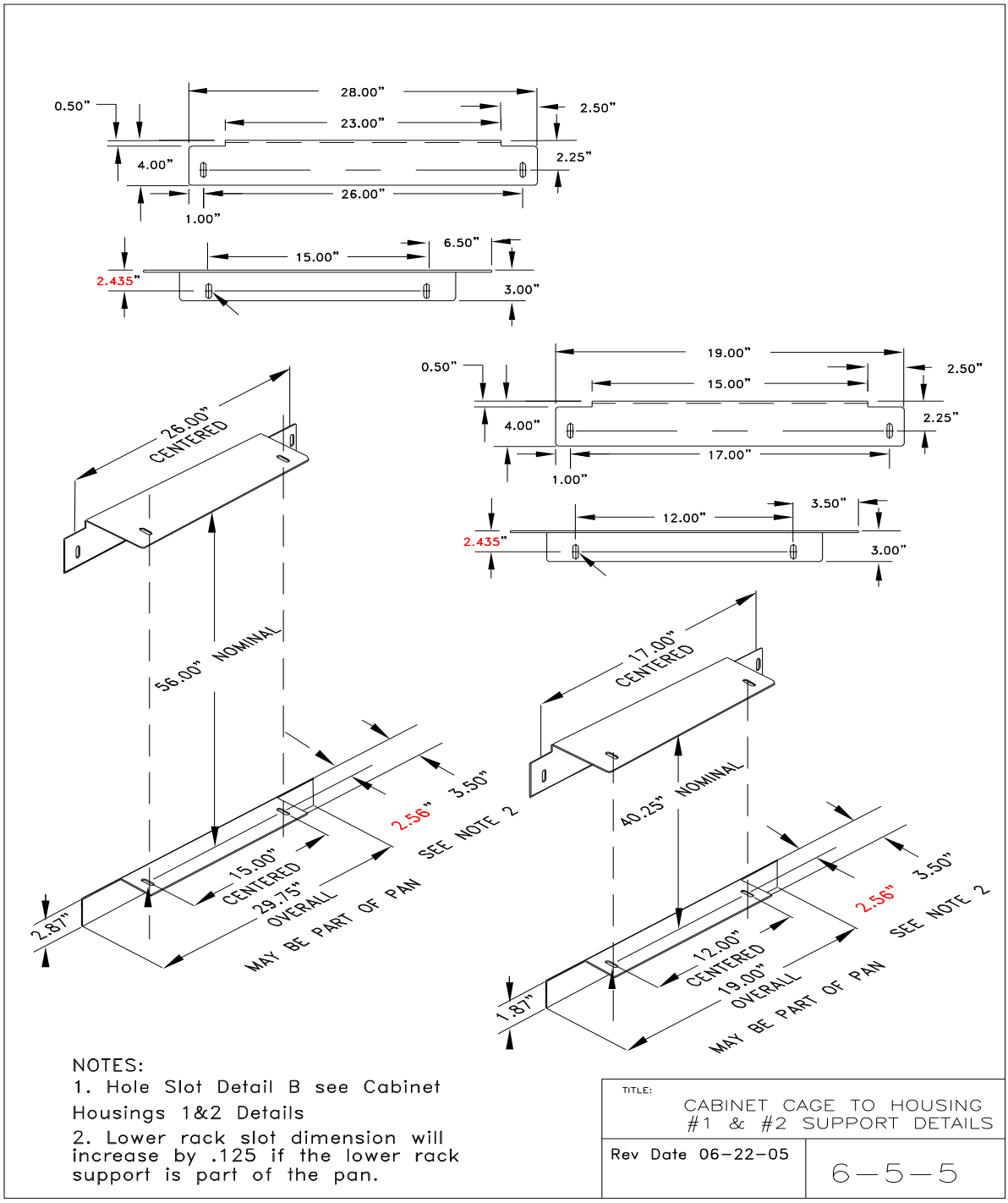


Figure 30
Cabinet Cage to Housing # 1 and # 2 Supports

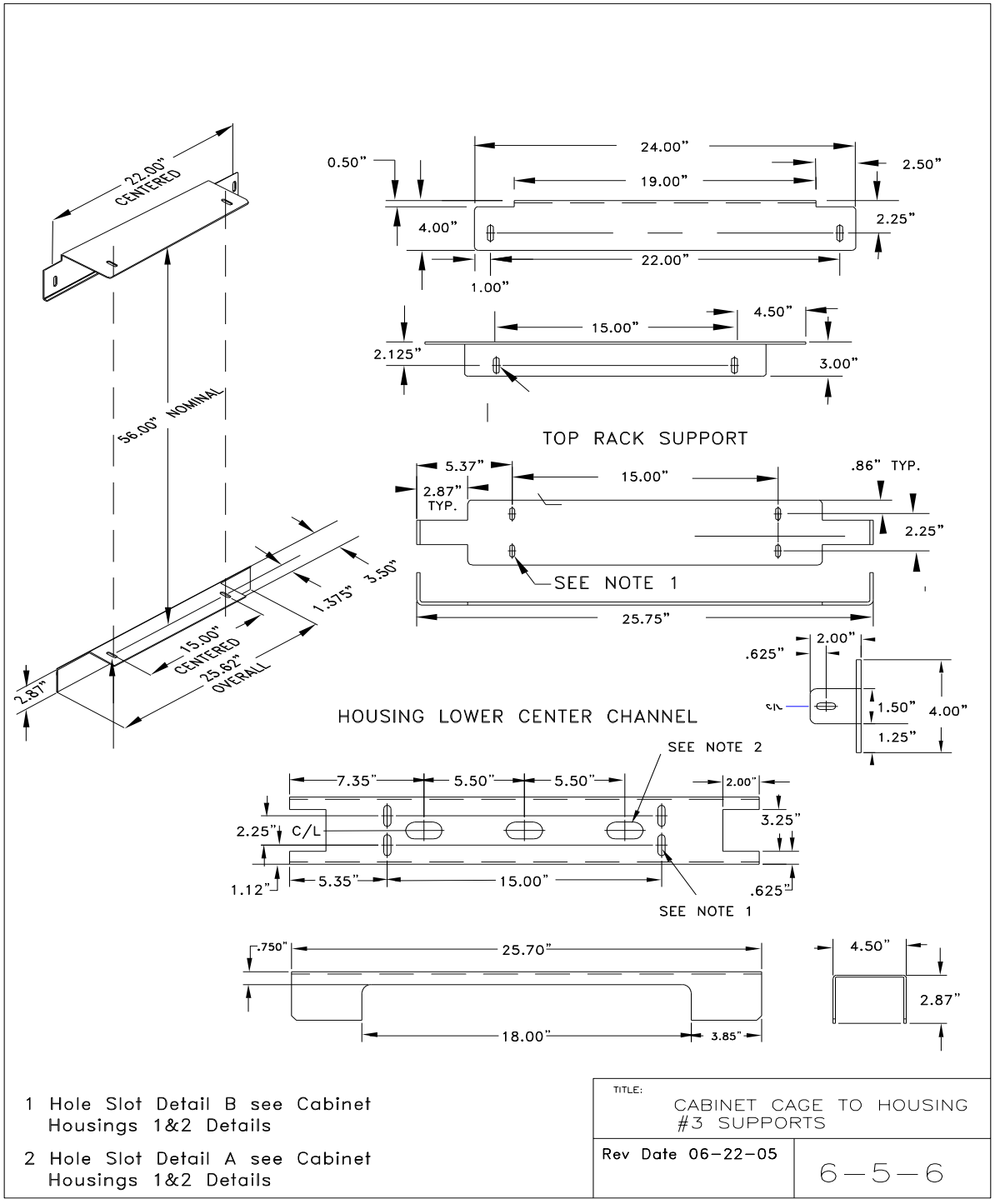


Figure 31
Cabinet Cage to Housing # 3 Supports

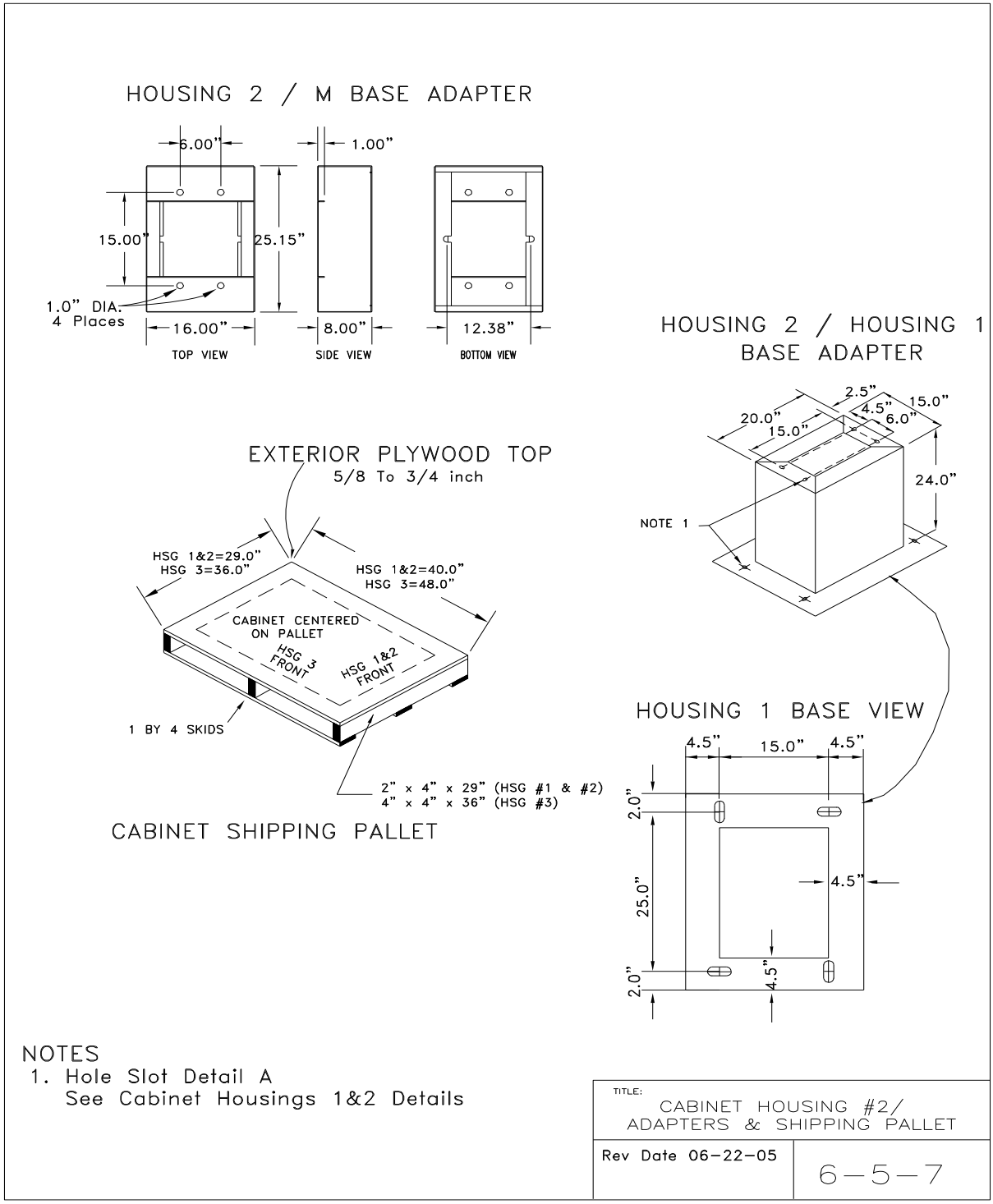


Figure 32
Cabinet Housing # 2/Adapters and Shipping Pallet

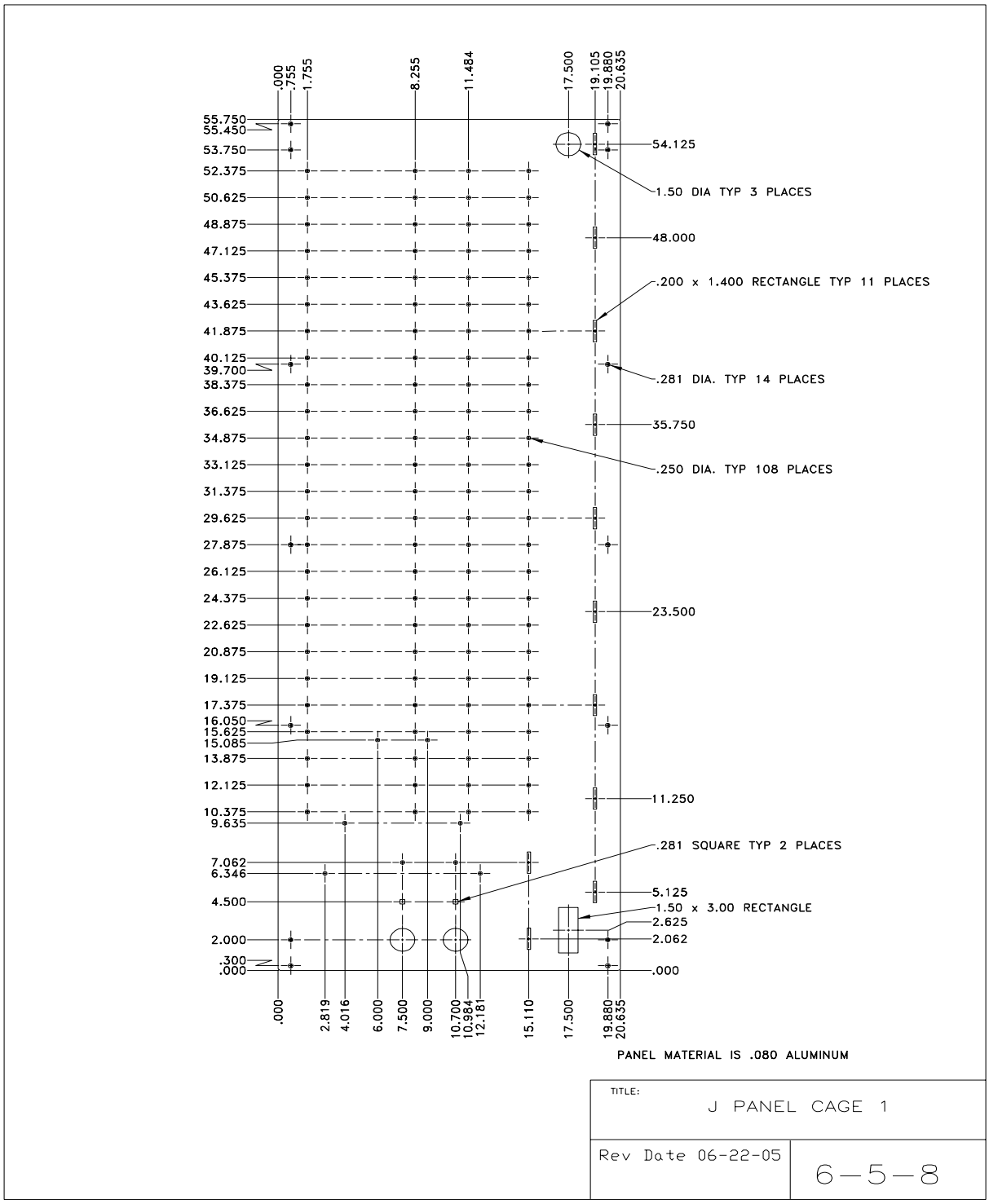


Figure 33
"J" Panels – Cage 1

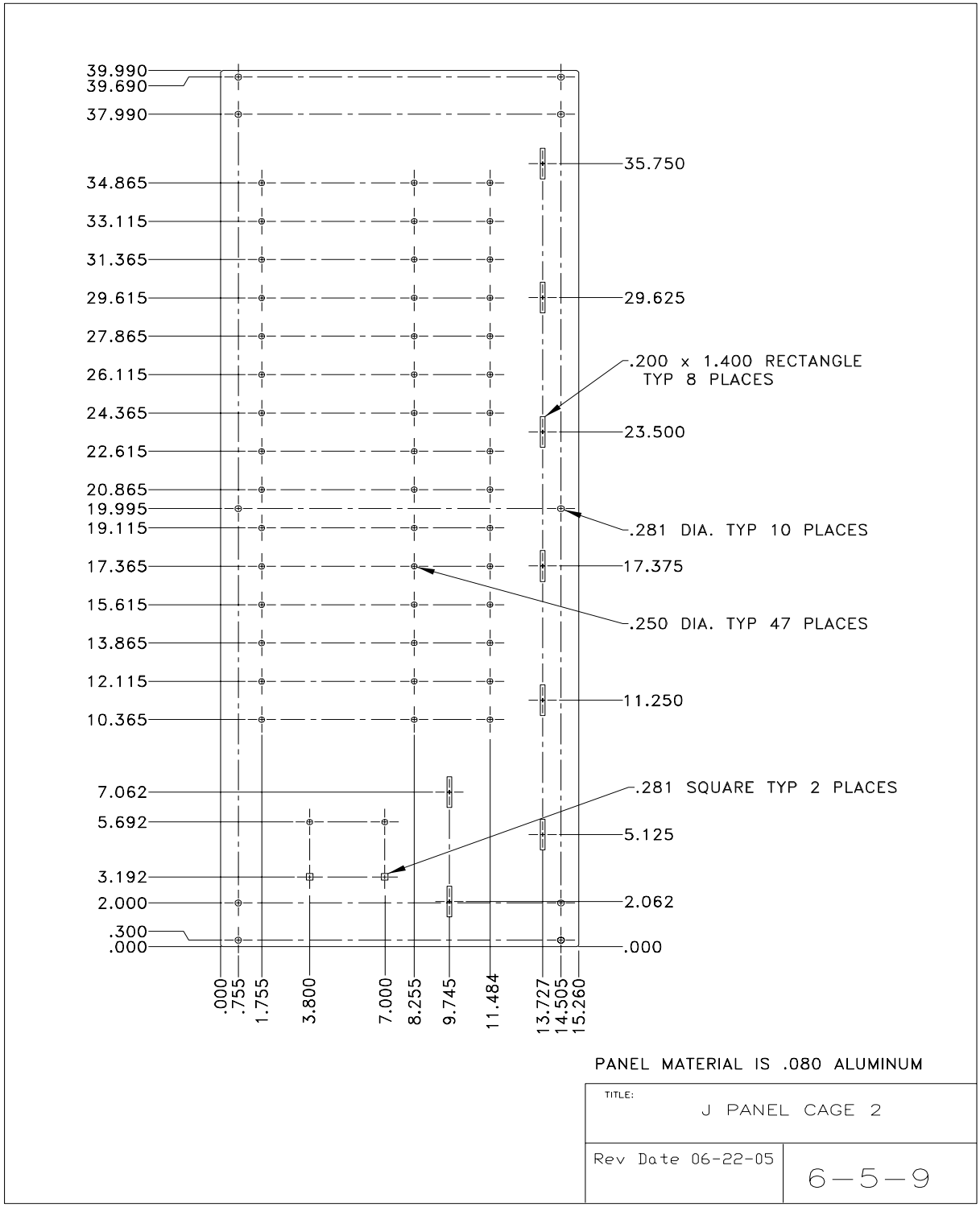


Figure 34
"J" Panels – Cage 2

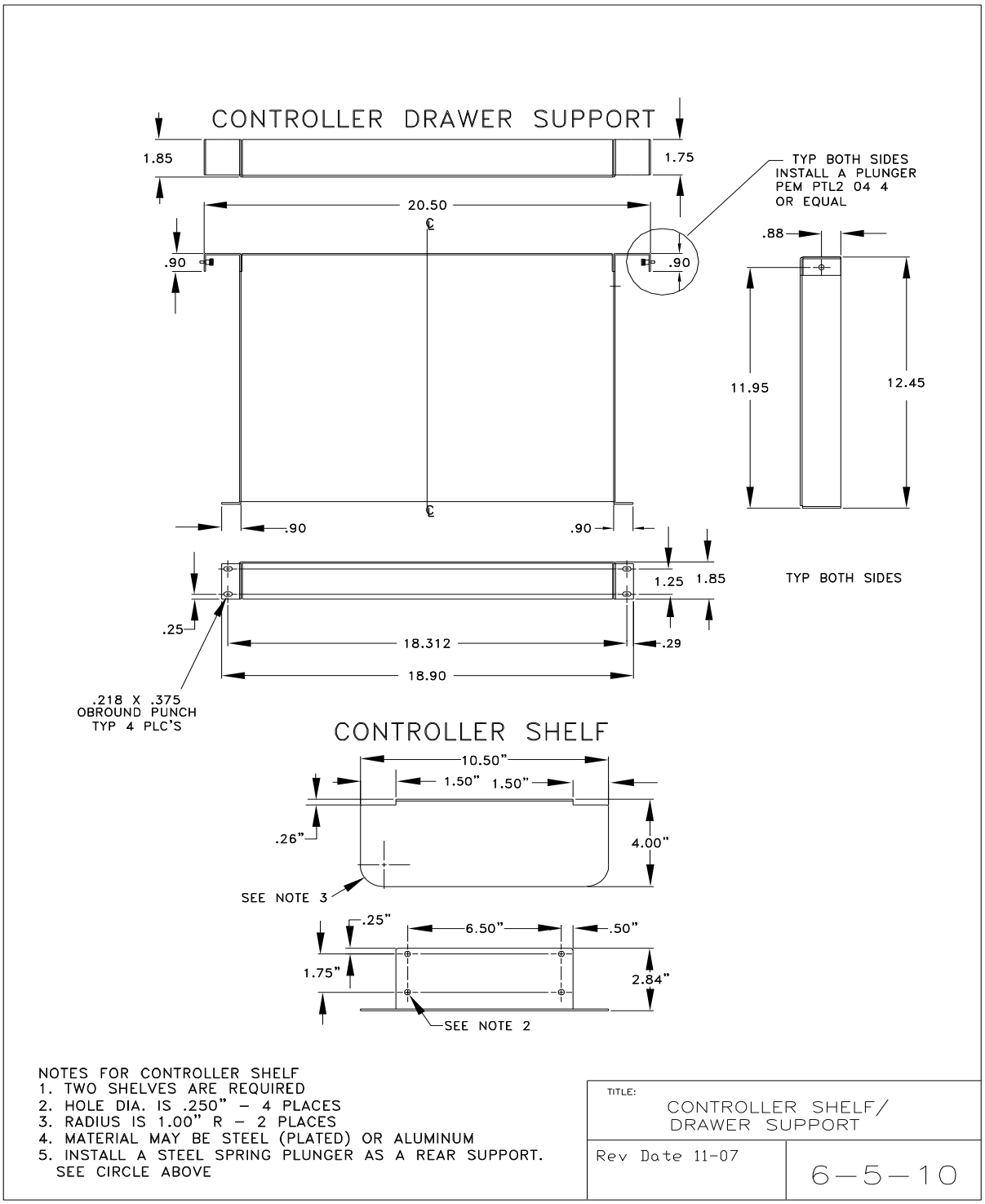


Figure 35
Controller Shelf/Drawer Support Assembly

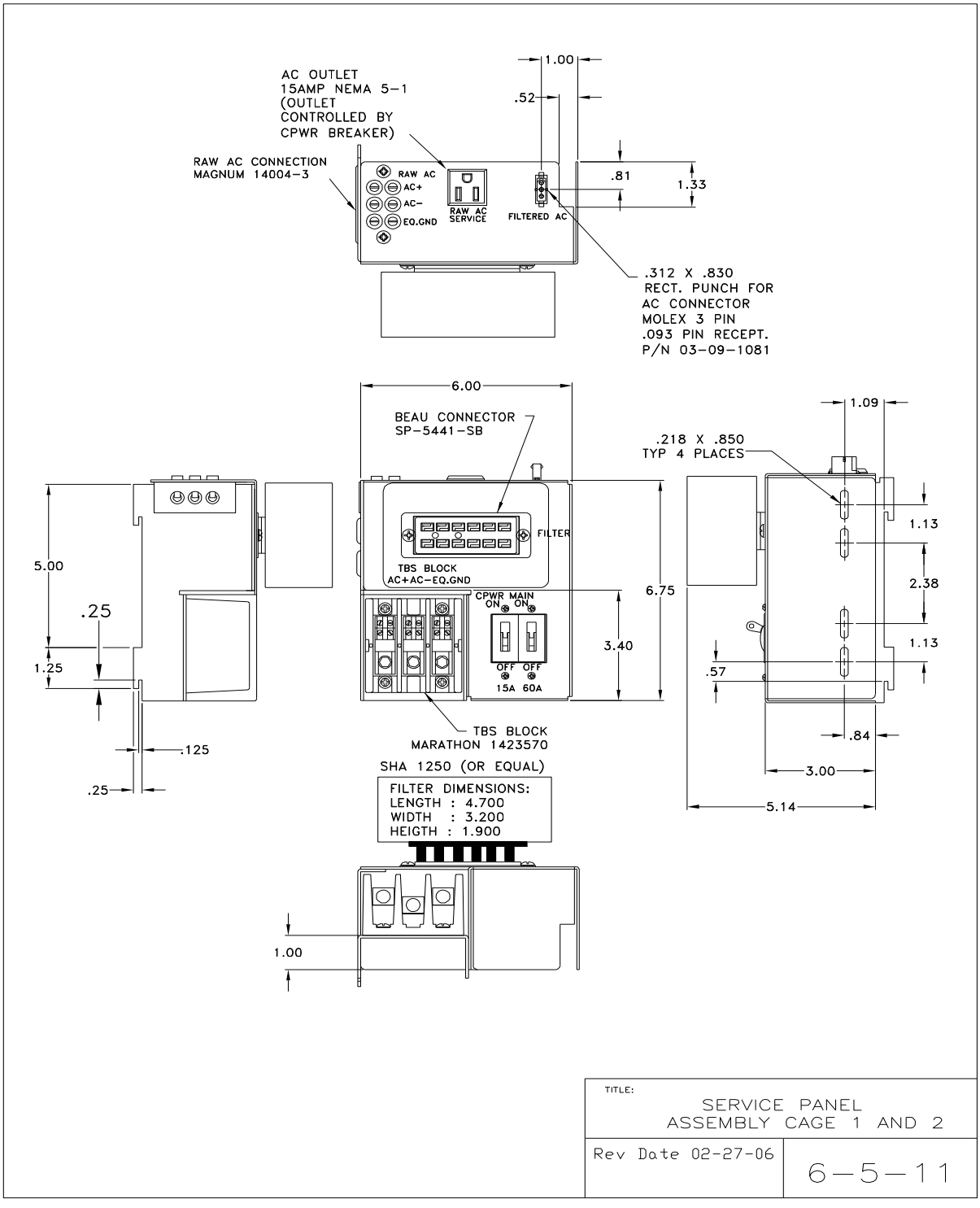


Figure 36
Service Panel Assembly Cage 1 and 2

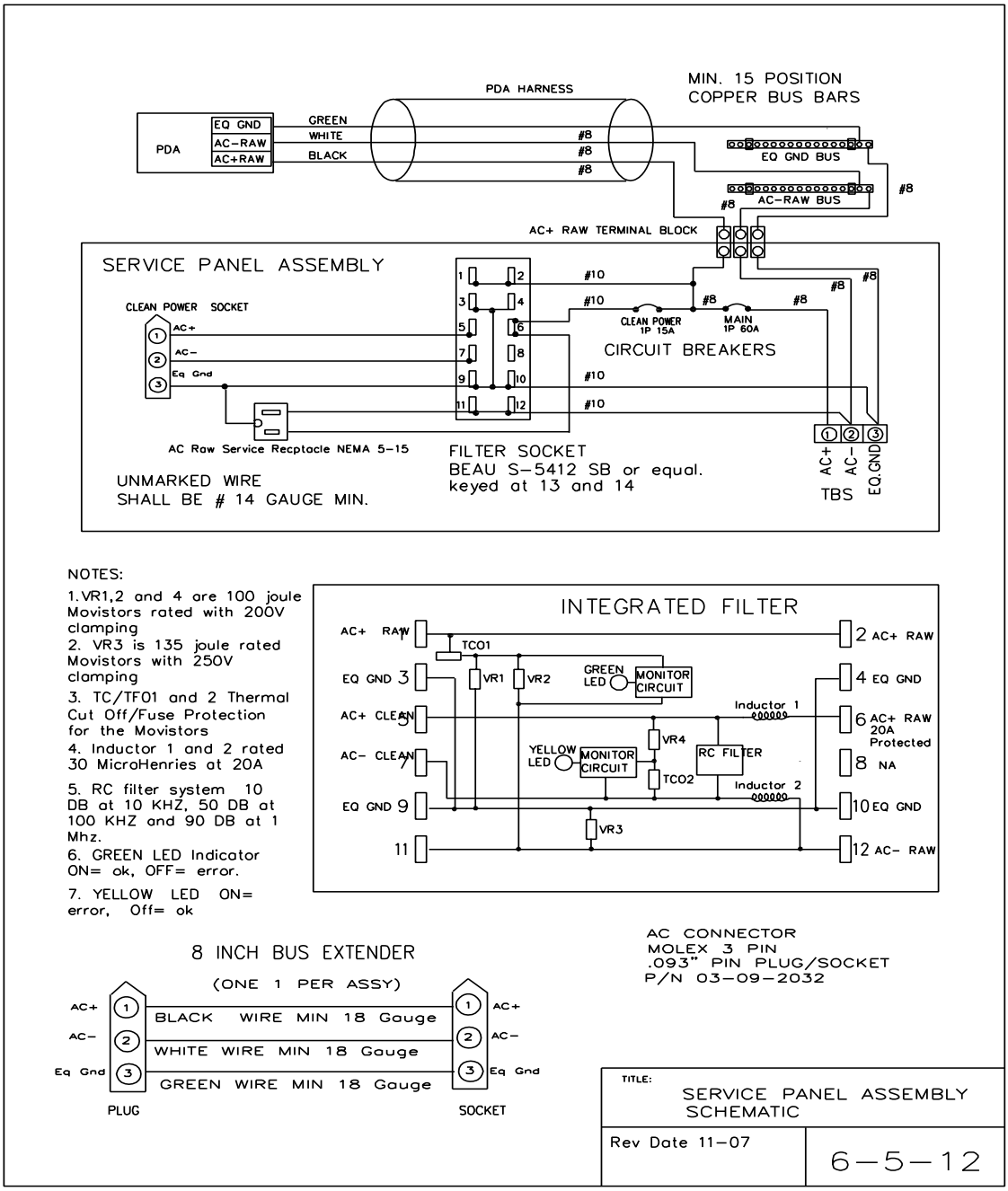


Figure 37
Service Panel Assembly Schematic

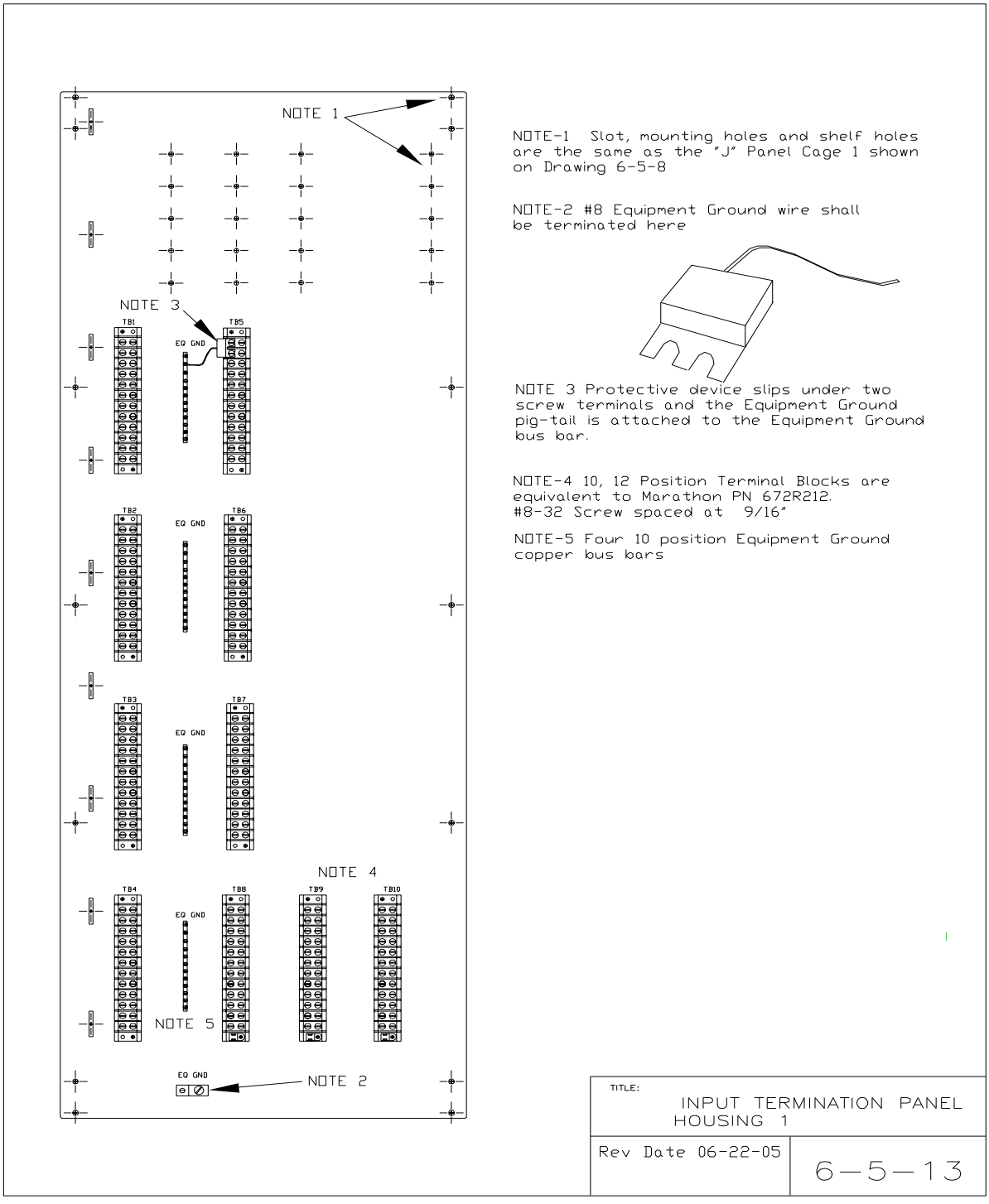


Figure 38
Input Termination Panel Housing #1

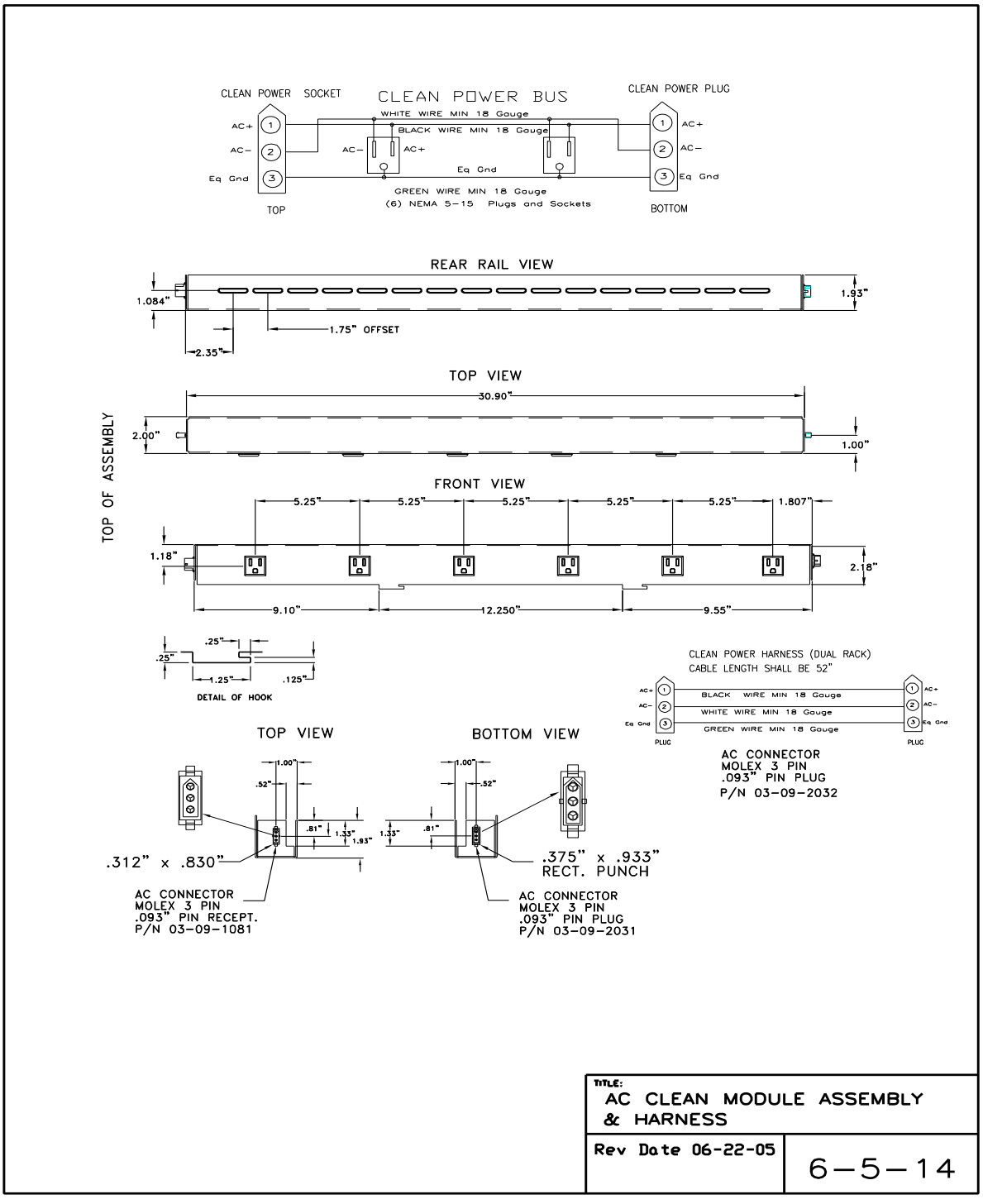


Figure 39
AC Clean Module Assembly and Harness

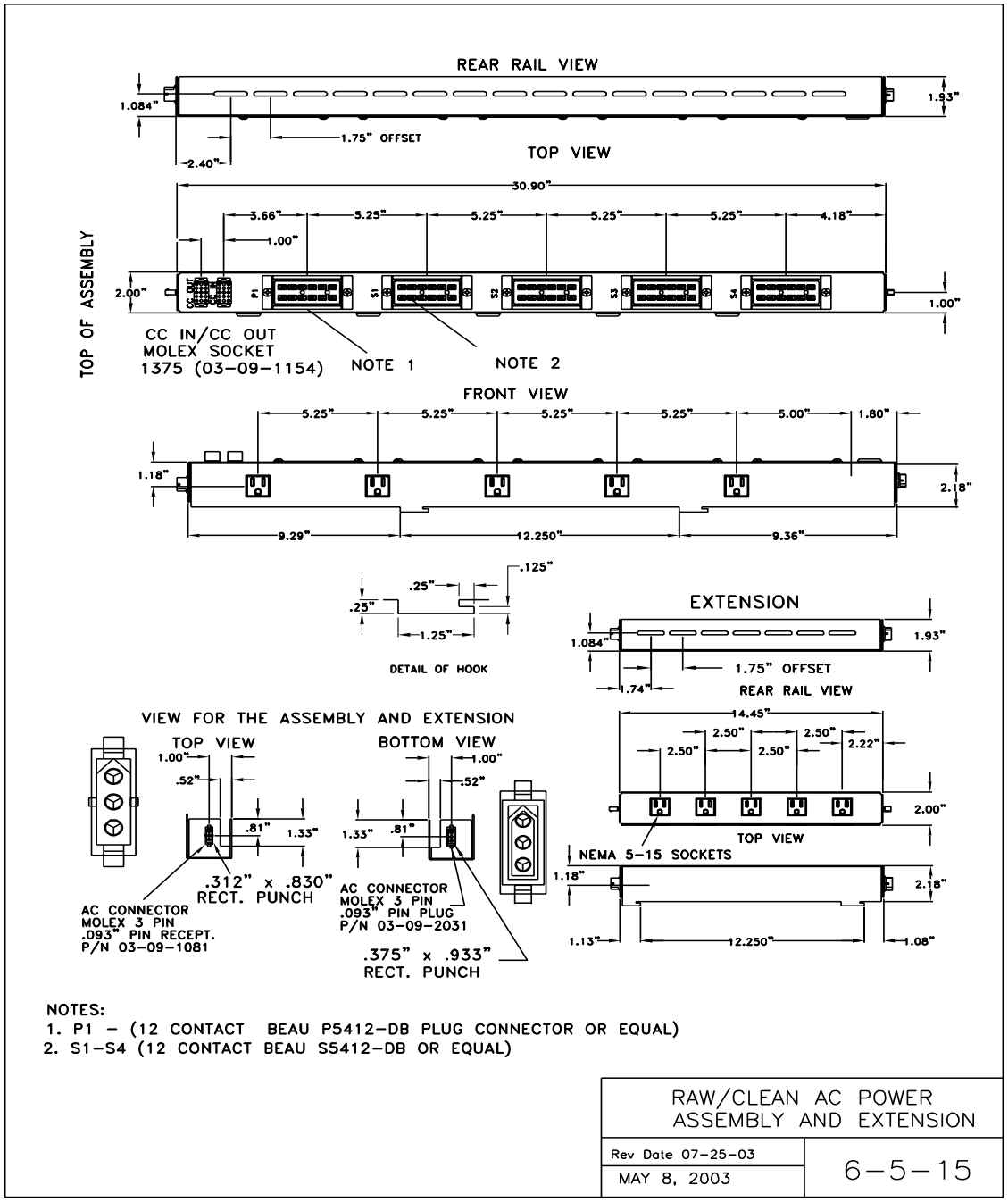


Figure 40
Raw/Clean AC Power Assembly and Extension 4 Socket

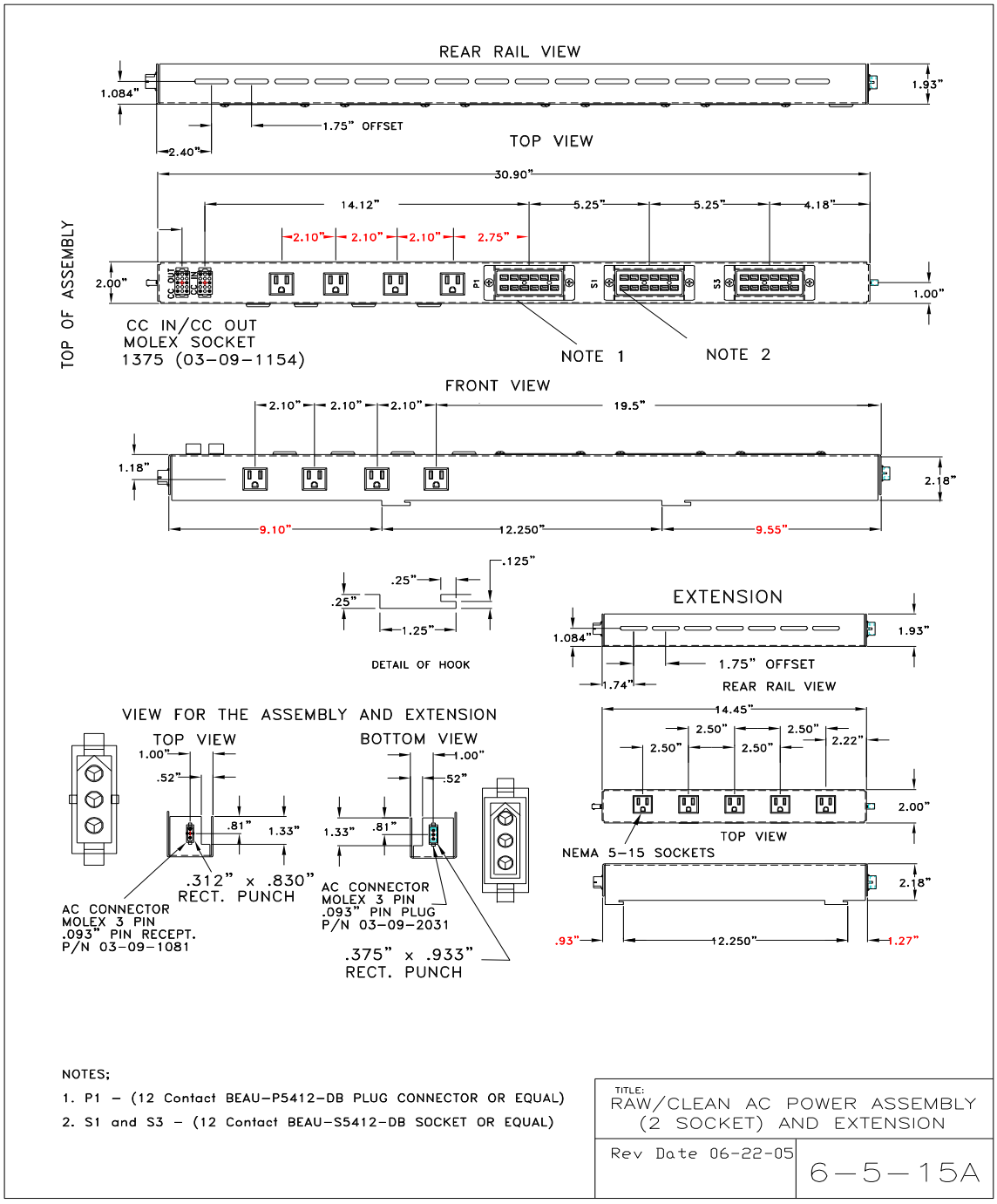
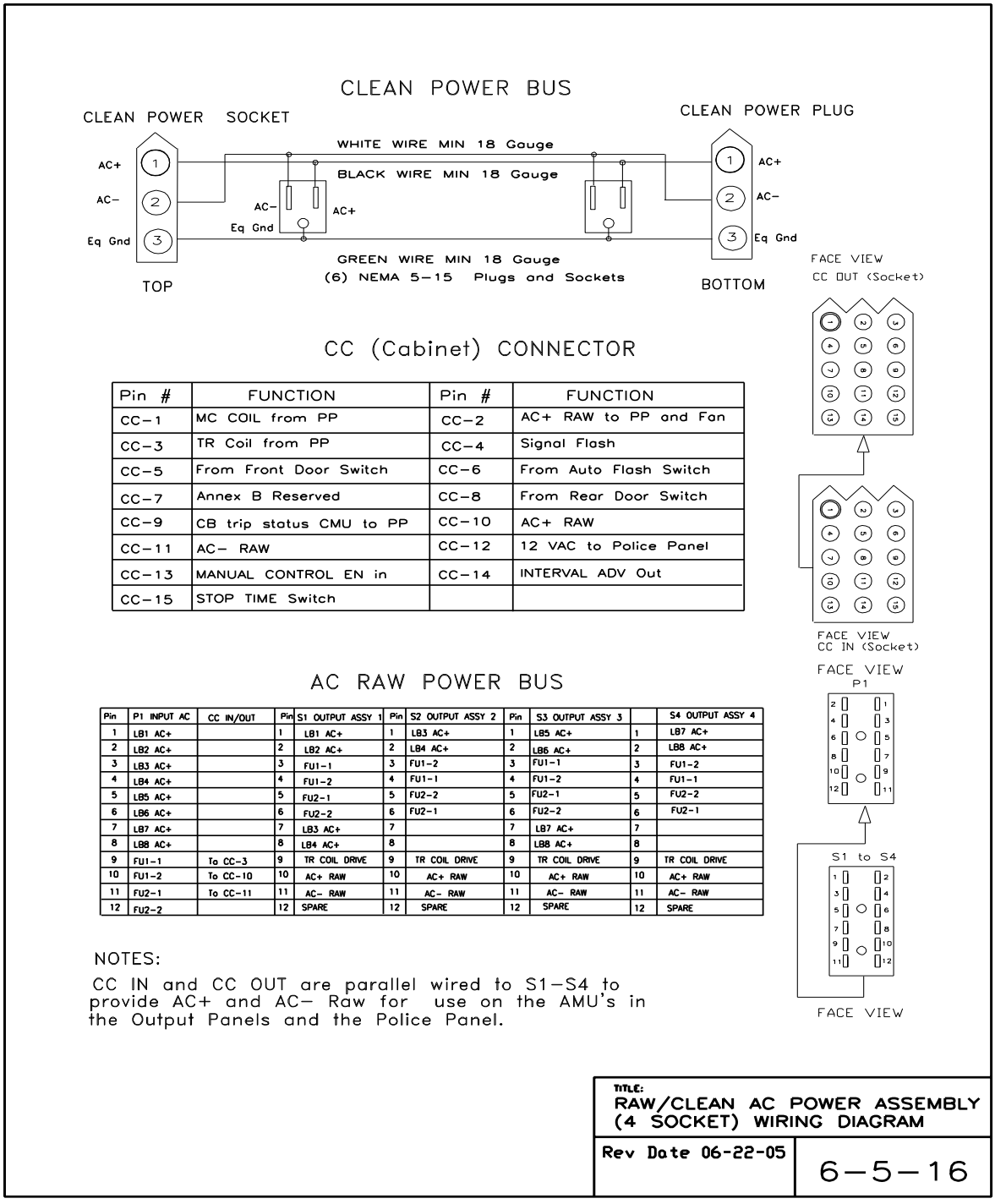


Figure 41
Raw/Clean AC Power Assembly and Extension 2 Socket



CC (Cabinet) CONNECTOR

Pin #	FUNCTION	Pin #	FUNCTION
CC−1	MC COIL from PP	CC−2	AC+ RAW to PP and Fan
CC−3	TR Coil from PP	CC−4	Signal Flash
CC−5	From Front Door Switch	CC−6	From Auto Flash Switch
CC−7	Annex B Reserved	CC−8	From Rear Door Switch
CC−9	CB trip status CMU to PP	CC−10	AC+ RAW
CC−11	AC− RAW	CC−12	12 VAC to Police Panel
CC−13	MANUAL CONTROL EN in	CC−14	INTERVAL ADV Out
CC−15	STOP TIME Switch		

AC RAW POWER BUS

Pin	P1 INPUT AC	CC IN/OUT	Pin	S1 OUTPUT ASSY 1	Pin	S2 OUTPUT ASSY 2	Pin	S3 OUTPUT ASSY 3		S4 OUTPUT ASSY 4
1	LB1 AC+		1	LB1 AC+	1	LB3 AC+	1	LB5 AC+	1	LB7 AC+
2	LB2 AC+		2	LB2 AC+	2	LB4 AC+	2	LB6 AC+	2	LB8 AC+
3	LB3 AC+		3	FU1-1	3	FU1-2	3	FU1-1	3	FU1-2
4	LB4 AC+		4	FU1-2	4	FU1-1	4	FU1-2	4	FU1-1
5	LB5 AC+		5	FU2-1	5	FU2-2	5	FU2-1	5	FU2-2
6	LB6 AC+		6	FU2-2	6	FU2-1	6	FU2-2	6	FU2-1
7	LB7 AC+		7	LB3 AC+	7		7	LB7 AC+	7	
8	LB8 AC+		8	LB4 AC+	8		8	LB8 AC+	8	
9	FU1-1	To CC-3	9	TR COIL DRIVE	9	TR COIL DRIVE	9	TR COIL DRIVE	9	TR COIL DRIVE
10	FU1-2	To CC-10	10	AC+ RAW	10	AC+ RAW	10	AC+ RAW	10	AC+ RAW
11	FU2-1	To CC-11	11	AC- RAW	11	AC- RAW	11	AC- RAW	11	AC- RAW
12	FU2-2		12	SPARE	12	SPARE	12	SPARE	12	SPARE

NOTES:

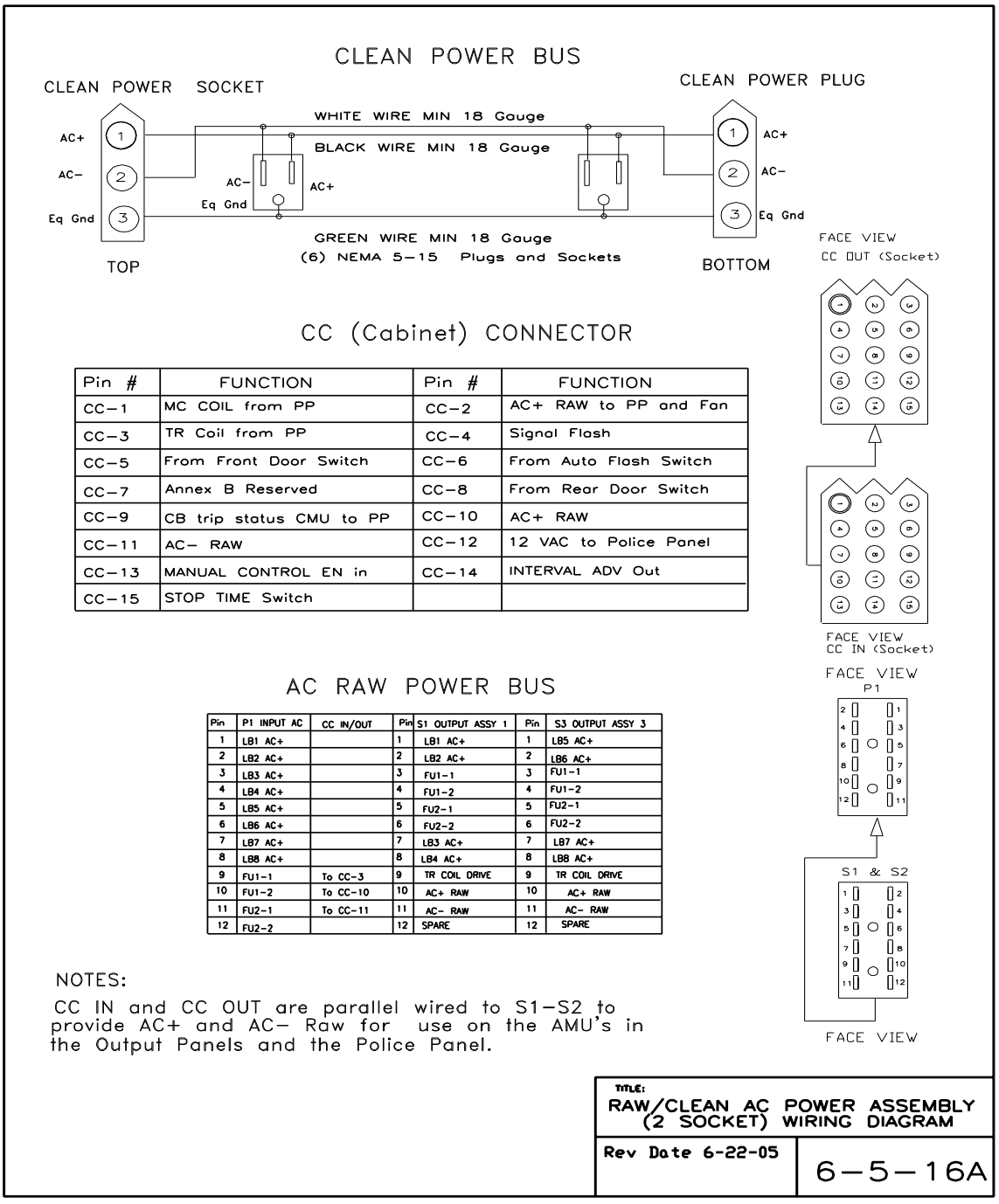
CC IN and CC OUT are parallel wired to S1−S4 to provide AC+ and AC− Raw for use on the AMU's in the Output Panels and the Police Panel.

TITLE:
RAW/CLEAN AC POWER ASSEMBLY
(4 SOCKET) WIRING DIAGRAM

Rev Date 06-22-05

6−5−16

Figure 42
Raw/Clean AC Power Assembly Wiring Diagram 4 Socket



Pin #	FUNCTION	Pin #	FUNCTION
CC−1	MC COIL from PP	CC−2	AC+ RAW to PP and Fan
CC−3	TR Coil from PP	CC−4	Signal Flash
CC−5	From Front Door Switch	CC−6	From Auto Flash Switch
CC−7	Annex B Reserved	CC−8	From Rear Door Switch
CC−9	CB trip status CMU to PP	CC−10	AC+ RAW
CC−11	AC− RAW	CC−12	12 VAC to Police Panel
CC−13	MANUAL CONTROL EN in	CC−14	INTERVAL ADV Out
CC−15	STOP TIME Switch		

Pin	P1 INPUT AC	CC IN/OUT	Pin	S1 OUTPUT ASSY 1	Pin	S3 OUTPUT ASSY 3
1	LB1 AC+		1	LB1 AC+	1	LB5 AC+
2	LB2 AC+		2	LB2 AC+	2	LB6 AC+
3	LB3 AC+		3	FU1-1	3	FU1-1
4	LB4 AC+		4	FU1-2	4	FU1-2
5	LB5 AC+		5	FU2-1	5	FU2-1
6	LB6 AC+		6	FU2-2	6	FU2-2
7	LB7 AC+		7	LB3 AC+	7	LB7 AC+
8	LB8 AC+		8	LB4 AC+	8	LB8 AC+
9	FU1-1	To CC-3	9	TR COIL DRIVE	9	TR COIL DRIVE
10	FU1-2	To CC-10	10	AC+ RAW	10	AC+ RAW
11	FU2-1	To CC-11	11	AC- RAW	11	AC- RAW
12	FU2-2		12	SPARE	12	SPARE

Figure 43
Raw/Clean AC Power Assembly Wiring Diagram 2 Socket

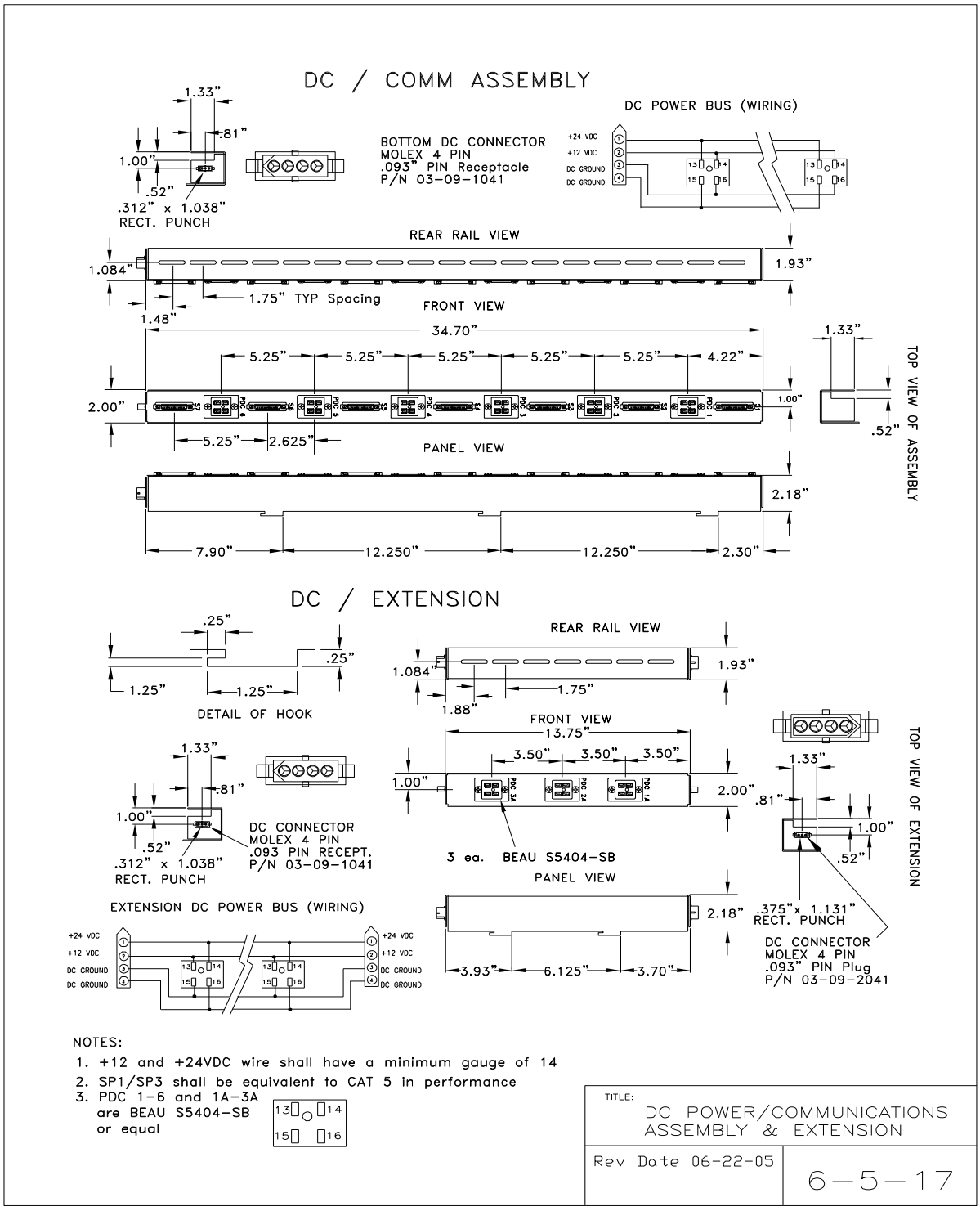
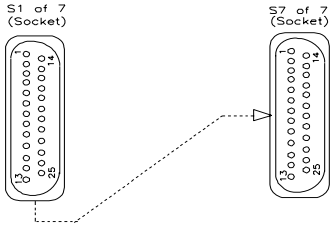


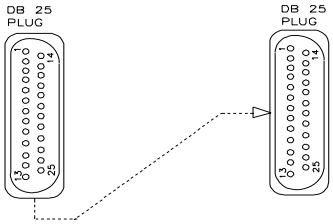
Figure 44
DC Power/Communications Assembly and Extension

COMMUNICATIONS INTERFACE
FOR DC/COMM ASSEMBLY

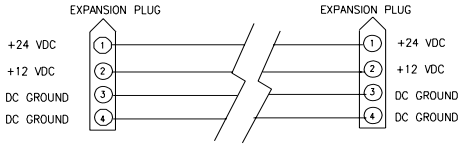


DC/COMM ASSEMBLY (COM WIRING)
S1 through S7 are daisy chained within the assembly
Pins 1/14, 2/15,3/16,4/17,5/18, 6/19,7/20,8/21,9/22,10/23,11/24, 12/25 and 13/spare are twisted pairs within the cable harness.

Pin	AT THE CONTROLLER	Pin	AT THE CONTROLLER
1	SB1 TXD+	14	SB1 TXD−
2	SB1 RXD+	15	SB1 RXD−
3	SB1 TXC+	16	SB1 TXC−
4	SB1 RXC+	17	SB1 RXC−
5	SB2 TXD+	18	SB2 TXD−
6	SB2 RXD+	19	SB2 RXD−
7	SB2 TXC+	20	SB2 TXC−
8	SB2 RXC+	21	SB2 RXC−
9	LINE SYNC+	22	LINE SYNC−
10	NRESET+	23	NRESET−
11	PWR DWN+	24	PWR DWN−
12	+5VDC ISO	25	EQ GND
13	ISO GND		



COMM HARNESS EXTENSION CABLE LENGTH 52”



DC POWER EXTENSION CABLE PLUGS
MOLEX 4 PIN .093” PLUG
P/N 03-09-2042
CABLE LENGTH IS 52”

DC POWER BUS EXTENSION CABLE

NOTES:

1. DC power cable shall be 14 Gauge Minimum.
2. Communications Interface shall meet CAT 5 electrical characteristics
3. DC Power/Communications Assembly DB25 D Sub Connectors shall be mounted with 4−40 jack female sockets

TITLE: COMM ASSEMBLY WIRING
COMM EXTENSION CABLE
DC POWER EXTENSION CABLE

Rev Date 06-22-05

6−5−18

Figure 45
DC Power/Communications Assembly Wiring Diagram

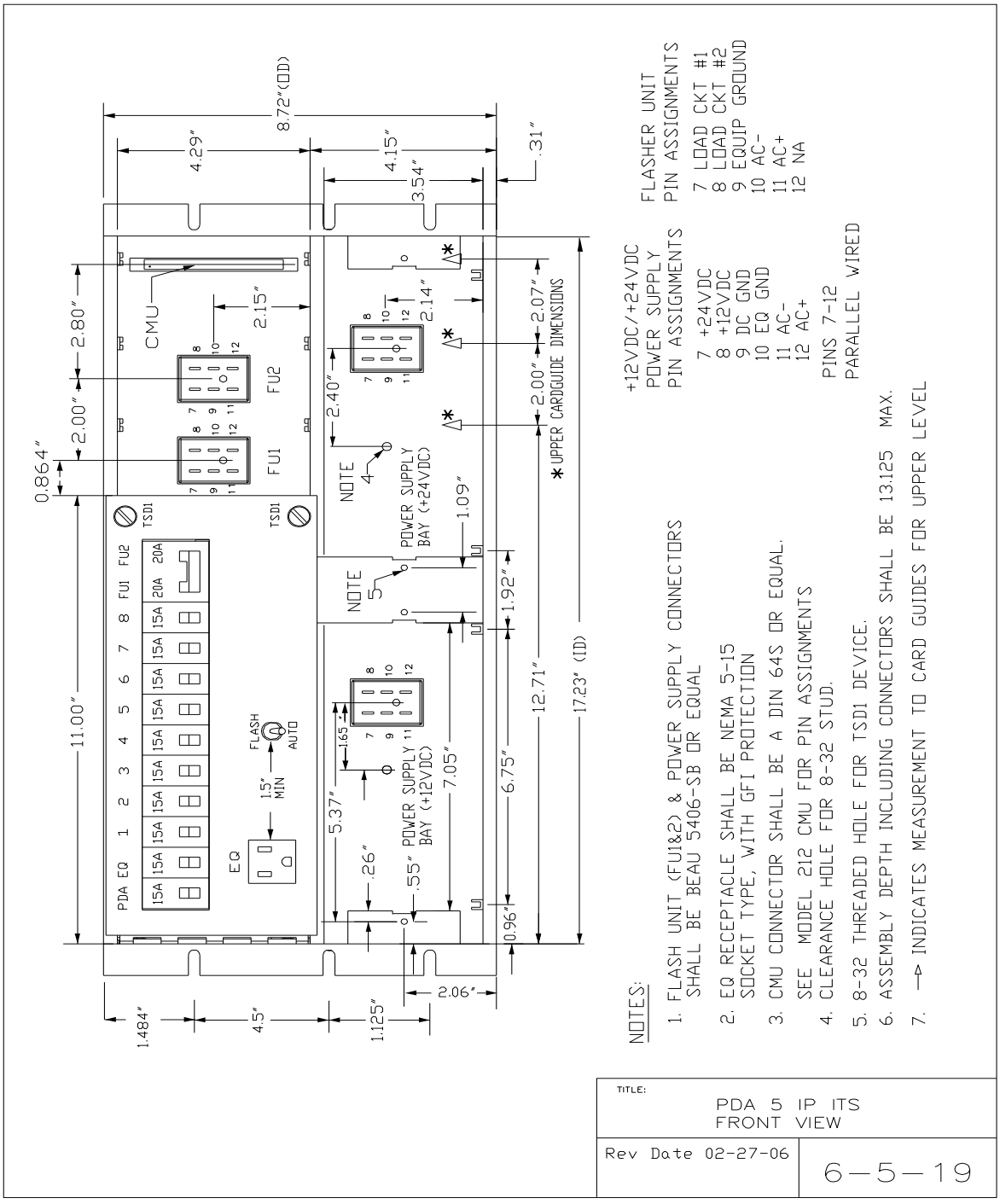


Figure 46
PDA 5 IP ITS – Front View

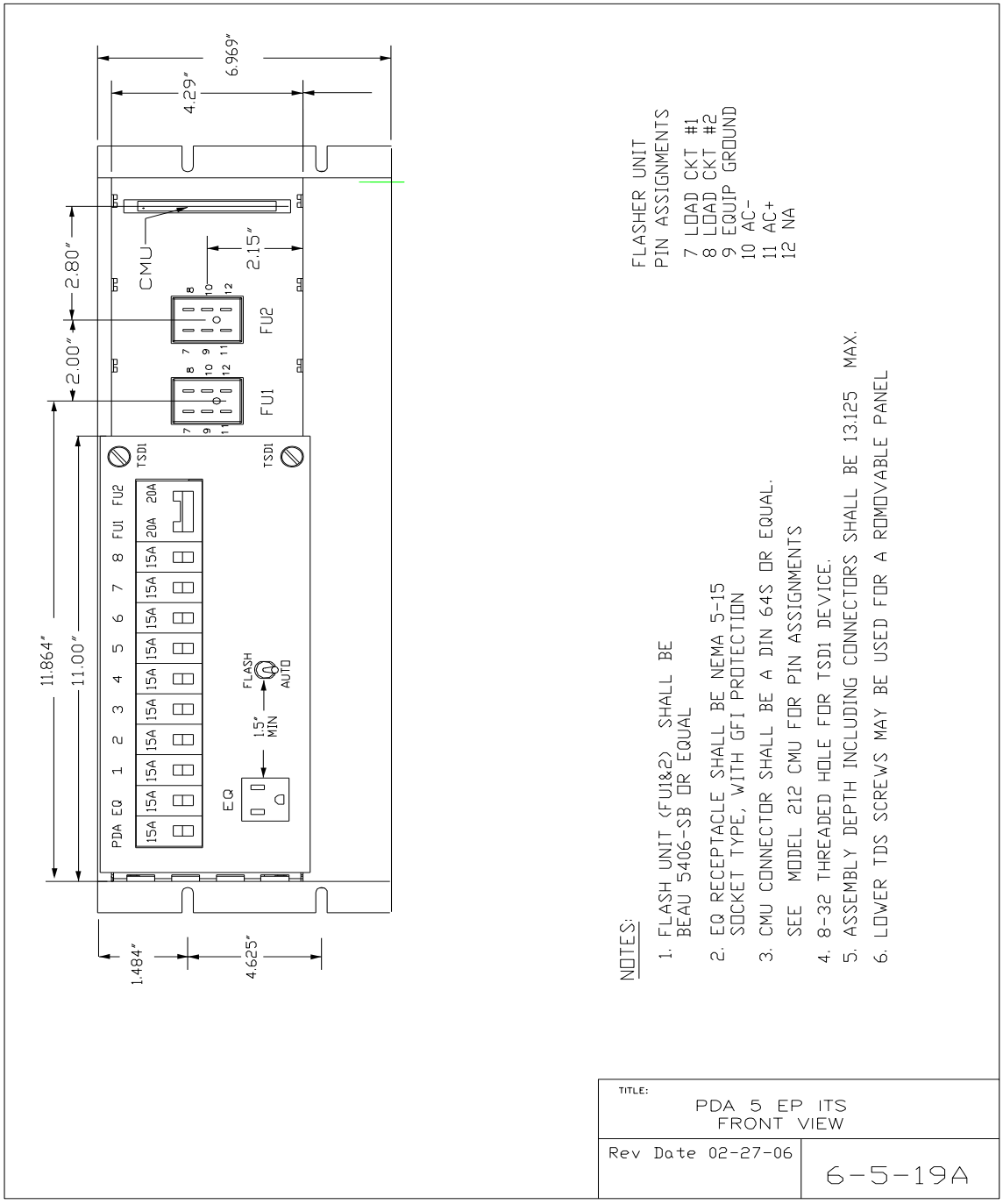


Figure 47
PDA 5 EP ITS – Front View

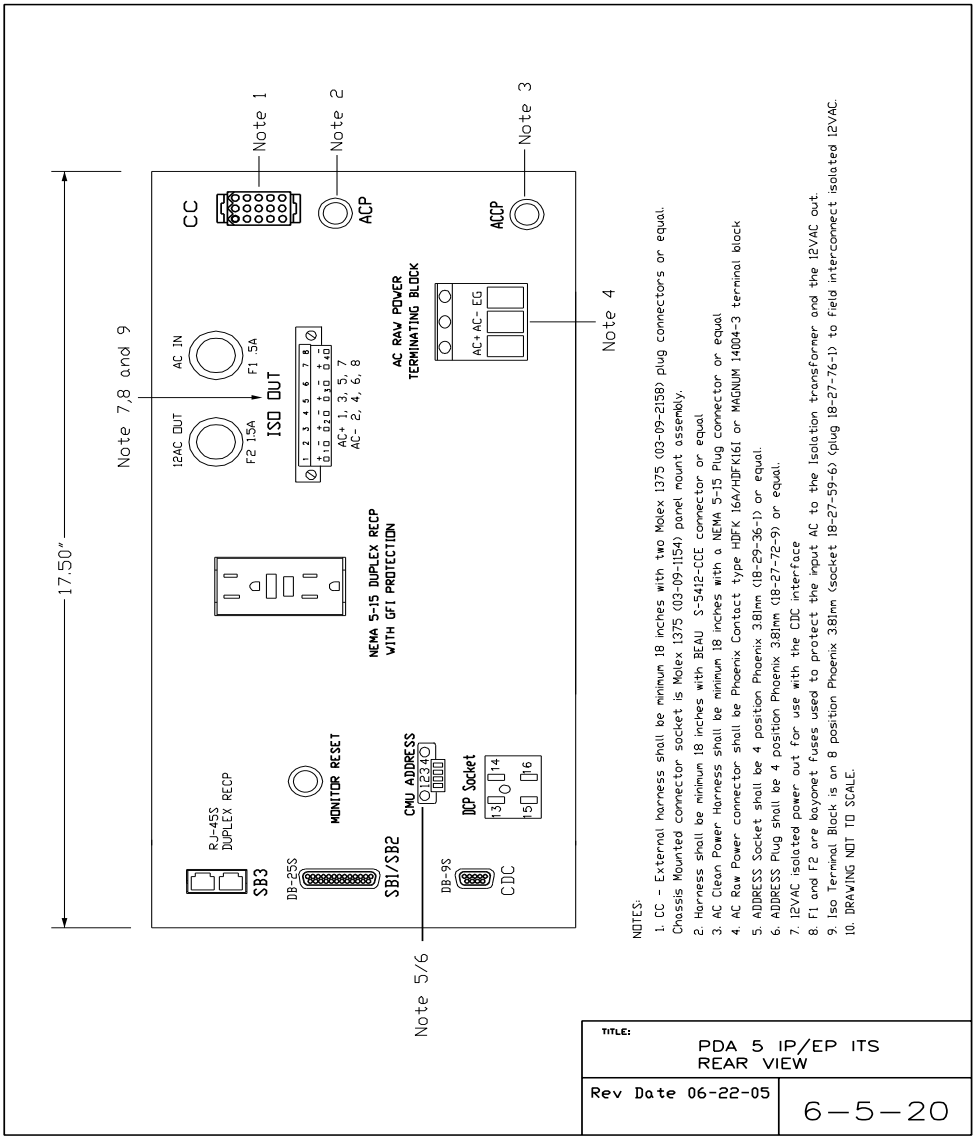


Figure 48
PDA 5 IP/EP ITS – Rear View

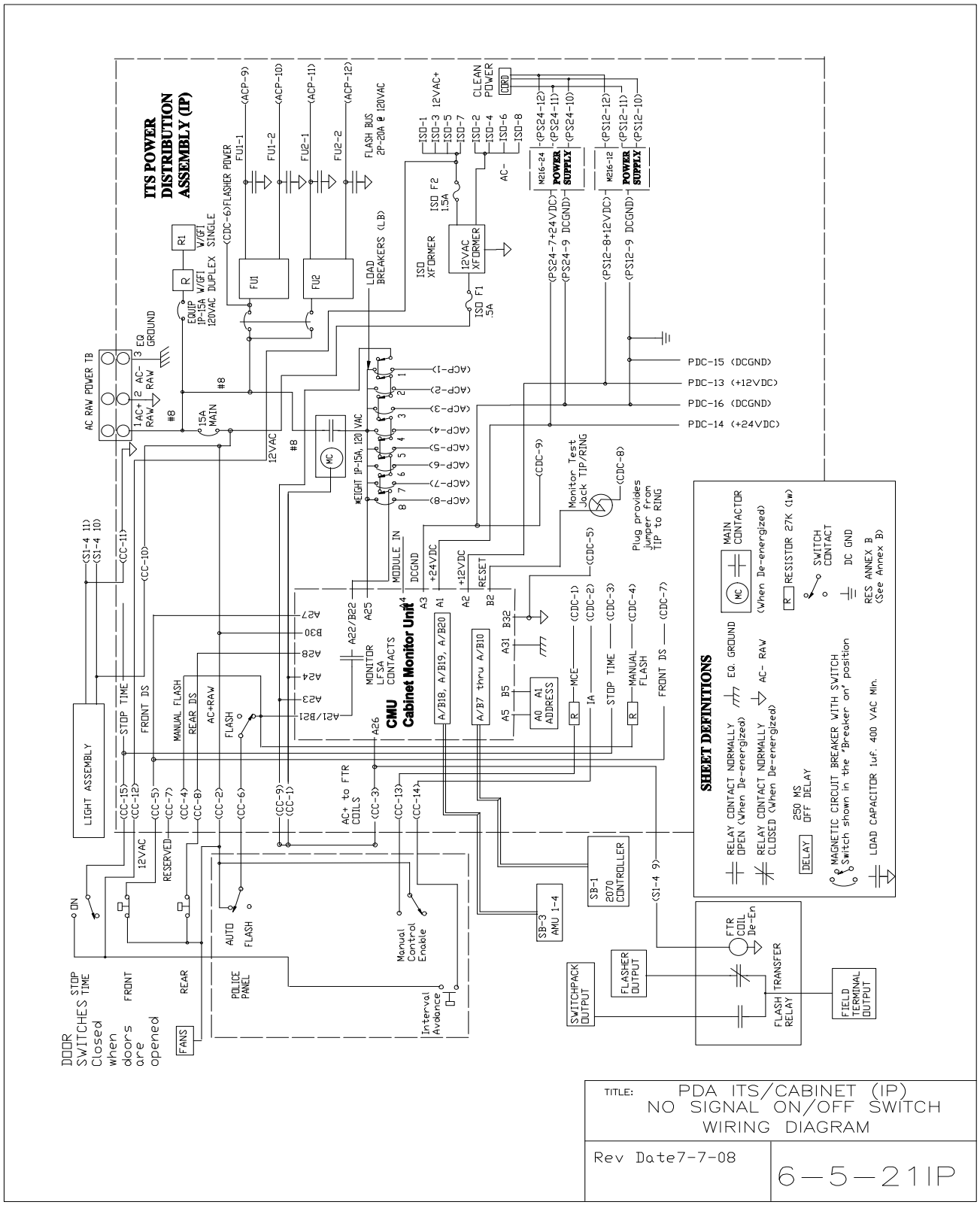


Figure 49
PDA 5 IP ITS/Cabinet – Wiring Diagram

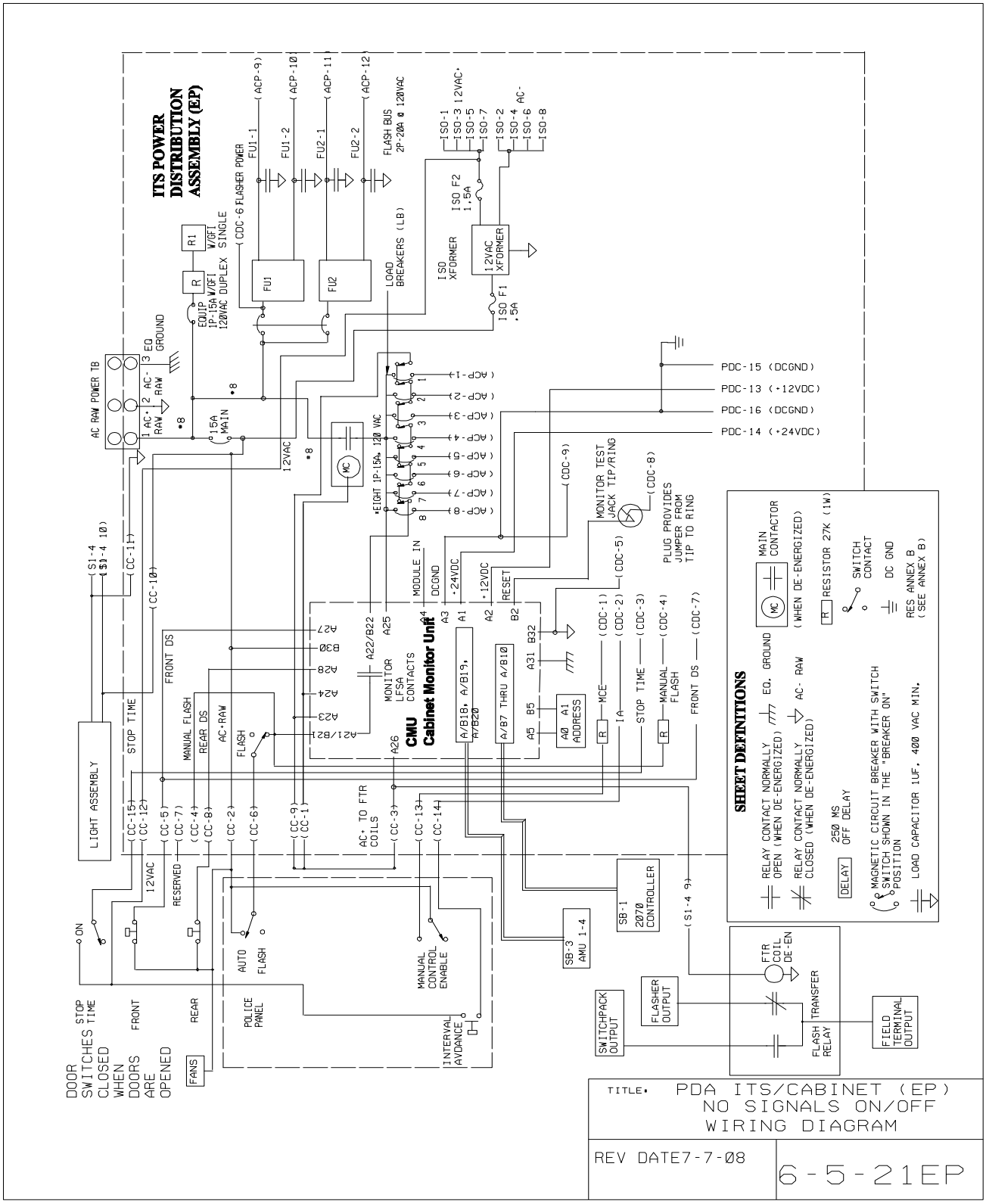
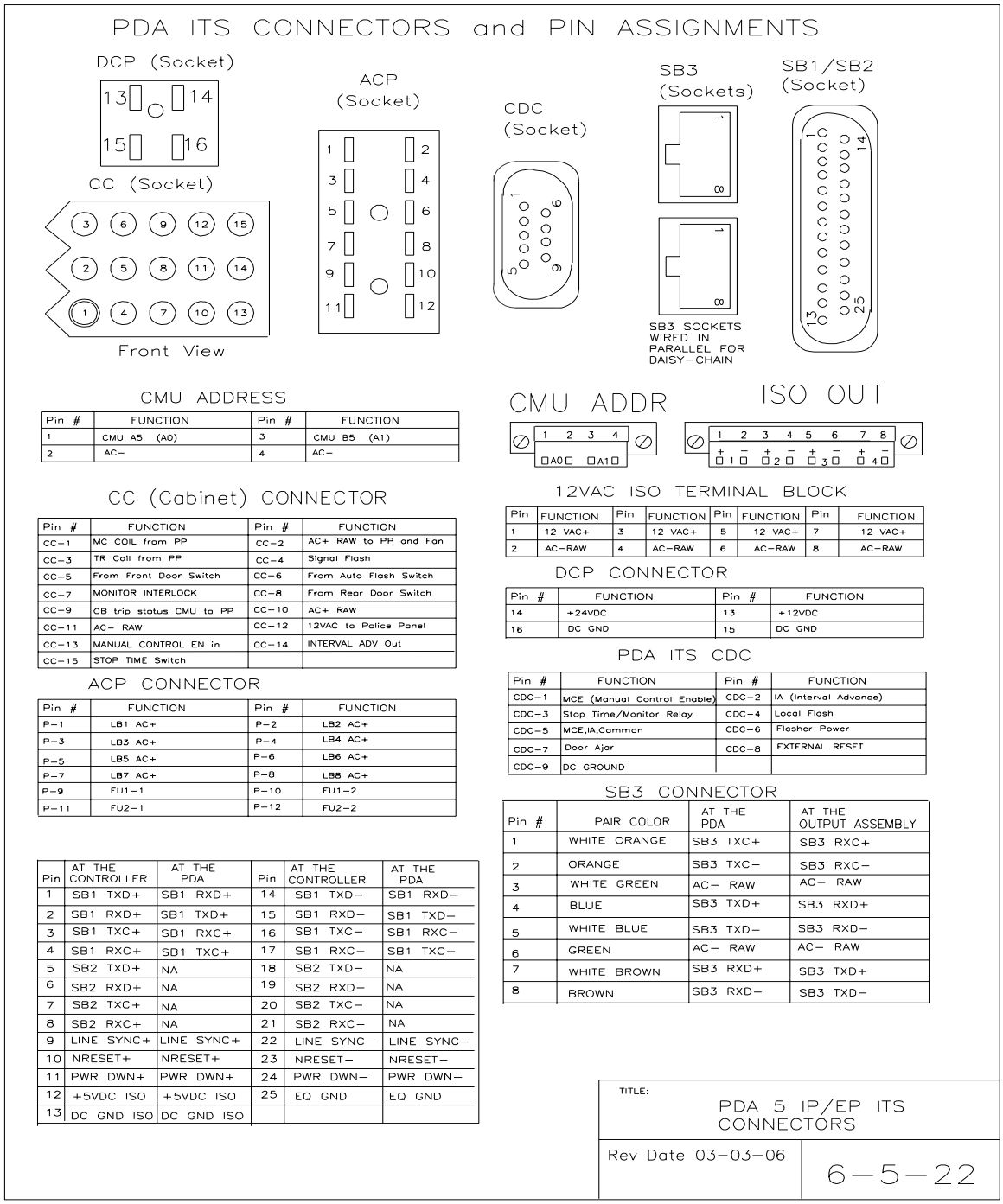


Figure 50
PDA ITS/Cabinet (EP) Wiring Diagram



Pin #	FUNCTION	Pin #	FUNCTION
1	CMU A5 (A0)	3	CMU B5 (A1)
2	AC−	4	AC−

Pin #	FUNCTION	Pin #	FUNCTION
CC−1	MC COIL from PP	CC−2	AC+ RAW to PP and Fan
CC−3	TR Coil from PP	CC−4	Signal Flash
CC−5	From Front Door Switch	CC−6	From Auto Flash Switch
CC−7	MONITOR INTERLOCK	CC−8	From Rear Door Switch
CC−9	CB trip status CMU to PP	CC−10	AC+ RAW
CC−11	AC− RAW	CC−12	12VAC to Police Panel
CC−13	MANUAL CONTROL EN in	CC−14	INTERVAL ADV Out
CC−15	STOP TIME Switch		

Pin #	FUNCTION	Pin #	FUNCTION
P−1	LB1 AC+	P−2	LB2 AC+
P−3	LB3 AC+	P−4	LB4 AC+
P−5	LB5 AC+	P−6	LB6 AC+
P−7	LB7 AC+	P−8	LB8 AC+
P−9	FU1−1	P−10	FU1−2
P−11	FU2−1	P−12	FU2−2

Pin	AT THE CONTROLLER	AT THE PDA	Pin	AT THE CONTROLLER	AT THE PDA
1	SB1 TXD+	SB1 RXD+	14	SB1 TXD−	SB1 RXD−
2	SB1 RXD+	SB1 TXD+	15	SB1 RXD−	SB1 TXD−
3	SB1 TXC+	SB1 RXC+	16	SB1 TXC−	SB1 RXC−
4	SB1 RXC+	SB1 TXC+	17	SB1 RXC−	SB1 TXC−
5	SB2 TXD+	NA	18	SB2 TXD−	NA
6	SB2 RXD+	NA	19	SB2 RXD−	NA
7	SB2 TXC+	NA	20	SB2 TXC−	NA
8	SB2 RXC+	NA	21	SB2 RXC−	NA
9	LINE SYNC+	LINE SYNC+	22	LINE SYNC−	LINE SYNC−
10	NRESET+	NRESET+	23	NRESET−	NRESET−
11	PWR DWN+	PWR DWN+	24	PWR DWN−	PWR DWN−
12	+5VDC ISO	+5VDC ISO	25	EQ GND	EQ GND
13	DC GND ISO	DC GND ISO			

Pin #	FUNCTION	Pin #	FUNCTION
1	12 VAC+	3	12 VAC+
2	AC−RAW	4	AC−RAW
5	12 VAC+	7	12 VAC+
6	AC−RAW	8	AC−RAW

Pin #	FUNCTION	Pin #	FUNCTION
14	+24VDC	13	+12VDC
16	DC GND	15	DC GND

Pin #	FUNCTION	Pin #	FUNCTION
CDC−1	MCE (Manual Control Enable)	CDC−2	IA (Interval Advance)
CDC−3	Stop Time/Monitor Relay	CDC−4	Local Flash
CDC−5	MCE,IA,Common	CDC−6	Flasher Power
CDC−7	Door Ajar	CDC−8	EXTERNAL RESET
CDC−9	DC GROUND		

Pin #	PAIR COLOR	AT THE PDA	AT THE OUTPUT ASSEMBLY
1	WHITE ORANGE	SB3 TXC+	SB3 RXC+
2	ORANGE	SB3 TXC−	SB3 RXC−
3	WHITE GREEN	AC− RAW	AC− RAW
4	BLUE	SB3 TXD+	SB3 RXD+
5	WHITE BLUE	SB3 TXD−	SB3 RXD−
6	GREEN	AC− RAW	AC− RAW
7	WHITE BROWN	SB3 RXD+	SB3 TXD+
8	BROWN	SB3 RXD−	SB3 TXD−

Figure 51
PDA 5 IP/EP ITS – Connectors

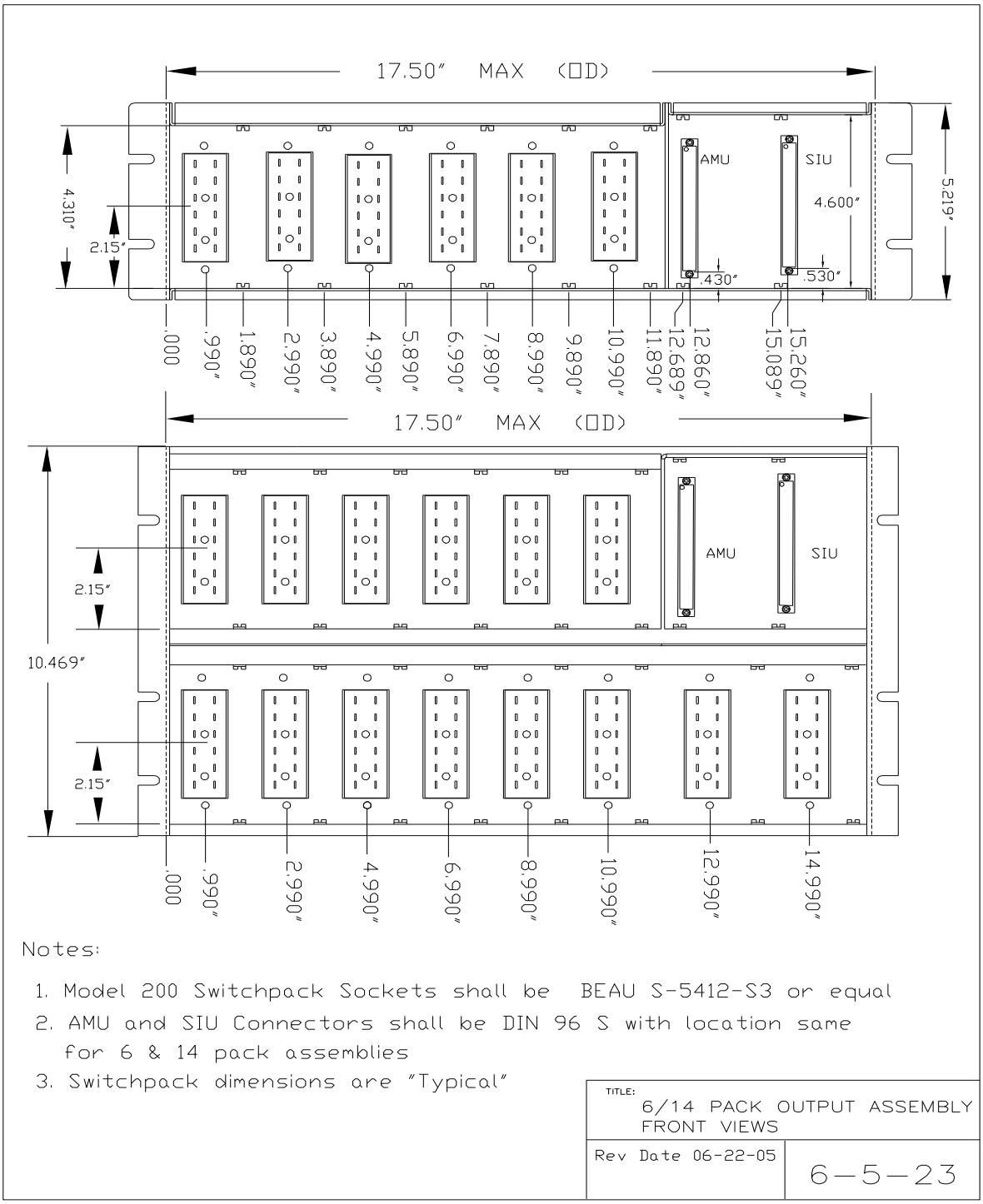
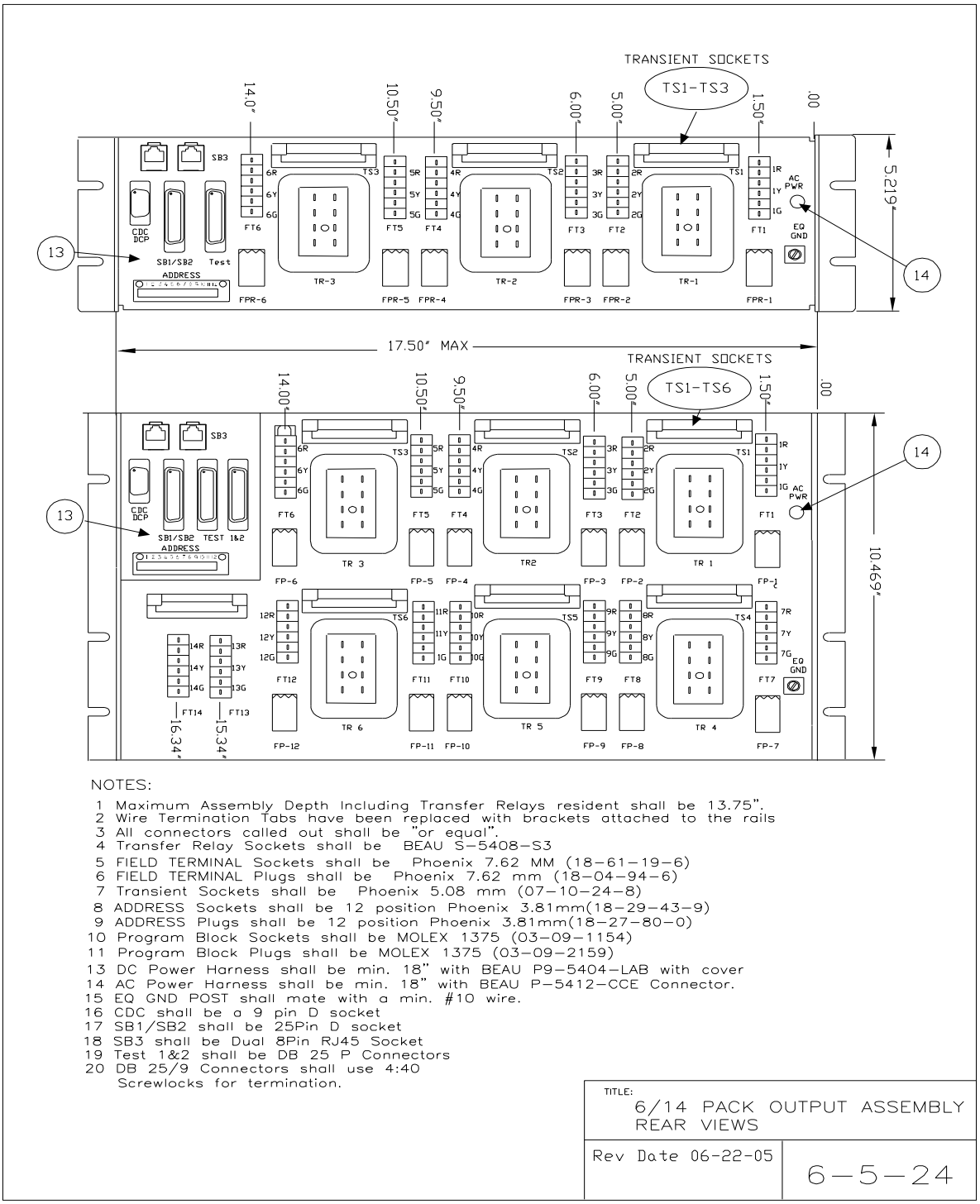


Figure 52
6/14 Pack Output Assembly – Front View



NOTES:

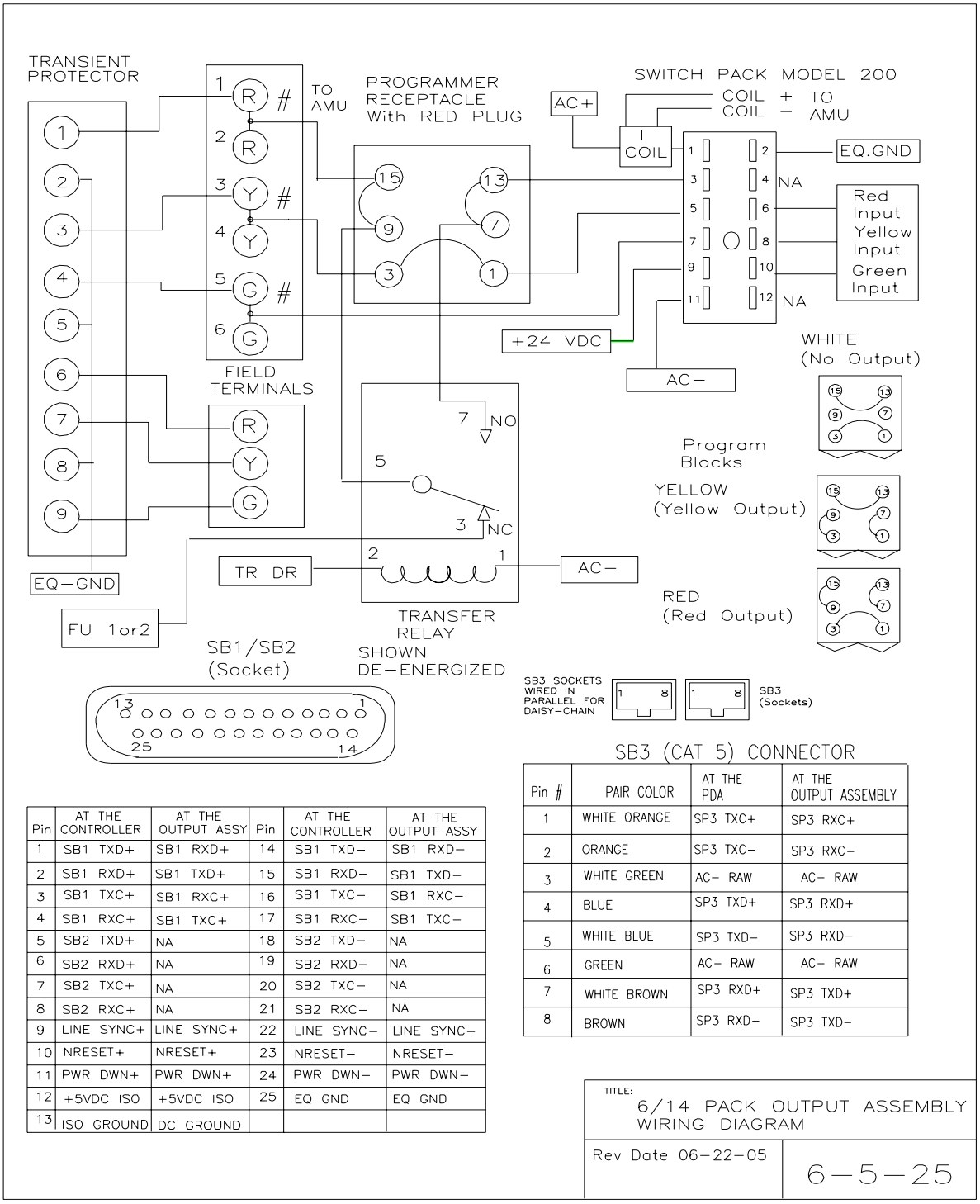
1 Maximum Assembly Depth Including Transfer Relays resident shall be 13.75".
2 Wire Termination Tabs have been replaced with brackets attached to the rails
3 All connectors called out shall be "or equal".
4 Transfer Relay Sockets shall be BEAU S-5408-S3
5 FIELD TERMINAL Sockets shall be Phoenix 7.62 MM (18-61-19-6)
6 FIELD TERMINAL Plugs shall be Phoenix 7.62 mm (18-04-94-6)
7 Transient Sockets shall be Phoenix 5.08 mm (07-10-24-8)
8 ADDRESS Sockets shall be 12 position Phoenix 3.81mm(18-29-43-9)
9 ADDRESS Plugs shall be 12 position Phoenix 3.81mm(18-27-80-0)
10 Program Block Sockets shall be MOLEX 1375 (03-09-1154)
11 Program Block Plugs shall be MOLEX 1375 (03-09-2159)
13 DC Power Harness shall be min. 18" with BEAU P9-5404-LAB with cover
14 AC Power Harness shall be min. 18" with BEAU P-5412-CCE Connector.
15 EQ GND POST shall mate with a min. #10 wire.
16 CDC shall be a 9 pin D socket
17 SB1/SB2 shall be 25Pin D socket
18 SB3 shall be Dual 8Pin RJ45 Socket
19 Test 1&2 shall be DB 25 P Connectors
20 DB 25/9 Connectors shall use 4:40 Screwlocks for termination.

TITLE: 6/14 PACK OUTPUT ASSEMBLY REAR VIEWS

Rev Date 06-22-05

6-5-24

Figure 53
6/14 Pack Output Assembly – Rear Views



SB3 (CAT 5) CONNECTOR

Pin #	PAIR COLOR	AT THE PDA	AT THE OUTPUT ASSEMBLY
1	WHITE ORANGE	SP3 TXC+	SP3 RXC+
2	ORANGE	SP3 TXC−	SP3 RXC−
3	WHITE GREEN	AC− RAW	AC− RAW
4	BLUE	SP3 TXD+	SP3 RXD+
5	WHITE BLUE	SP3 TXD−	SP3 RXD−
6	GREEN	AC− RAW	AC− RAW
7	WHITE BROWN	SP3 RXD+	SP3 TXD+
8	BROWN	SP3 RXD−	SP3 TXD−

Pin	AT THE CONTROLLER	AT THE OUTPUT ASSY	Pin	AT THE CONTROLLER	AT THE OUTPUT ASSY
1	SB1 TXD+	SB1 RXD+	14	SB1 TXD−	SB1 RXD−
2	SB1 RXD+	SB1 TXD+	15	SB1 RXD−	SB1 TXD−
3	SB1 TXC+	SB1 RXC+	16	SB1 TXC−	SB1 RXC−
4	SB1 RXC+	SB1 TXC+	17	SB1 RXC−	SB1 TXC−
5	SB2 TXD+	NA	18	SB2 TXD−	NA
6	SB2 RXD+	NA	19	SB2 RXD−	NA
7	SB2 TXC+	NA	20	SB2 TXC−	NA
8	SB2 RXC+	NA	21	SB2 RXC−	NA
9	LINE SYNC+	LINE SYNC+	22	LINE SYNC−	LINE SYNC−
10	NRESET+	NRESET+	23	NRESET−	NRESET−
11	PWR DWN+	PWR DWN+	24	PWR DWN−	PWR DWN−
12	+5VDC ISO	+5VDC ISO	25	EQ GND	EQ GND
13	ISO GROUND	DC GROUND			

TITLE: 6/14 PACK OUTPUT ASSEMBLY WIRING DIAGRAM

Rev Date 06−22−05

6−5−25

Figure 54
6/14 Pack Output Assembly – Wiring Diagram

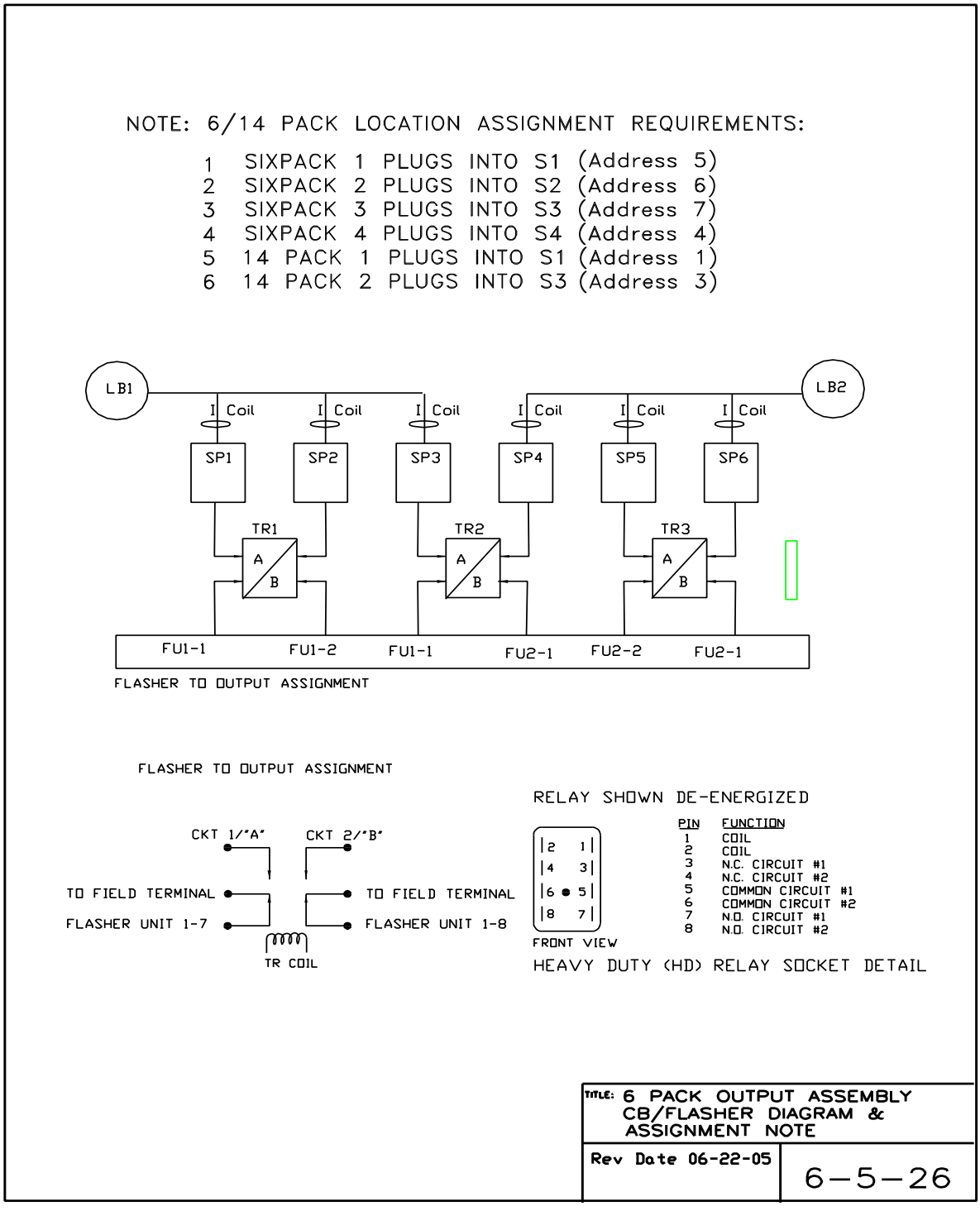


Figure 55
6 Pack O/A – CB/Flasher Diagram and Assignment Note

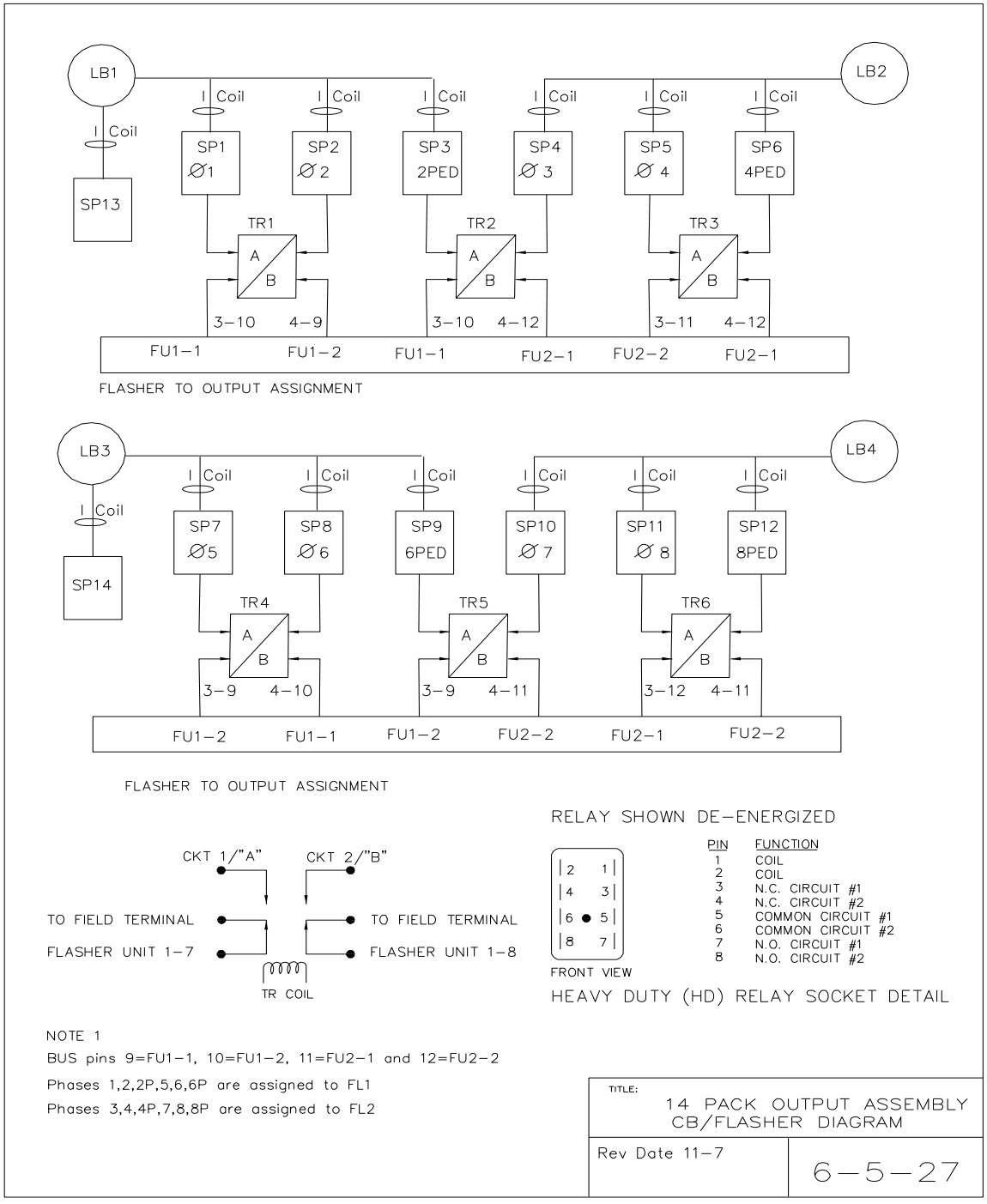
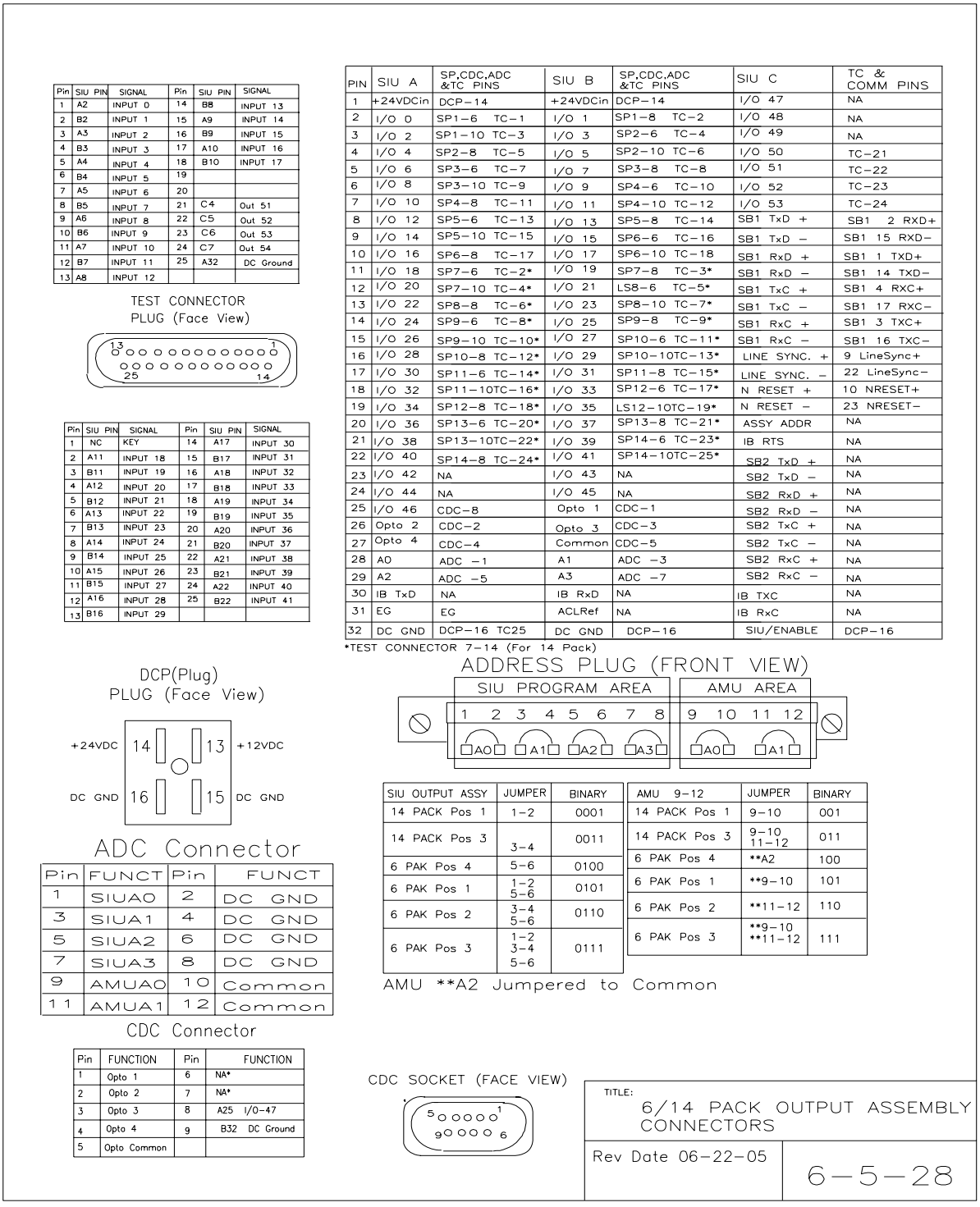


Figure 56
14 Pack O/A – CB/Flasher Diagram



Pin	SIU PIN	SIGNAL	Pin	SIU PIN	SIGNAL
1	A2	INPUT 0	14	B8	INPUT 13
2	B2	INPUT 1	15	A9	INPUT 14
3	A3	INPUT 2	16	B9	INPUT 15
4	B3	INPUT 3	17	A10	INPUT 16
5	A4	INPUT 4	18	B10	INPUT 17
6	B4	INPUT 5	19		
7	A5	INPUT 6	20		
8	B5	INPUT 7	21	C4	Out 51
9	A6	INPUT 8	22	C5	Out 52
10	B6	INPUT 9	23	C6	Out 53
11	A7	INPUT 10	24	C7	Out 54
12	B7	INPUT 11	25	A32	DC Ground
13	A8	INPUT 12			

Pin	SIU PIN	SIGNAL	Pin	SIU PIN	SIGNAL
1	NC	KEY	14	A17	INPUT 30
2	A11	INPUT 18	15	B17	INPUT 31
3	B11	INPUT 19	16	A18	INPUT 32
4	A12	INPUT 20	17	B18	INPUT 33
5	B12	INPUT 21	18	A19	INPUT 34
6	A13	INPUT 22	19	B19	INPUT 35
7	B13	INPUT 23	20	A20	INPUT 36
8	A14	INPUT 24	21	B20	INPUT 37
9	B14	INPUT 25	22	A21	INPUT 38
10	A15	INPUT 26	23	B21	INPUT 39
11	B15	INPUT 27	24	A22	INPUT 40
12	A16	INPUT 28	25	B22	INPUT 41
13	B16	INPUT 29			

PIN	SIU A	SP,CDC,ADC &TC PINS	SIU B	SP,CDC,ADC &TC PINS	SIU C	TC & COMM PINS
1	+24VDCin	DCP-14	+24VDCin	DCP-14	I/O 47	NA
2	I/O 0	SP1-6 TC-1	I/O 1	SP1-8 TC-2	I/O 48	NA
3	I/O 2	SP1-10 TC-3	I/O 3	SP2-6 TC-4	I/O 49	NA
4	I/O 4	SP2-8 TC-5	I/O 5	SP2-10 TC-6	I/O 50	TC-21
5	I/O 6	SP3-6 TC-7	I/O 7	SP3-8 TC-8	I/O 51	TC-22
6	I/O 8	SP3-10 TC-9	I/O 9	SP4-6 TC-10	I/O 52	TC-23
7	I/O 10	SP4-8 TC-11	I/O 11	SP4-10 TC-12	I/O 53	TC-24
8	I/O 12	SP5-6 TC-13	I/O 13	SP5-8 TC-14	SB1 TxD +	SB1 2 RXD+
9	I/O 14	SP5-10 TC-15	I/O 15	SP6-6 TC-16	SB1 TxD -	SB1 15 RXD-
10	I/O 16	SP6-8 TC-17	I/O 17	SP6-10 TC-18	SB1 RxD +	SB1 1 TXD+
11	I/O 18	SP7-6 TC-2*	I/O 19	SP7-8 TC-3*	SB1 RxD -	SB1 14 TXD-
12	I/O 20	SP7-10 TC-4*	I/O 21	LS8-6 TC-5*	SB1 TxC +	SB1 4 RXC+
13	I/O 22	SP8-8 TC-6*	I/O 23	SP8-10 TC-7*	SB1 TxC -	SB1 17 RXC-
14	I/O 24	SP9-6 TC-8*	I/O 25	SP9-8 TC-9*	SB1 RxC +	SB1 3 TXC+
15	I/O 26	SP9-10 TC-10*	I/O 27	SP10-6 TC-11*	SB1 RxC -	SB1 16 TXC-
16	I/O 28	SP10-8 TC-12*	I/O 29	SP10-10TC-13*	LINE SYNC. +	9 LineSync+
17	I/O 30	SP11-6 TC-14*	I/O 31	SP11-8 TC-15*	LINE SYNC. -	22 LineSync-
18	I/O 32	SP11-10TC-16*	I/O 33	SP12-6 TC-17*	N RESET +	10 NRESET+
19	I/O 34	SP12-8 TC-18*	I/O 35	LS12-10TC-19*	N RESET -	23 NRESET-
20	I/O 36	SP13-6 TC-20*	I/O 37	SP13-8 TC-21*	ASSY ADDR	NA
21	I/O 38	SP13-10TC-22*	I/O 39	SP14-6 TC-23*	IB RTS	NA
22	I/O 40	SP14-8 TC-24*	I/O 41	SP14-10TC-25*	SB2 TxD +	NA
23	I/O 42	NA	I/O 43	NA	SB2 TxD -	NA
24	I/O 44	NA	I/O 45	NA	SB2 RxD +	NA
25	I/O 46	CDC-8	Opto 1	CDC-1	SB2 RxD -	NA
26	Opto 2	CDC-2	Opto 3	CDC-3	SB2 TxC +	NA
27	Opto 4	CDC-4	Common	CDC-5	SB2 TxC -	NA
28	A0	ADC -1	A1	ADC -3	SB2 RxC +	NA
29	A2	ADC -5	A3	ADC -7	SB2 RxC -	NA
30	IB TxD	NA	IB RxD	NA	IB TXC	NA
31	EG	EG	ACLRef	NA	IB RxC	NA
32	DC GND	DCP-16 TC25	DC GND	DCP-16	SIU/ENABLE	DCP-16

*TEST CONNECTOR 7-14 (For 14 Pack)

ADC Connector

Pin	FUNCT	Pin	FUNCT
1	SIUA0	2	DC GND
3	SIUA1	4	DC GND
5	SIUA2	6	DC GND
7	SIUA3	8	DC GND
9	AMUA0	10	Common
11	AMUA1	12	Common

CDC Connector

Pin	FUNCTION	Pin	FUNCTION
1	Opto 1	6	NA*
2	Opto 2	7	NA*
3	Opto 3	8	A25 I/O-47
4	Opto 4	9	B32 DC Ground
5	Opto Common		

SIU OUTPUT ASSY	JUMPER	BINARY
14 PACK Pos 1	1-2	0001
14 PACK Pos 3	3-4	0011
6 PAK Pos 4	5-6	0100
6 PAK Pos 1	1-2 5-6	0101
6 PAK Pos 2	3-4 5-6	0110
6 PAK Pos 3	1-2 3-4 5-6	0111

AMU 9-12	JUMPER	BINARY
14 PACK Pos 1	9-10	001
14 PACK Pos 3	9-10 11-12	011
6 PAK Pos 4	**A2	100
6 PAK Pos 1	**9-10	101
6 PAK Pos 2	**11-12	110
6 PAK Pos 3	**9-10 **11-12	111

Figure 57
6/14 Pack Output Assembly Connectors

AMU TO OUTPUT ASSEMBLY INTERCONECT

Pin #	FUNCTION	Pin #	FUNCTION	Pin #	FUNCTION
A1	VDC Ground	B1	+24 VDC in	C1	Address Common
A2	SB3 RxC+	B2	SB3 TxD−	C2	SB3 TxD+
A3	SB3 RxC−	B3	SB3 RxD−	C3	SB3 RxD+
A4	ADDR 0	B4	ADDR 1	C4	ADDR 2
A5	SP3 Coil 3+	B5	SP2 Coil 2+	C5	SP1 Coil 1+
A6	SP3 Coil 3−	B6	SP2 Coil 2−	C6	SP1 Coil 1−
A7	SP6 Coil 6+	B7	SP5 Coil 5+	C7	SP4 Coil 4+
A8	SP6 Coil 6−	B8	SP5 Coil 5−	C8	SP4 Coil 4−
A9	SP9 Coil 9+	B9	SP8 Coil 8+	C9	SP7 Coil 7+
A10	SP9 Coil 9−	B10	SP8 Coil 8−	C10	SP7 Coil 7−
A11	SP12 Coil 12+	B11	SP11 Coil 11+	C11	SP10 Coil 10+
A12	SP12 Coil 12−	B12	SP11 Coil 11−	C12	SP10 Coil 10−
A13	SP14 Coil 14+	B13	SP13 Coil 13−	C13	SP13 Coil 13+
A14	SP14 Coil 14−	B14	FU2−1	C14	FU1−1
A15	NA	B15	FU2−2	C15	FU1−2
A16	Sp1 Green FT1 5/6	B16	SP1 Yellow FT1 3/4	C16	SP1 Red FT1 1/2
A17	SP2 Green FT2 5/6	B17	SP2 Yellow FT2 3/4	C17	SP2 Red FT2 1/2
A18	SP3 Green FT3 5/6	B18	SP3 Yellow FT3 3/4	C18	SP3 Red FT3 1/2
A19	SP4 Green FT4 5/6	B19	SP4 Yellow FT4 3/4	C19	SP4 Red FT4 1/2
A20	SP5 Green FT5 5/6	B20	SP5 Yellow FT5 3/4	C20	SP5 Red FT5 1/2
A21	SP6 Green FT6 5/6	B21	SP6 Yellow FT6 3/4	C21	SP6 Red FT6 1/2
A22	SP7 Green FT7 5/6	B22	SP7 Yellow FT7 3/4	C22	SP7 Red FT7 1/2
A23	SP8 Green FT8 5/6	B23	SP8 Yellow FT8 3/4	C23	SP8 Red FT8 1/2
A24	SP9 Green FT9 5/6	B24	SP9 Yellow FT9 3/4	C24	SP9 Red FT9 1/2
A25	SP10Green FT10 5/6	B25	SP10Yellow FT10 3/4	C25	SP10Red FT10 1/2
A26	SP11Green FT11 5/6	B26	SP11Yellow FT11 3/4	C26	SP11Red FT11 1/2
A27	SP12Green FT12 5/6	B27	SP12Yellow FT12 3/4	C27	SP12Red FT12 1/2
A28	SP13Green FT13 5/6	B28	SP13Yellow FT13 3/4	C28	SP13Red FT13 1/2
A29	SP14Green FT14 5/6	B29	SP14Yellow FT14 3/4	C29	SP14Red FT14 1/2
A30	NA	B30	AC+ RAW	C30	AC+ RAW
A31	EQ Ground	B31	NA	C31	NA
A32	NA	B32	AC− RAW	C32	AC− RAW

TITLE: AMU TO OUTPUT ASSEMBLY INTERCONNECT

Rev Date 06−22−05

6−5−29

Figure 58
AMU to Output Assembly Interconnect

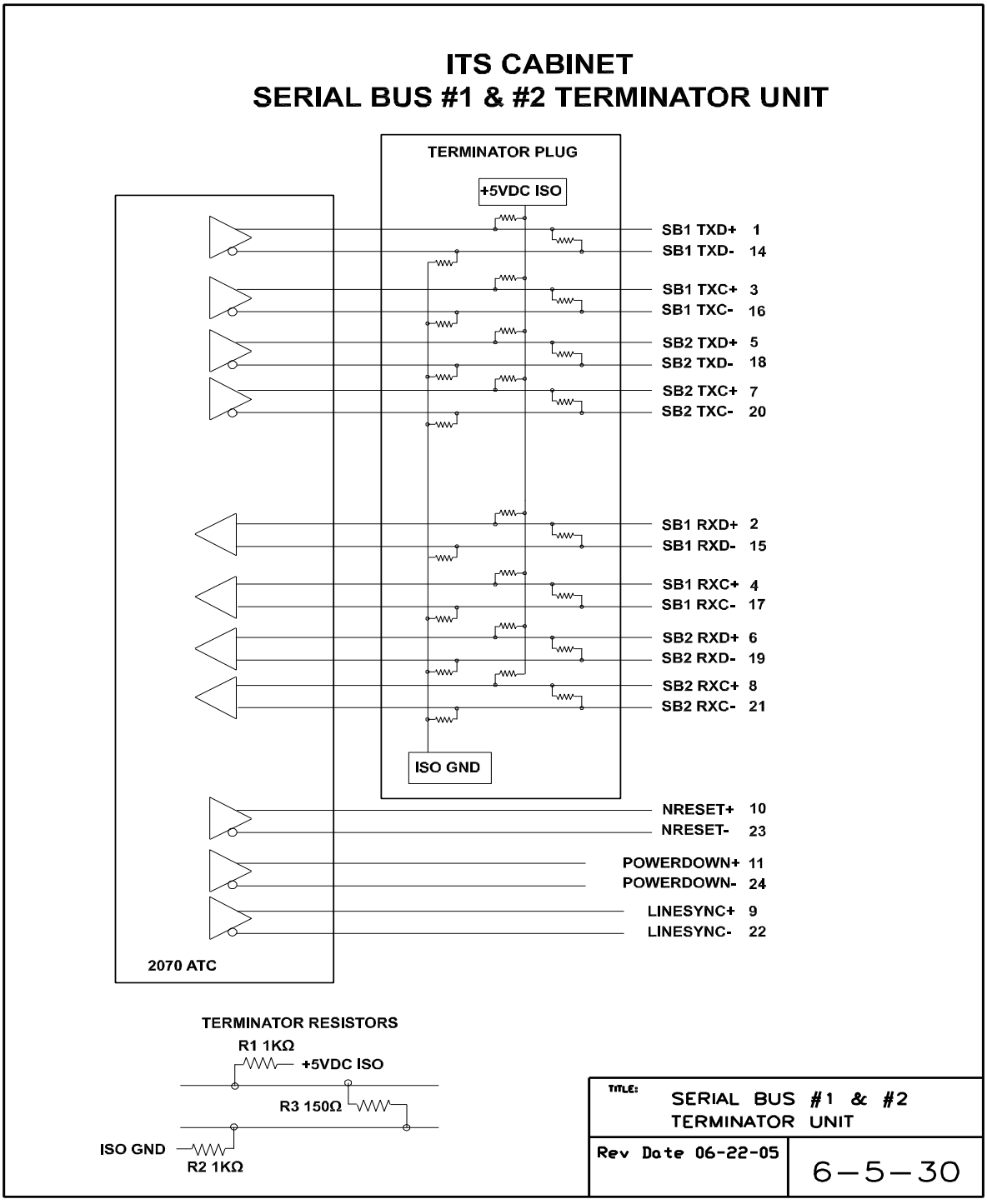


Figure 59
Serial Bus #1 and #2 Terminator Unit

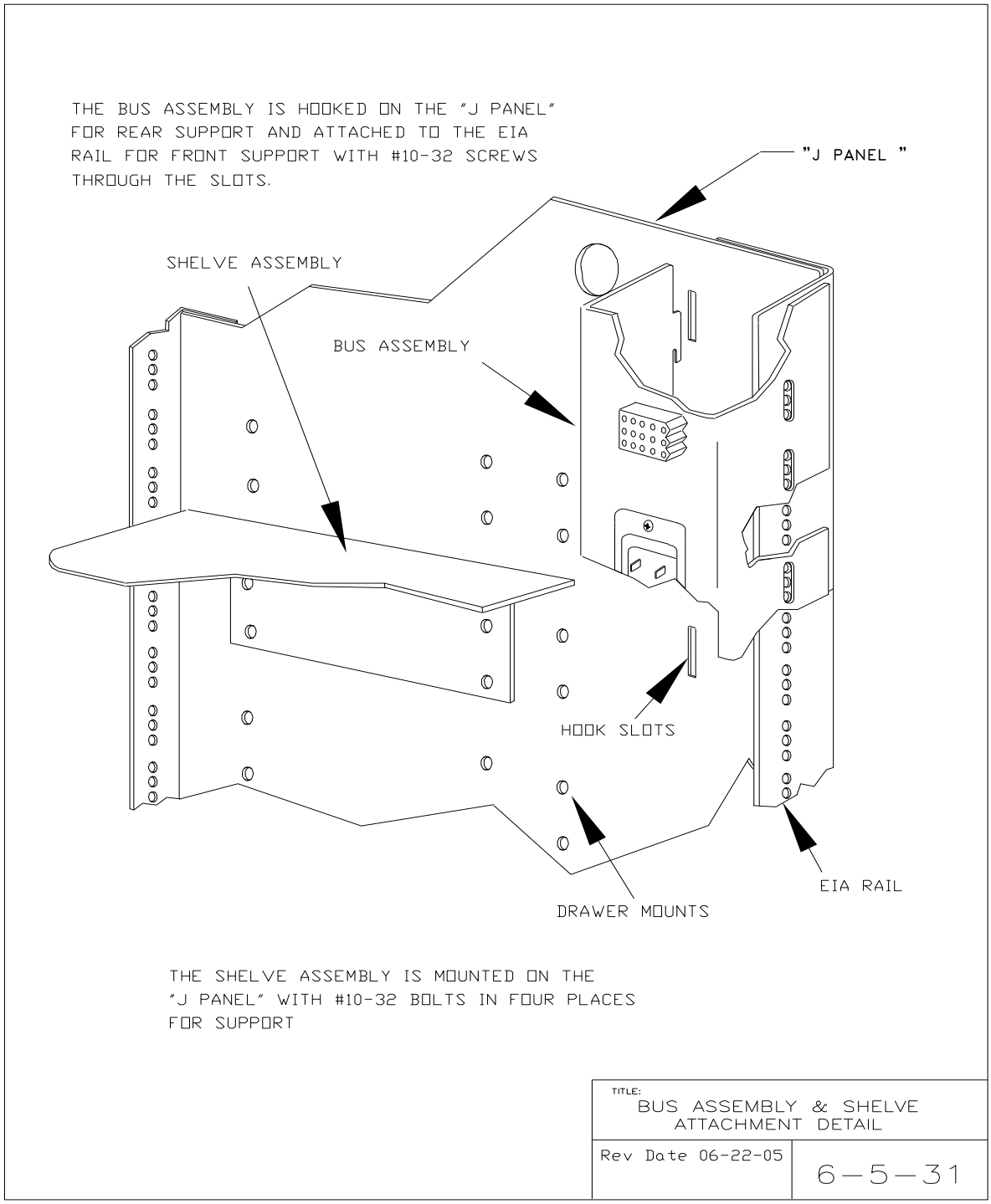
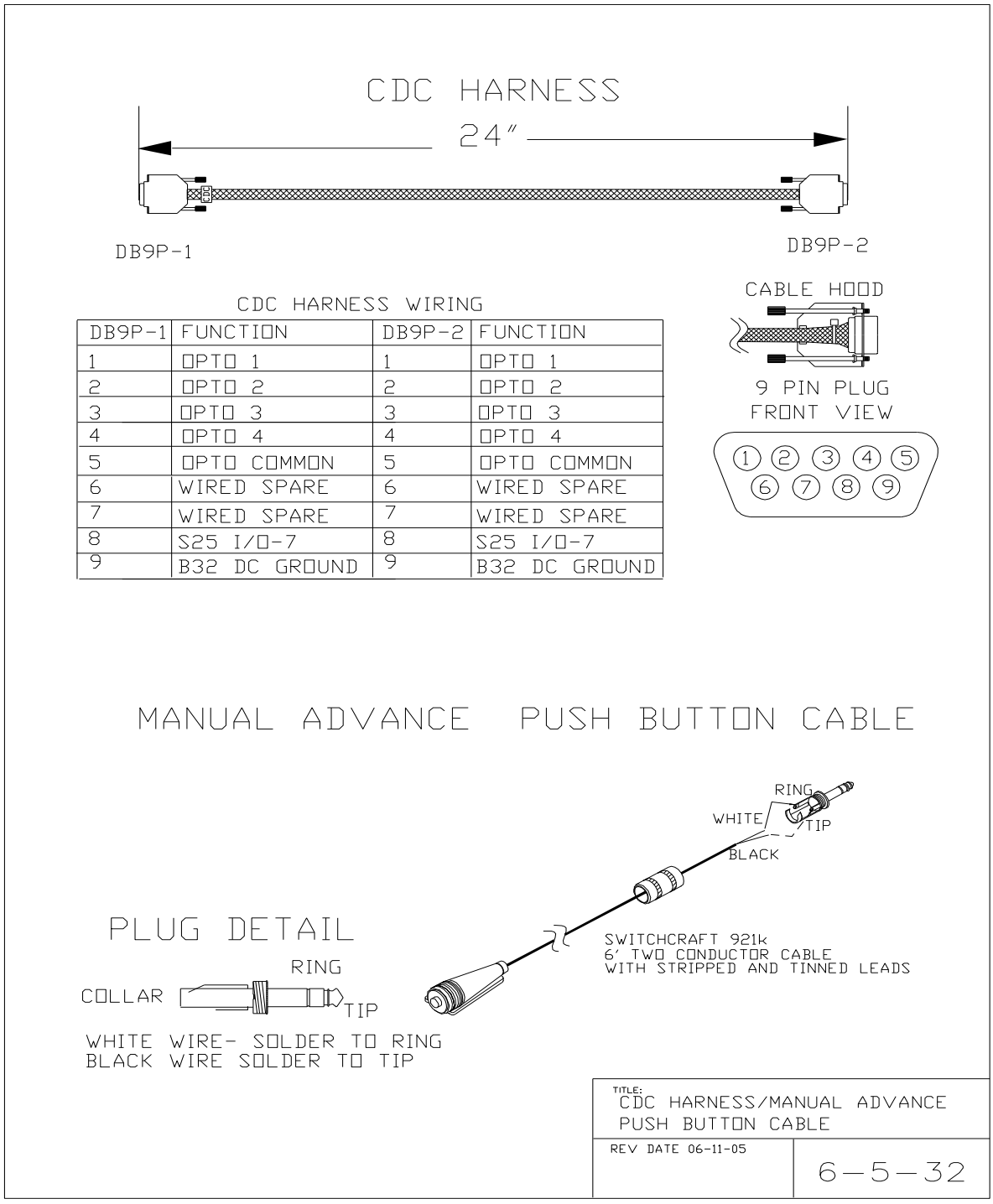


Figure 60
Bus Assembly and Shelve Attachment Detail



DB9P-1	FUNCTION	DB9P-2	FUNCTION
1	OPTO 1	1	OPTO 1
2	OPTO 2	2	OPTO 2
3	OPTO 3	3	OPTO 3
4	OPTO 4	4	OPTO 4
5	OPTO COMMON	5	OPTO COMMON
6	WIRED SPARE	6	WIRED SPARE
7	WIRED SPARE	7	WIRED SPARE
8	S25 I/O-7	8	S25 I/O-7
9	B32 DC GROUND	9	B32 DC GROUND

Figure 61
CDC Harness/Manual Advance Push Button Cable

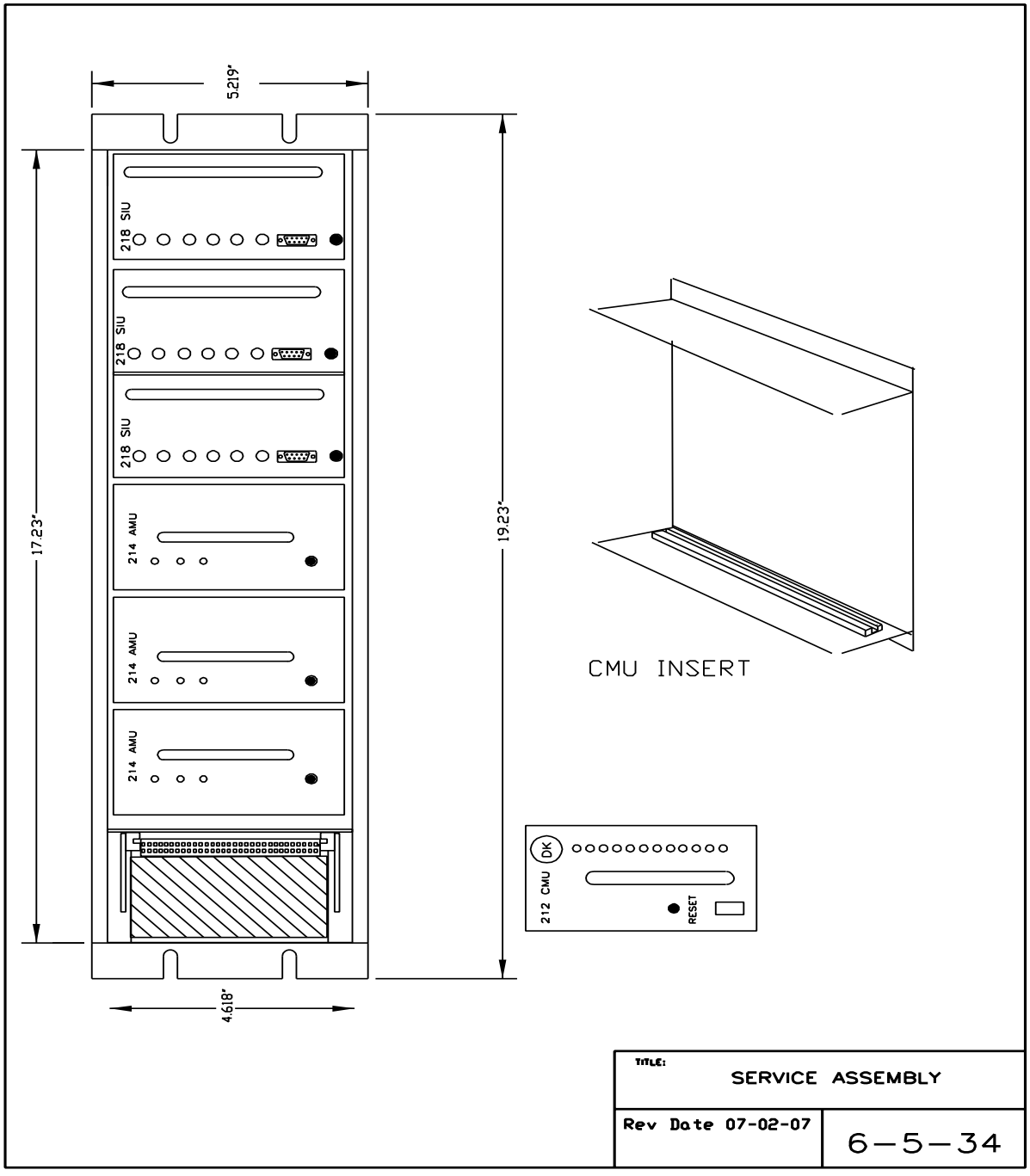


Figure 62
Service Assembly 1

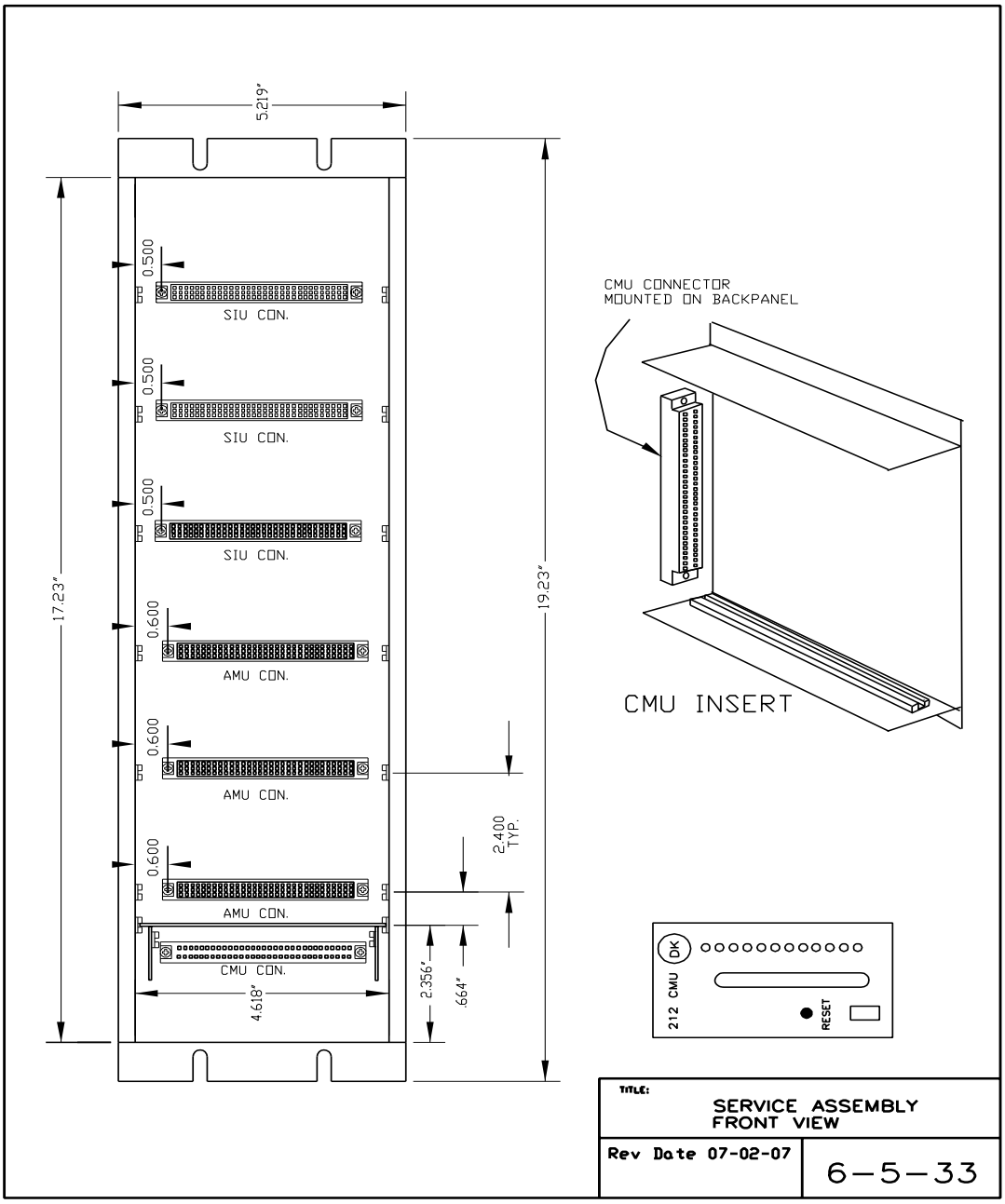


Figure 63
Service Assembly 2

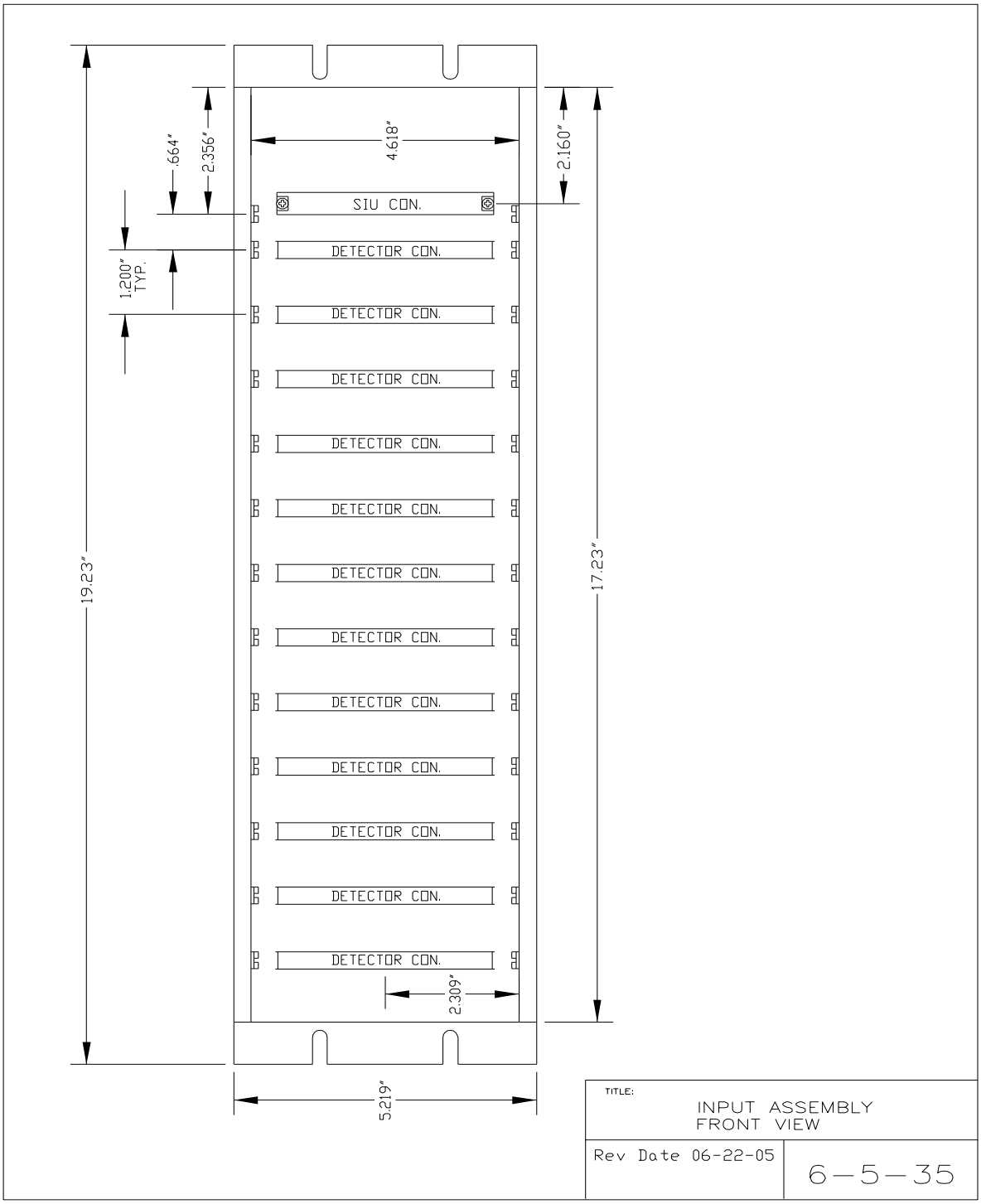


Figure 64
Input Assembly – Front View

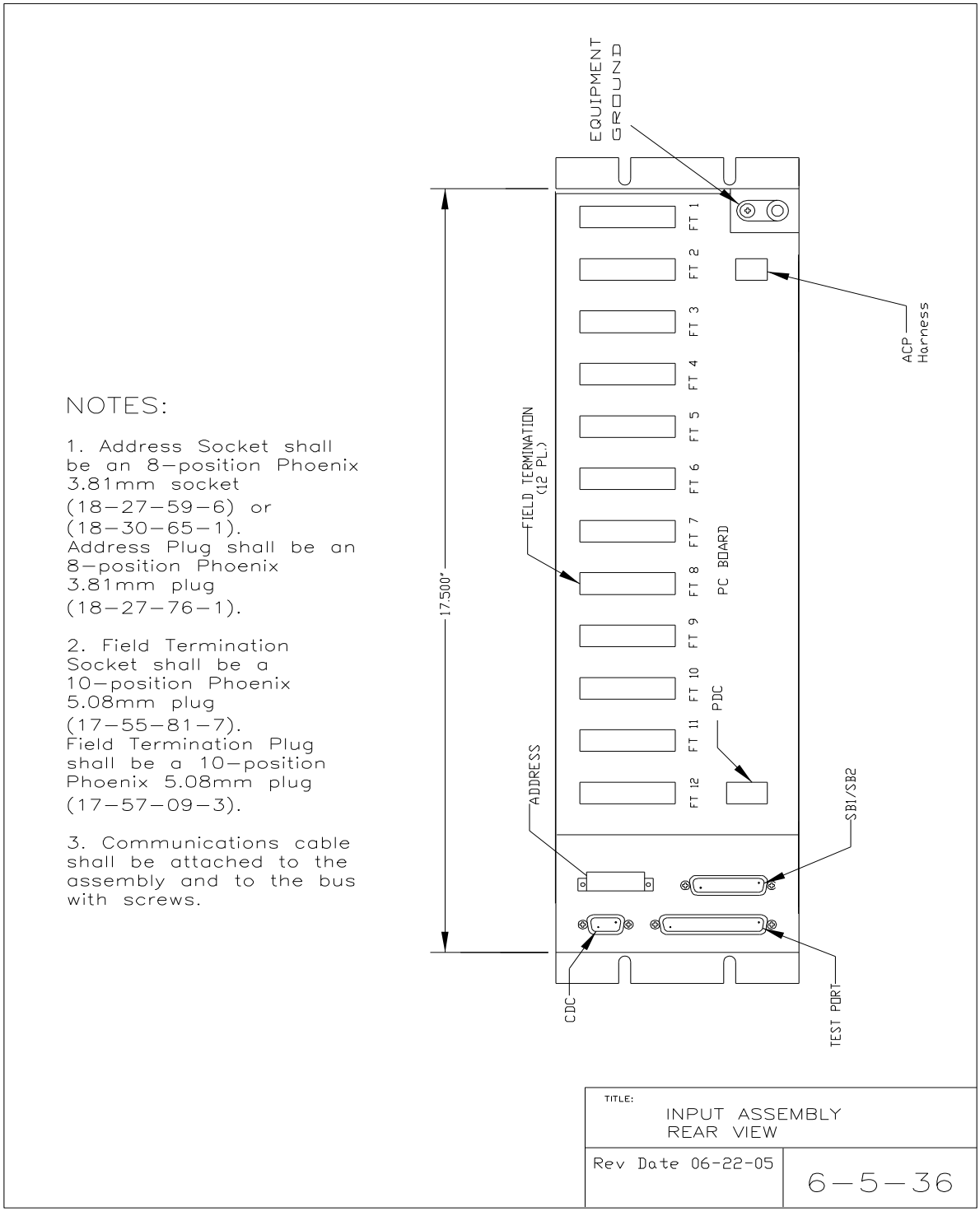
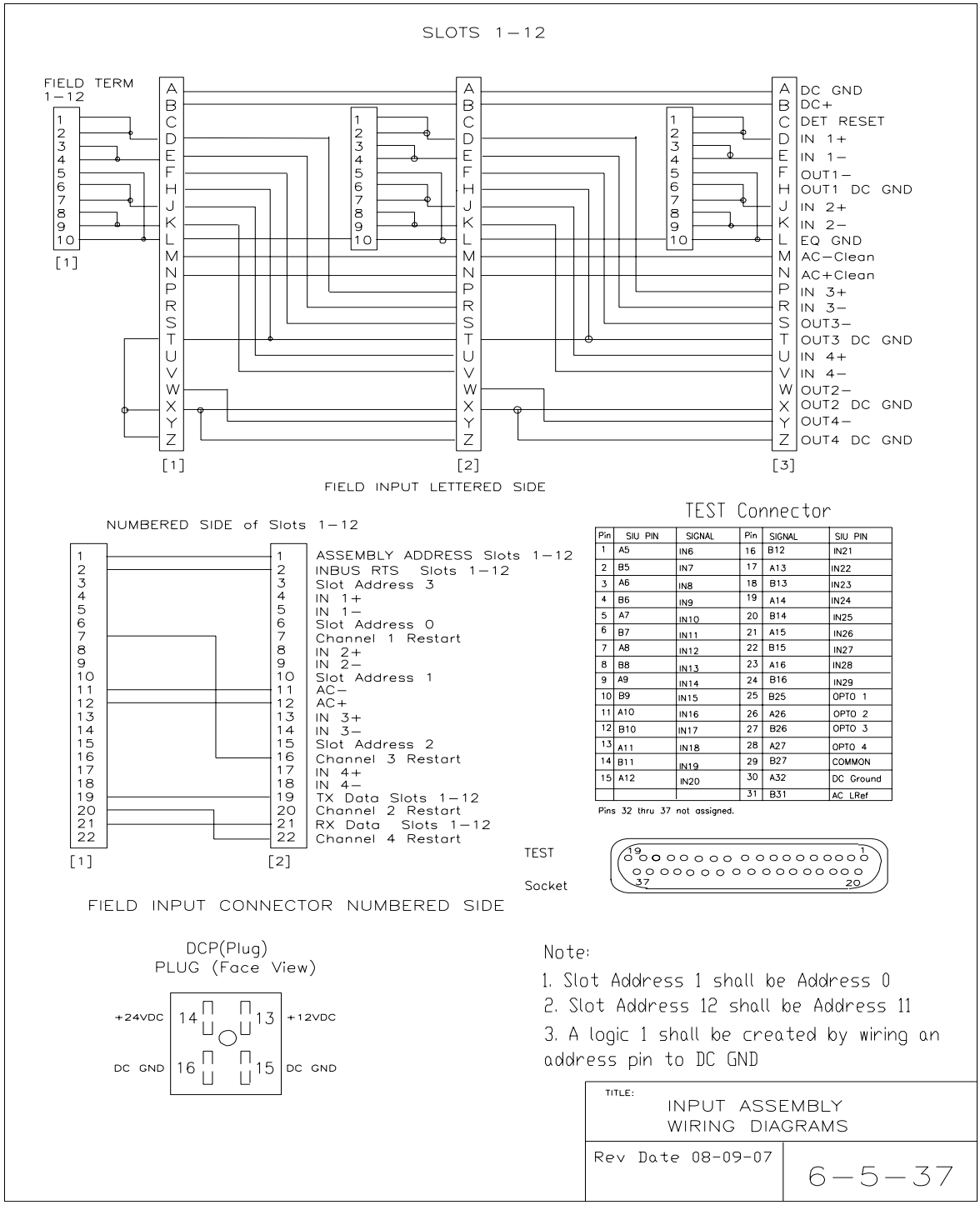
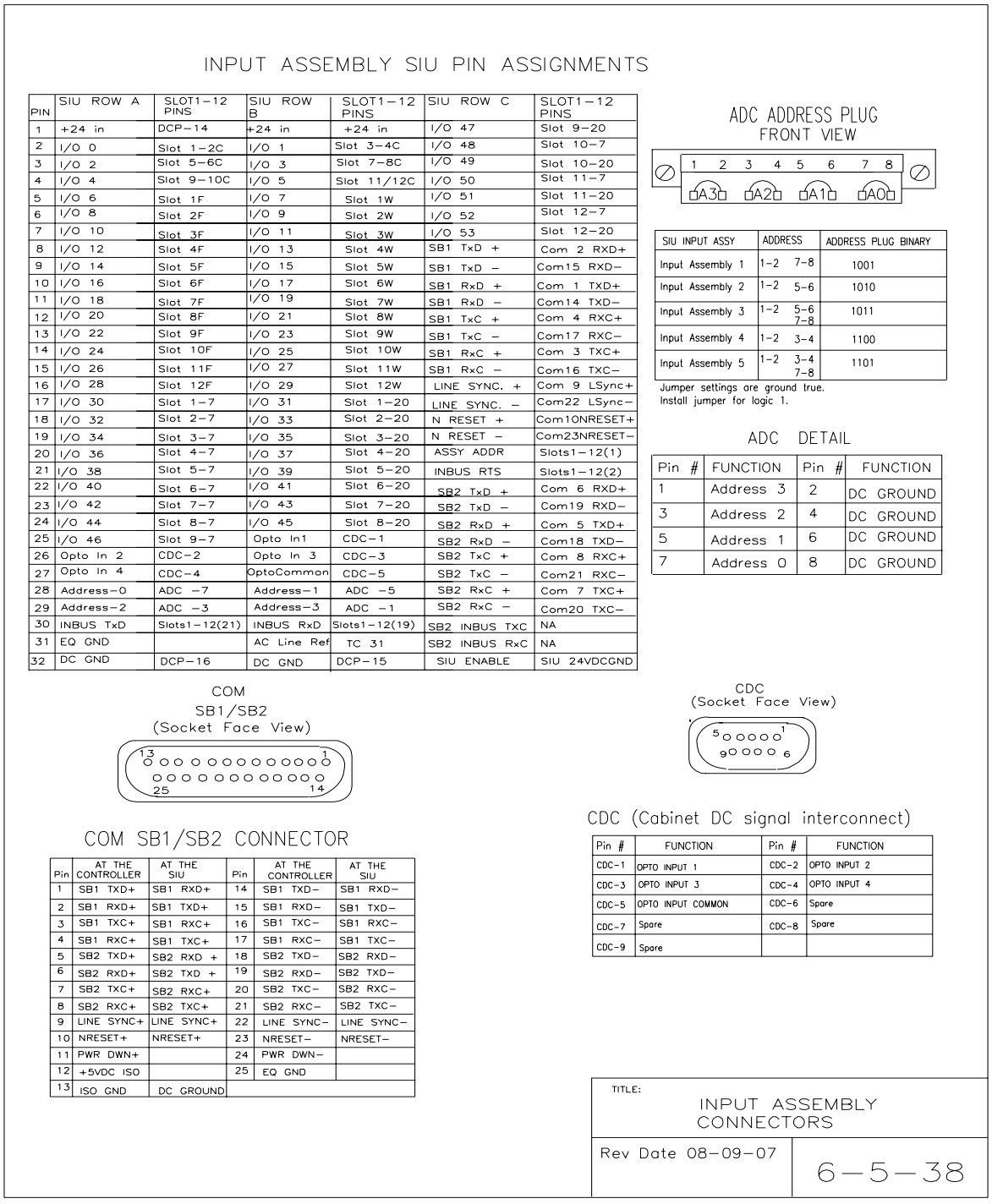


Figure 65
Input Assembly – Rear View



Pin	SIU PIN	SIGNAL	Pin	SIGNAL	SIU PIN
1	A5	IN6	16	B12	IN21
2	B5	IN7	17	A13	IN22
3	A6	IN8	18	B13	IN23
4	B6	IN9	19	A14	IN24
5	A7	IN10	20	B14	IN25
6	B7	IN11	21	A15	IN26
7	A8	IN12	22	B15	IN27
8	B8	IN13	23	A16	IN28
9	A9	IN14	24	B16	IN29
10	B9	IN15	25	B25	OPTO 1
11	A10	IN16	26	A26	OPTO 2
12	B10	IN17	27	B26	OPTO 3
13	A11	IN18	28	A27	OPTO 4
14	B11	IN19	29	B27	COMMON
15	A12	IN20	30	A32	DC Ground
			31	B31	AC LRef

Figure 66
Input Assembly – Wiring Diagram



INPUT ASSEMBLY SIU PIN ASSIGNMENTS

PIN	SIU ROW A	SLOT1-12 PINS	SIU ROW B	SLOT1-12 PINS	SIU ROW C	SLOT1-12 PINS
1	+24 in	DCP-14	+24 in	+24 in	I/O 47	Slot 9-20
2	I/O 0	Slot 1-2C	I/O 1	Slot 3-4C	I/O 48	Slot 10-7
3	I/O 2	Slot 5-6C	I/O 3	Slot 7-8C	I/O 49	Slot 10-20
4	I/O 4	Slot 9-10C	I/O 5	Slot 11/12C	I/O 50	Slot 11-7
5	I/O 6	Slot 1F	I/O 7	Slot 1W	I/O 51	Slot 11-20
6	I/O 8	Slot 2F	I/O 9	Slot 2W	I/O 52	Slot 12-7
7	I/O 10	Slot 3F	I/O 11	Slot 3W	I/O 53	Slot 12-20
8	I/O 12	Slot 4F	I/O 13	Slot 4W	SB1 TxD +	Com 2 RXD+
9	I/O 14	Slot 5F	I/O 15	Slot 5W	SB1 TxD -	Com15 RXD-
10	I/O 16	Slot 6F	I/O 17	Slot 6W	SB1 RxD +	Com 1 TXD+
11	I/O 18	Slot 7F	I/O 19	Slot 7W	SB1 RxD -	Com14 TXD-
12	I/O 20	Slot 8F	I/O 21	Slot 8W	SB1 TxC +	Com 4 RXC+
13	I/O 22	Slot 9F	I/O 23	Slot 9W	SB1 TxC -	Com17 RXC-
14	I/O 24	Slot 10F	I/O 25	Slot 10W	SB1 RxC +	Com 3 TXC+
15	I/O 26	Slot 11F	I/O 27	Slot 11W	SB1 RxC -	Com16 TXC-
16	I/O 28	Slot 12F	I/O 29	Slot 12W	LINE SYNC. +	Com 9 LSync+
17	I/O 30	Slot 1-7	I/O 31	Slot 1-20	LINE SYNC. -	Com22 LSync-
18	I/O 32	Slot 2-7	I/O 33	Slot 2-20	N RESET +	Com10NRESET+
19	I/O 34	Slot 3-7	I/O 35	Slot 3-20	N RESET -	Com23NRESET-
20	I/O 36	Slot 4-7	I/O 37	Slot 4-20	ASSY ADDR	Slots1-12(1)
21	I/O 38	Slot 5-7	I/O 39	Slot 5-20	INBUS RTS	Slots1-12(2)
22	I/O 40	Slot 6-7	I/O 41	Slot 6-20	SB2 TxD +	Com 6 RXD+
23	I/O 42	Slot 7-7	I/O 43	Slot 7-20	SB2 TxD -	Com19 RXD-
24	I/O 44	Slot 8-7	I/O 45	Slot 8-20	SB2 RxD +	Com 5 TXD+
25	I/O 46	Slot 9-7	Opto In1	CDC-1	SB2 RxD -	Com18 TXD-
26	Opto In 2	CDC-2	Opto In 3	CDC-3	SB2 TxC +	Com 8 RXC+
27	Opto In 4	CDC-4	OptoCommon	CDC-5	SB2 TxC -	Com21 RXC-
28	Address-0	ADC -7	Address-1	ADC -5	SB2 RxC +	Com 7 TXC+
29	Address-2	ADC -3	Address-3	ADC -1	SB2 RxC -	Com20 TXC-
30	INBUS TxD	Slots1-12(21)	INBUS RxD	Slots1-12(19)	SB2 INBUS TXC	NA
31	EQ GND		AC Line Ref	TC 31	SB2 INBUS RxC	NA
32	DC GND	DCP-16	DC GND	DCP-15	SIU ENABLE	SIU 24VDCGND

ADC ADDRESS PLUG
FRONT VIEW

1 2 3 4 5 6 7 8
A3 A2 A1 A0

SIU INPUT ASSY	ADDRESS	ADDRESS PLUG BINARY
Input Assembly 1	1-2 7-8	1001
Input Assembly 2	1-2 5-6	1010
Input Assembly 3	1-2 5-6 7-8	1011
Input Assembly 4	1-2 3-4	1100
Input Assembly 5	1-2 3-4 7-8	1101

Jumper settings are ground true.
Install jumper for logic 1.

ADC DETAIL

Pin #	FUNCTION	Pin #	FUNCTION
1	Address 3	2	DC GROUND
3	Address 2	4	DC GROUND
5	Address 1	6	DC GROUND
7	Address 0	8	DC GROUND

COM
SB1/SB2
(Socket Face View)

13 1
25 14

COM SB1/SB2 CONNECTOR

Pin	AT THE CONTROLLER	AT THE SIU	Pin	AT THE CONTROLLER	AT THE SIU
1	SB1 TXD+	SB1 RXD+	14	SB1 TXD-	SB1 RXD-
2	SB1 RXD+	SB1 TXD+	15	SB1 RXD-	SB1 TXD-
3	SB1 TXC+	SB1 RXC+	16	SB1 TXC-	SB1 RXC-
4	SB1 RXC+	SB1 TXC+	17	SB1 RXC-	SB1 TXC-
5	SB2 TXD+	SB2 RXD +	18	SB2 TXD-	SB2 RXD-
6	SB2 RXD+	SB2 TXD +	19	SB2 RXD-	SB2 TXD-
7	SB2 TXC+	SB2 RXC+	20	SB2 TXC-	SB2 RXC-
8	SB2 RXC+	SB2 TXC+	21	SB2 RXC-	SB2 TXC-
9	LINE SYNC+	LINE SYNC+	22	LINE SYNC-	LINE SYNC-
10	NRESET+	NRESET+	23	NRESET-	NRESET-
11	PWR DWN+		24	PWR DWN-	
12	+5VDC ISO		25	EQ GND	
13	ISO GND	DC GROUND			

CDC
(Socket Face View)

5 1
9 6

CDC (Cabinet DC signal interconnect)

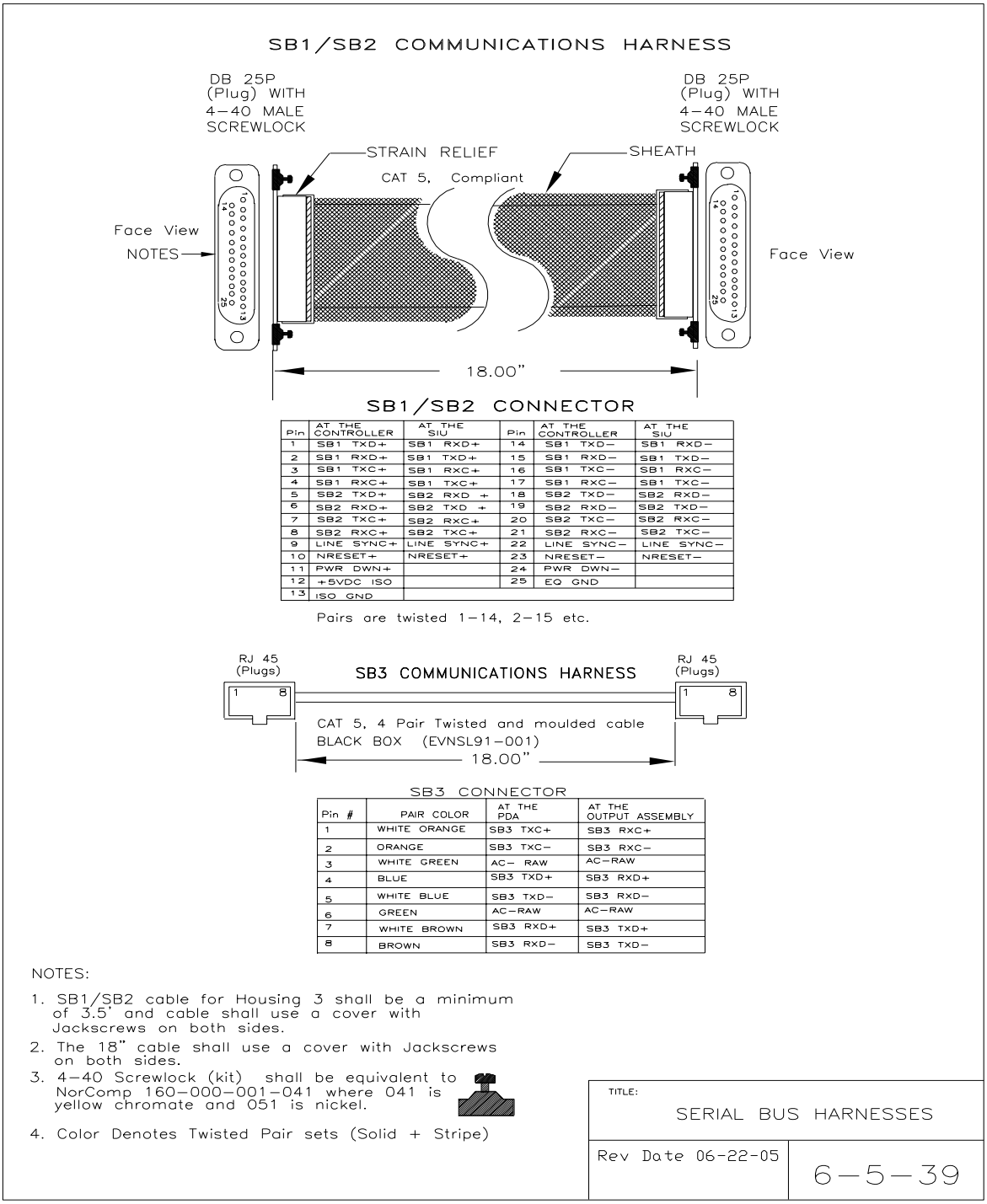
Pin #	FUNCTION	Pin #	FUNCTION
CDC-1	OPTO INPUT 1	CDC-2	OPTO INPUT 2
CDC-3	OPTO INPUT 3	CDC-4	OPTO INPUT 4
CDC-5	OPTO INPUT COMMON	CDC-6	Spare
CDC-7	Spare	CDC-8	Spare
CDC-9	Spare		

TITLE:
INPUT ASSEMBLY
CONNECTORS

Rev Date 08-09-07

6-5-38

Figure 67
Input Assembly – Connectors



SB1/SB2 CONNECTOR

Pin	AT THE CONTROLLER	AT THE SIU	Pin	AT THE CONTROLLER	AT THE SIU
1	SB1 TXD+	SB1 RXD+	14	SB1 TXD−	SB1 RXD−
2	SB1 RXD+	SB1 TXD+	15	SB1 RXD−	SB1 TXD−
3	SB1 TXC+	SB1 RXC+	16	SB1 TXC−	SB1 RXC−
4	SB1 RXC+	SB1 TXC+	17	SB1 RXC−	SB1 TXC−
5	SB2 TXD+	SB2 RXD +	18	SB2 TXD−	SB2 RXD−
6	SB2 RXD+	SB2 TXD +	19	SB2 RXD−	SB2 TXD−
7	SB2 TXC+	SB2 RXC+	20	SB2 TXC−	SB2 RXC−
8	SB2 RXC+	SB2 TXC+	21	SB2 RXC−	SB2 TXC−
9	LINE SYNC+	LINE SYNC+	22	LINE SYNC−	LINE SYNC−
10	NRESET+	NRESET+	23	NRESET−	NRESET−
11	PWR DWN+		24	PWR DWN−	
12	+5VDC ISO		25	EQ GND	
13	ISO GND				

Pairs are twisted 1−14, 2−15 etc.

SB3 CONNECTOR

Pin #	PAIR COLOR	AT THE PDA	AT THE OUTPUT ASSEMBLY
1	WHITE ORANGE	SB3 TXC+	SB3 RXC+
2	ORANGE	SB3 TXC−	SB3 RXC−
3	WHITE GREEN	AC− RAW	AC−RAW
4	BLUE	SB3 TXD+	SB3 RXD+
5	WHITE BLUE	SB3 TXD−	SB3 RXD−
6	GREEN	AC−RAW	AC−RAW
7	WHITE BROWN	SB3 RXD+	SB3 TXD+
8	BROWN	SB3 RXD−	SB3 TXD−

NOTES:

1. SB1/SB2 cable for Housing 3 shall be a minimum of 3.5' and cable shall use a cover with Jackscrews on both sides.
2. The 18" cable shall use a cover with Jackscrews on both sides.
3. 4−40 Screwlock (kit) shall be equivalent to NorComp 160−000−001−041 where 041 is yellow chromate and 051 is nickel.

4. Color Denotes Twisted Pair sets (Solid + Stripe)

TITLE: SERIAL BUS HARNESSES

Rev Date 06-22-05

6−5−39

Figure 68
Serial Bus Harness

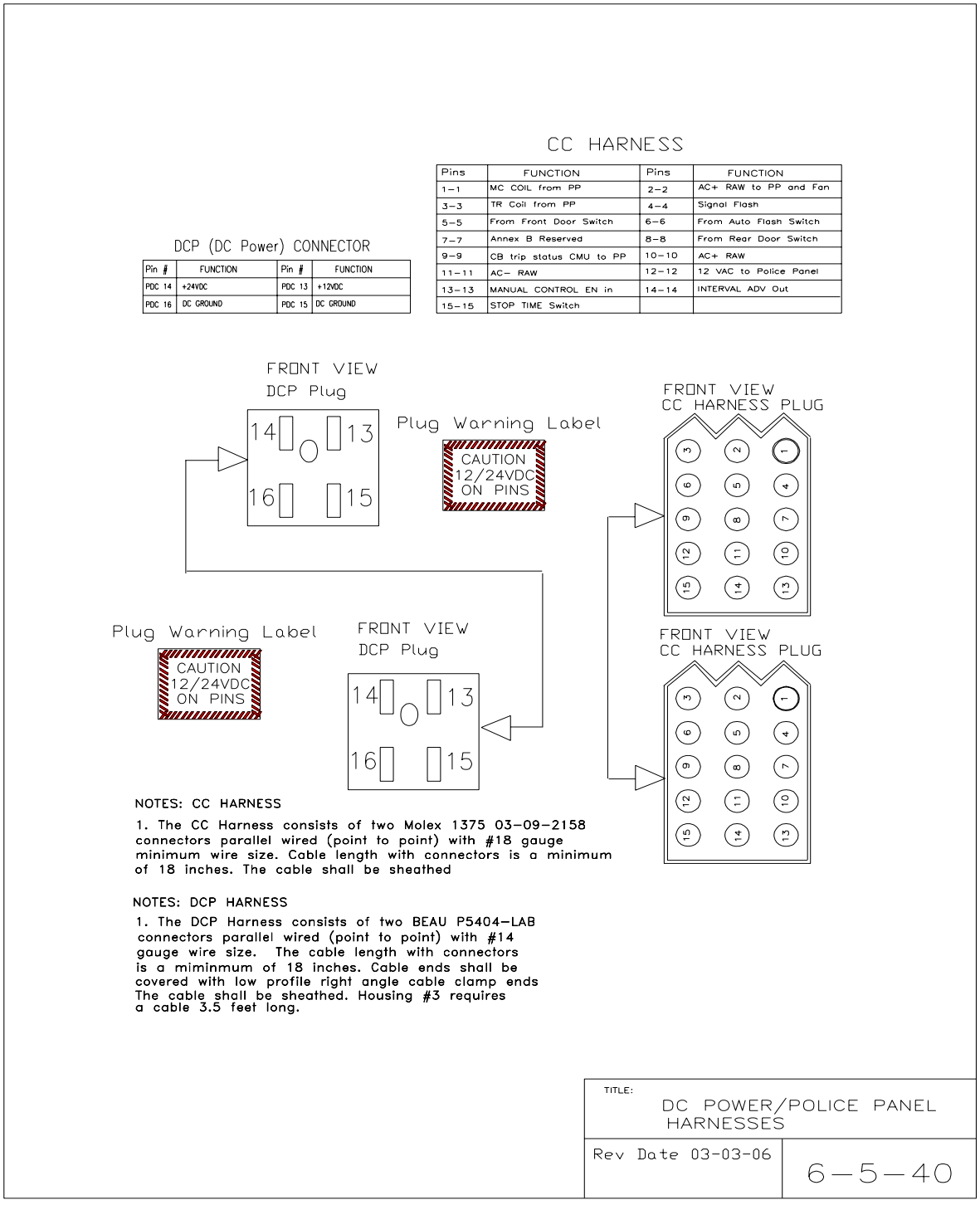


Figure 69
DC Power/Police Panel Harnesses

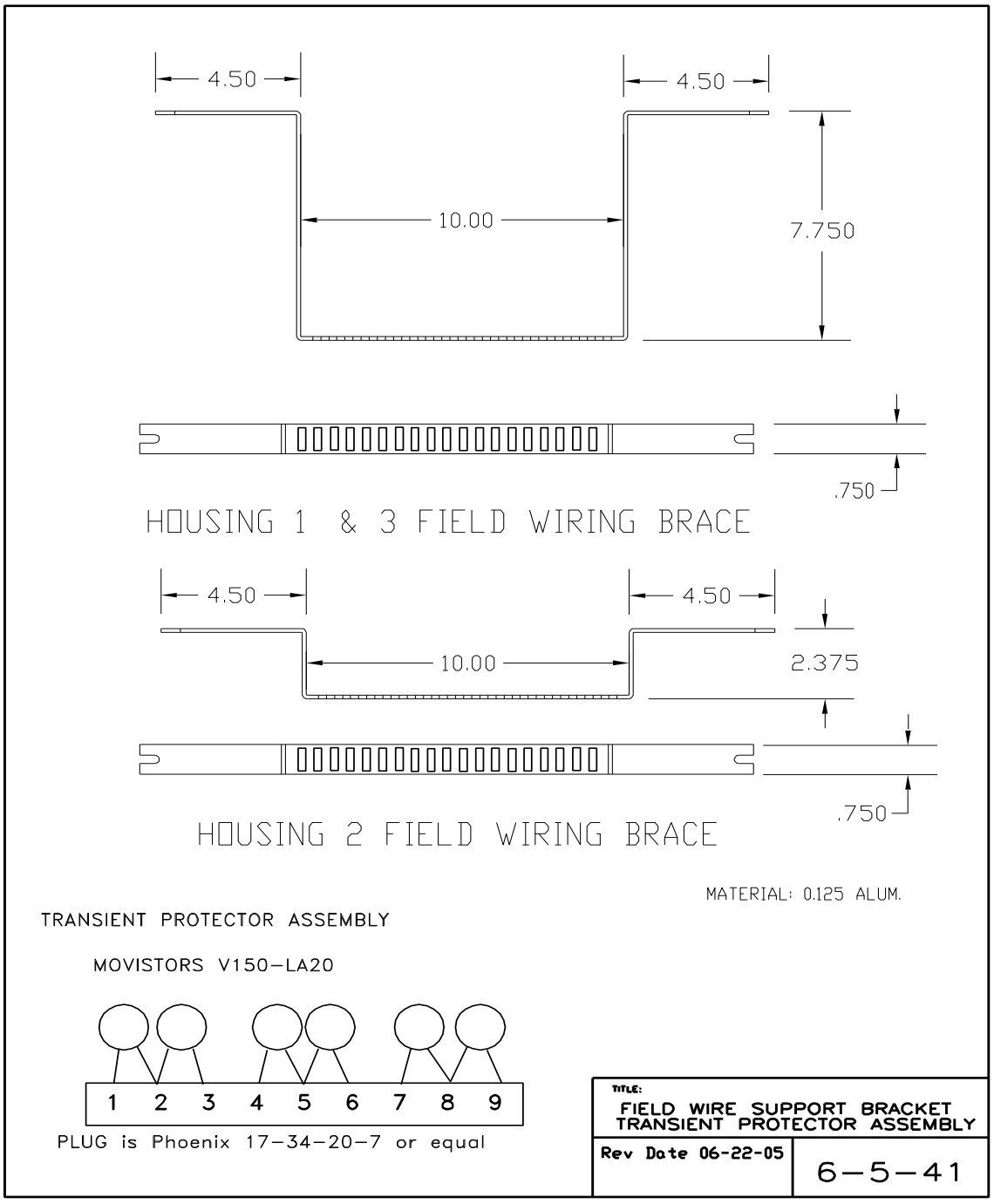


Figure 70
Field Wire Support Bracket/Transient Protector Assembly

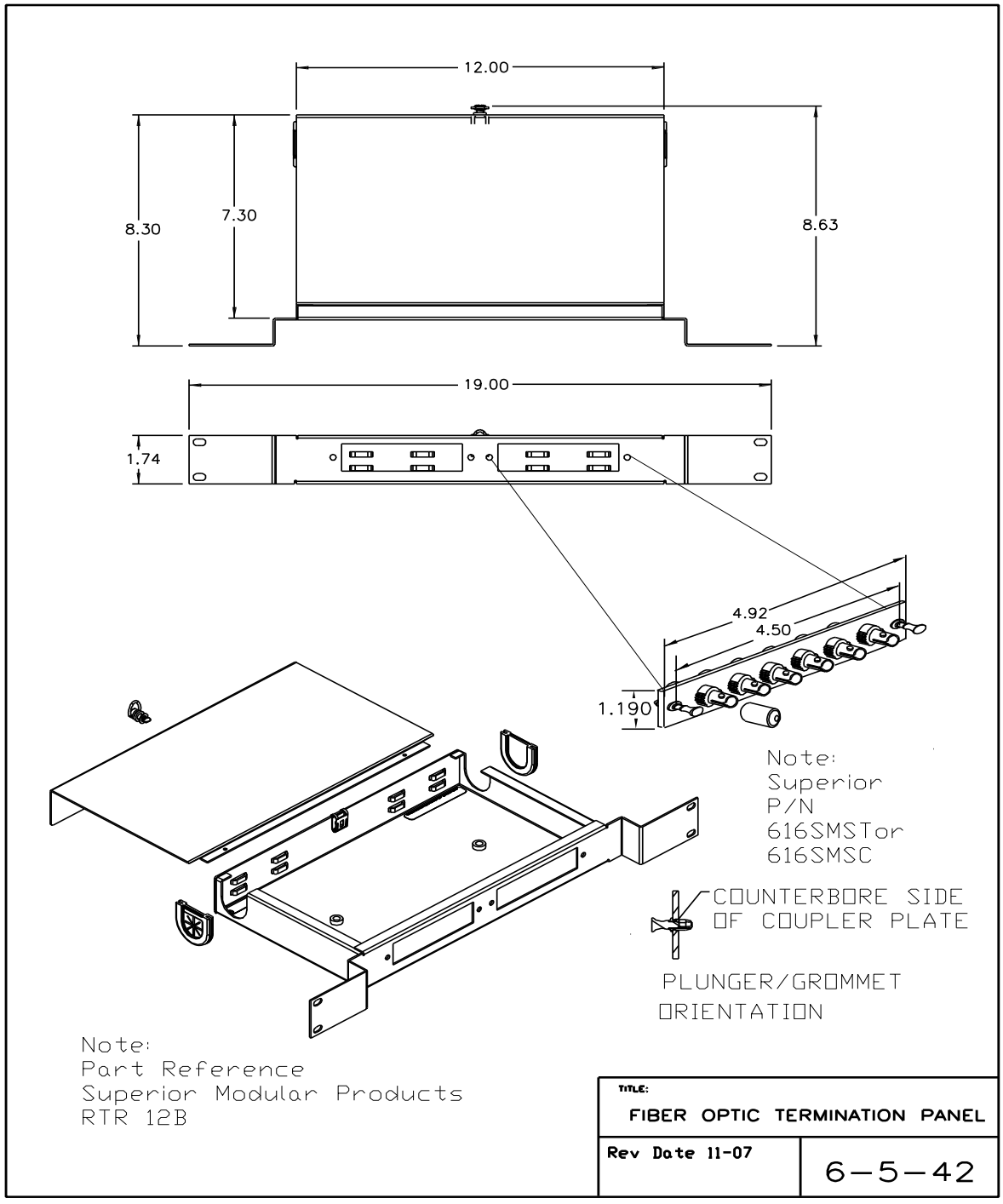


Figure 71
Fiber Optic Termination Panel
Provide P/N 616SMSC

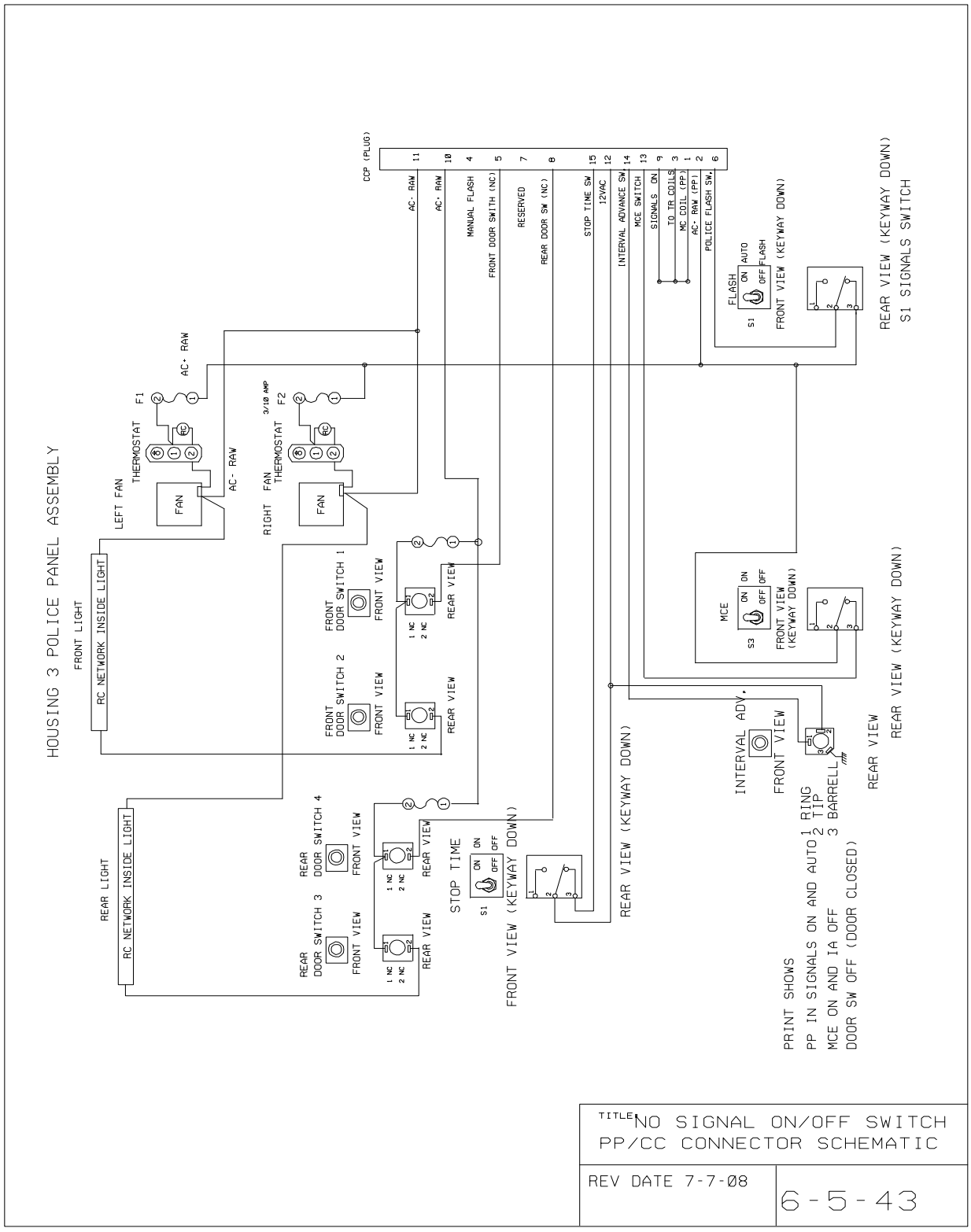


Figure 72
Police Panel and CC Schematic (CMU Bypass)

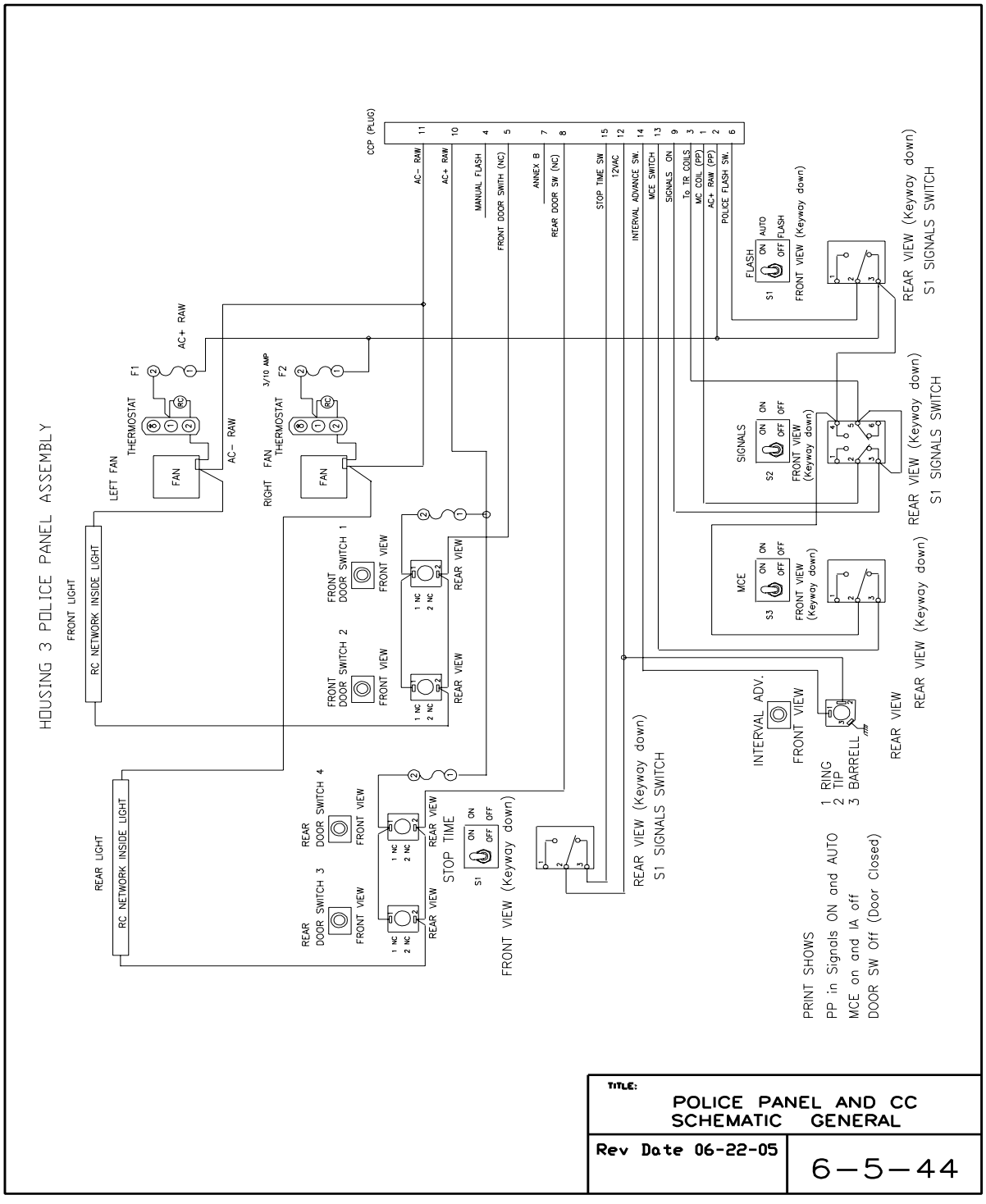


Figure 73
Police Panel and CC Schematic General

2.13 LEGACY DEVICE IMPLEMENTATION

A. A prototyping effort was conducted along with the development of this ITS Cabinet Standard. During the early stages of the prototyping effort, there were no SIU, AMU, and CMU devices available. As a result, a C1 and C11 interconnect list was developed to establish a method for using legacy 2070 controller applications. The list was developed with the Caltrans Model 332 and Model 336 Housing 2 Cabinets in mind. ITS Cabinet Housing #3 (with two internal racks) was the target prototype model being deployed in Harris County Texas, Housing 1 and Housing 2 ITS Cabinets have been deployed in small numbers.

B. The Input Assemblies and Output Assemblies are equipped with "Test Connectors" that are tied to the Detector Pins F and W on the Input Assembly and to the DC Switch Pack drives on the Output Assembly. While not specifically prototyped, the NEMA "A," "B," and "C" connectors could be assigned in-lieu of the C1 and C11 connectors to provide an interconnection of legacy NEMA devices within the ITS Cabinet.

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 16731

MODEL 2070 CONTROLLER UNIT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This specification defines the minimum detailed requirements applicable to the Type 2070 Advanced Transportation Controller (ATC) unit. The Advanced Transportation controller (ATC) is a general purpose programmable controller that is intended for continuous unattended operation in harsh environments.

B. This specification defines specific, interchangeable modules that are combined to form a Type 2070 ATC that is capable of running control software that might be provided from a variety of providers. This specification defines several module options that can be arranged in a variety of composition configurations to meet the needs of the user.

C. The Type 2070 version of the ATC is designed such that all components are fully standardized and are therefore interchangeable.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMNT AND PAYMENT

A. Unit Prices.

1. Measurement: This Item will be measured as each traffic signal controller unit furnished, or furnished and installed complete and in place.

2. Payment: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" as each specified controller unit furnished or furnished and installed, and made fully functional and operational and tested in accordance with the requirements in this specification.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERNCES

A. Advanced Transportation Controller (ATC) Standard, version 5.2b

B. Advanced Transportation Controller (ATC) 5202 – Model 2070 Controller Standard

C. API 5401, Application Programming Interface (API) Standard for the Advanced Transportation Controller (ATC)

D. ANSI/IEEE C62.41 – Practice for Surge Voltages in Low-Voltage AC Power Circuits

E. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

F. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

G. ASTM B633 – Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel

H. IPC-J-STD-001 - Requirements for Soldered Electrical and Electronic Assemblies

I. IPC-2221B – Generic Standard on Printed Board Design

J. Military Specification MIL-P-13949G – Printed Wiring Board

K. Military Specification MIL-PRF-55110 – Printed Wiring Boards, (Single, Double and Multilayer)

L. Military Specifications MIL-R-11G – Resistors Fixed Composition

M. Military Specification MIL-PRF-22684 – Resistors Fixed Film

N. Military Specifications MIL-W-16878E/1 – Wire, Hook up

O. Military Specifications MIL-W-16878/17 – Stranded Tinned Copper Plated Conductors

P. NEMA TS1 – Traffic Control Systems

Q. NEMA TS2-2021 - Traffic Controller Assemblies with NTCIP Requirements

1.05 WARRANTY

A. All materials furnished will be warranted by the supplier for a period of two (2) years from date of delivery.

1.06 SUBMITTALS

A. Manuals: A manual for each piece of equipment shall be provided to the City of Houston upon request in PDF format. The City of Houston reserves the right to make copies of these manuals for internal use only. A minimum of Times New Roman or Arial 10 point font must be used for all manual text, excluding drawings and schematics. Drawing text may use a smaller font size.

1. Manual Contents. Each manual must include the following sections in the order listed:

    a. Table of Contents

    b. Glossary

    c. Manufacturer Contact Information:

        (1) Address

        (2) Telephone Number

        (3) Fax Number

        (4) General Email Address

    d. General Description

    e. General Characteristics

    f. Installation

    g. Adjustments

    h. Theory of Operation:

        (1) Systems Description (include block diagram)

        (2) Detailed Description of Circuit Operation

    i. Maintenance:

        (1) Preventive Maintenance

        (2) Trouble Analysis

        (3) Trouble Shooting Sequence Chart

        (4) Wave Forms

        (5) Voltage Measurements

        (6) Alignment Procedures

    j. Parts List (include circuit and board designation, part type and class, power rating, component manufacturer, mechanical part manufacturer, data specification sheets for special design components and original manufacturer's part number).

k. Electrical Interconnection Details & Drawings

l. Schematic and Logic Diagram

m. Assembly Drawings and a pictorial diagram showing physical locations and identification of each component or part

n. The date, model numbers and revision numbers of equipment covered by the manuals must be included on the front cover of the manuals

B. A complete quality control / final test report must be supplied with each item. Quality control procedures must be submitted to the City of Houston prior to production. The test report must indicate the name of the tester and be signed by a responsible manager.

C. The quality control procedure and test report format must be supplied to the City of Houston for approval upon request. The quality control procedure must include the following, in the order shown:

1. Design Acceptance testing of all supplied components.

2. Physical and functional testing of all modules and items.

3. Environmental testing reports for all equipment.

4. Physical and functional testing of all items.

D. Separate certifications must be provided for Design and Production.

1.07 QUALITY ASSURANCE

A. Components. All components must be lot sampled to assure a consistent high conformance standard to the design specification of the equipment.

B. Subassembly, Unit or Module. Complete electrical, environmental and timing compliance testing must be performed on each module, unit, printed circuit or subassembly. Components will be tested as a complete controller assembly. Housing, chassis, and connection terminals must be inspected for mechanical sturdiness, and harnessing to sockets to be electrically tested for proper wiring sequence. The equipment must be visually and physically inspected to assure proper placement, mounting, and compatibility of subassemblies.

C. Pre-delivery Repair:

1. Any defects or deficiencies found by the inspection system involving mechanical structure or wiring must be returned through the manufacturing process or special repair process for correction.

2. PCB flow soldering is allowed a second time if copper runs and joints are not satisfactorily coated on the first run. Do not flow solder a PCB more than twice.

3. Hand soldering is allowed for printed circuit repair.

1.08 DELIVERY, STORAGE AND HANDLING

A. Packaging: Each item delivered must be individually packed in its own shipping container. When loose Styrofoam is used for packing the item, the item must be sealed in a plastic bag to prevent direct contact with the Styrofoam.

B. Delivery: Each item delivered for testing must be complete, including manuals, and ready for testing.

PART 2 PRODUCTS

2.01 CONTROLLER DESCRIPTIONS

A. Controller Housing. The Type 2070 controller defines a controller housing that is intended to fit an EIA 19 in. rack mounted form commonly found in the Type 332 and ITS family of cabinets. A NEMA base module is defined for those NEMA TS1 and TS2 shelf mounted applications.

B. CPU Module. The CPU module consists of the main CPU, memory, software and interfaces to the remainder of the controller. The Type 2070-1C configuration is intended to interface with the "engine board" specified by the ATC v5.2 standard.

C. Field I/O Module. The Field I/O Module provides a mechanism for input and output interfaces. The Type 2070-2A Modules are intended to provide a parallel I/O interface with the Type 332 family of cabinets using the C1S and C11S connectors, and a serial I/O interface to the ITS cabinet family. The Type 2070-2B Module is intended to provide a serial I/O interface to the NEMA interface to TS1 cabinets (2070LN).

D. Front Panel Module. A controller Front Panel usually contains a keyboard and display that comprise the user field interface. The Type 2070-3B Front Panel includes a small character (8 lines of 40 characters) LCD.

E. Power Supply Module. A power supply module is used to convert 120 volt power to voltages required to operate the electronics inside the Type 2070 controller unit. This power supply must meet certain minimum electrical characteristics defined herein for its intended use. The Type 2070-4B identifies a 3.5 ampere power supply. Power cord to be supplied with the module should have a minimum length of 4 feet.

F. Communications Module. The Type 2070-7 series of modules are for serial communications.

G. NEMA Interface. This standard includes requirements for an optional module to interface with the NEMA TS1 cabinets. The Type 2070-8 NEMA Field I/O Module is an external module that attaches to the bottom of the 2070 and provides for the typical "A", "B", "C" and "D" NEMA connectors.

2.02 CONTROLLER REQUIREMENTS

A. General. All furnished equipment must be new and unused. Vacuum or gaseous tubes and electro-mechanical devices (unless specifically called out) must not be used.

B. Controller Configurations are specified in section 2.08.

2.03 COMPONENTS

A. General. All components must be second sourced and must be of such design, fabrication, nomenclature or other identification as to be purchased from a wholesale distributor or from the component manufacturer. When a component is of such special design that it precludes the purchase of identical components from any wholesale distributor or component manufacturer, one spare duplicate component must be furnished with each twenty, or fraction thereof, components used. The electronic circuit design must be such that all components of the same generic type, regardless of manufacturer, must function equally in accordance with the specifications.

B. Electronic Components:

1. No device to be socket mounted unless specifically called out.

2. No component to be operated above 80% of its maximum rated voltage, current or power ratings. Digital components must not be operated above 3% over their nominal voltage, current or power ratings.

3. No component to be provided where the manufactured date is three years older than the contract award date. The design life of all components, operating for twenty- four hours a day and operating in their circuit application, must be ten years or longer.

4. Components must be arranged so they are easily accessible, replaceable and identifiable for testing and maintenance. Where damage by shock or vibration exists, a clamp, fastener, retainer, or hold-down bracket must support the component mechanically.

5. The Manufacturer must submit detailed engineering technical data on all components at the request of the City of Houston. The Manufacturer must certify that the component application meets the requirements of this standard.

C. Capacitors. The DC and AC voltage ratings as well as the dissipation factor of a capacitor must exceed the worst-case design parameters of the circuitry by 150%. Capacitor encasements must be resistant to cracking, peeling and discoloration. All capacitors must be insulated and must be marked with their capacitance values and working voltages. Electrolytic capacitors must not be used for capacitance values of less than 1.0 microfarad and must be marked with polarity.

D. Potentiometers. Potentiometers with ratings from 1 to 2 watts must meet Military Type RV4 requirements. Less than 1 Watt potentiometers must be used only for trimmer type function. The potentiometer power rating must be at least 100% greater than the maximum power requirements of the circuit.

E. Resistors. Fixed carbon film, deposited carbon, or composition-insulated resistors must conform to the performance requirements of Military Specifications MIL-R-11G or MIL-PRF-22684. All resistors must be insulated and be marked with their resistance values. Resistance values must be indicated by the EIA color codes, or stamped value. The value of the resistors must not vary by more than 5% between -37 degrees C and 74 degrees C.

1. Special ventilation or heat sinking must be provided for all 2- watt or greater resistors. They must be insulated from the PCB.

F. Semiconductor Devices:

1. All transistors, integrated circuits, and diodes must be a standard type listed by EIA and clearly identifiable.

2. All metal oxide semiconductor components must contain circuitry to protect their inputs and outputs against damage due to high static voltages or electrical fields.

3. Device pin "1" locations must be properly marked on the PCB adjacent to the pin.

G. Transformers and Inductors. All power transformers and inductors must have the manufacturer's name or logo and part number clearly and legibly printed on the case or lamination. All transformers and inductors must have their windings insulated, be protected to exclude moisture, and their leads color coded with an approved EIA color code or identified in a manner to facilitate proper installation.

H. Triacs. Each triac with a designed circuit load of greater than 0.5 Amperes at 120 VAC must be mounted to a heat sink with thermal conductive compound or material, in addition to being mechanically secured.

I. Circuit Breakers. Circuit breakers must be listed by UL or ETL. The trip and frame sizes must be plainly marked (marked on the breaker by the manufacturer), and the ampere rating visible from the front of the breaker. Contacts must be silver alloy and enclosed in an arc-quenching chamber. An ambient air temperature range of from -18 degrees C to 50 degrees C must not influence overload tripping. The minimum Interrupting Capacity must be 5,000 amperes, RMS when the breaker is secondary to a UL approved fuse or primary circuit breaker and both breakers in concert provide the rated capacity. For circuit breakers 80 amperes and above, the minimum interrupting capacity must be 10,000 amperes, RMS. Circuit breakers must be the trip-free type with medium trip delay characteristic (Carlingswitch Time Delay Curve #24 or equal).

1. Load Circuit Breaker Auxiliary Internal Switches. The Load Circuit Breakers used to power Switch Packs must have auxiliary switches. The auxiliary switches must "open" when the load breaker has tripped and the system will transfer the power from the Main Contactor to the Flash or Blank condition.

J. Fuses. All Fuses that are resident in a bayonet style fuse holder must have the fuse size rating labeled on the holder or on the panel adjacent to the holder. Fuses must be easily accessible and removable without use of tools.

K. Switches:

1. Dip. Dual-inline-package, quick snap switches must be rated for a minimum of 30,000 operations per position at 50 milliamperes, 30 VDC. The switch contact resistance must be 100 milliohms maximum at 2 milliamperes, 30 VDC. The contacts must be gold over brass.

2. Logic. The switch contacts must be rated for a minimum of 1-ampere resistive load at 120 VAC and must be silver over brass (or equal). The switch must be rated for a minimum of 40,000 operations.

3. Control. The switch contacts must be rated for a minimum of 5 amperes resistive load at 120 VAC or 28 VDC and be silver over brass (or equal). The switch must be rated for a minimum of 40,000 operations.

4. Power. Ratings must be the same as CONTROL, except the contact rating must be a minimum of 10 amperes at 125 VAC.

L. Terminal Blocks. The terminal blocks must be barrier type, rated at 20 amperes and 600 VAC RMS minimum. The terminal screws must be 0.3125 in. minimum length nickel- plated brass binder head type with screw inserts of the same material. Screw size is called out under the associated file, panel or assembly.

M. Screw Lug and Cam Driven Connectors. Provided the connectors mate, screw lug cam driven devices or crimp pin connectors must be allowable if the interface is part of a harness. For field termination, screw lug and cam driven assemblies are interchangeable for field wiring termination, provided they both accommodate 22-gauge wire on the inputs and 22-gauge wire on the outputs.

N. Wiring, Cabling and Harnesses:

1. Harnesses must be neat, firm and properly bundled with external protection. They must be tie-wrapped and routed to minimize crosstalk and electrical interference. Each harness must be of adequate length to allow any conductor to be connected properly to its associated connector or termination point. Conductors within an encased harness have no color requirements. Printed circuit motherboards are to be used where possible to eliminate or reduce cabinet wiring.

2. Wiring containing AC must be bundled separately or shielded separately from all DC logic voltage control circuits.

3. Wiring must be routed to prevent conductors from being in contact with metal edges. Wiring must be arranged so that any removable assembly may be removed without disturbing conductors not associated with that assembly.

4. All conductors, except those that can be readily traced, must be labeled. Labels attached to each end of the conductor must identify the destination of the other end of the conductor.

5. All conductors must conform to MIL-W-16878E/1 or better and have a minimum of 19 strands of copper. The insulation must be polyvinyl chloride with a minimum thickness of 10 mils or greater. Where insulation thickness is 15 mils or less, the conductor must conform to MIL-W-16878/17.

6. Conductor color identification must be as follows:

   a. AC- circuits - white

   b. Equip. Ground - solid green or continuous green color with 1 or more yellow stripes

   c. DC logic ground - continuous white with a red stripe

   d. AC+ circuits - continuous black or black with colored stripe

   e. DC logic ungrounded or signal - any color not specified

O. Indicators and Character Displays:

1. All indicators and character displays must be readily visible at a radius of up to 4 feet within the cone of visibility when the indicator is subjected to 97,000 lux (9,000 foot-candles) of white light with the light source at 45 degrees (+/- 2 degrees) to the front panel.

2. All indicators and character displays must have a minimum 90 degrees cone of visibility with its axis perpendicular to the panel on which the indicator is mounted. All indicators must be self-luminous. All indicators must have a rated life of 100,000 hours minimum. Each LED indicator must be white or clear when off. Indicators supplied on equipment requiring handles must be mounted such that a horizontal clearance is provided.

3. Liquid Crystal Displays (LCD) must be readable at temperatures of -20 degrees C to +70 degrees C. All controller unit functions are required to operate at temperatures of -37 degrees C to +74 degrees C.

P. Connectors. Connectors must be keyed to prevent improper insertion of the wrong connector where equipment damage or operator injury may result. The mating connectors must be designated as the connector number and male/female relationship, such as C1P (plug or PCB edge connector) and C1S (socket).

1. Type T. Type T connector must be a single row, 10 position, feed through terminal block. The terminal block must be a barrier type with 6-32, 0.25 in. or longer, nickel plated brass binder head screws. Each terminal must be permanently identified as to its function.

2. Plastic Circular and Type M. Pin and socket contacts for connectors must be beryllium copper construction subplated with 1.27 microns nickel and plated with 0.76 microns gold. Pin diameter must be 0.0618 in. All pin and socket connectors must use the AMP #601105-1 or #91002-1 contact insertion tool and the AMP #305183 contact extraction tool or equal.

3. Card Edge and Two Piece PCB:

a. Edge connectors must have bifurcated gold-plated contacts. The PCB receptacle connector must meet or exceed the following:

(1) Operating Voltage: 600 VAC (RMS)

(2) Current Rating: 5.0 Amperes

(3) Insulation Material: Diallyl Phthalate or Thermoplastic

(4) Insulation Resistance: 5,000 Megohms

(5) Contact Material: Copper alloy plated with 0.00005 in. of nickel and 0.000015 in. of gold

(6) Contact Resistance: 0.006 Ohm maximum

b. The two-piece PCB connector must meet or exceed the DIN 41612.

c. The PCB 22/44 Connector must have 22 independent contacts per side; dual sided with 0.156 in. contact centers.

4. Wire Terminal. Each wire terminal must be solderless with PVC insulation and a heavy-duty short -locking spade type connector. Crimp terminal connectors using a Controlled-Cycle type crimping tool.

5. Flat Cable. Each flat cable connector must be designed for use with 26 AWG cable; have dual cantilevered phosphor bronze contacts plated with 0.00015 in. of gold over 0.00005 in. of nickel; and have a current rating of 1 Ampere minimum and an insulation resistance of 5 Megohms minimum.

6. PCB Header Post. Each PCB header post must be 0.025 in. square by 0.3425 in. high from the plane of the PCB to the end of the pin; be mounted on 0.10 in. centers; and be tempered hard brass plated with 0.00015 in. of gold over 0.00005 in. of nickel.

7. PCB Header Socket. Each PCB header socket block must be nylon or diallyl phthalate. Each PCB header socket contact must be removable, but crimp-connected to its conductor. List the part number of the extraction tool recommended by its manufacturer. Each PCB header socket contact must be brass or phosphor bronze plated with 0.0015 in. of gold over 0.00005 in. of nickel.

Q. Surge Protection Device. The surge suppression device must comply with ANSI/IEEE C62.41 (100 Kilohertz Ring Wave, the 1.2/50 microseconds - 8/20 Combination Wave and the EFT Burst) at voltages and currents specified at "Location Category B2" and at "Test Severity" level III (i.e. up to 4.0 Kilovolts, open-circuit).

2.04 MECHANICAL REQUIREMENTS

A. Assemblies. All assemblies must be modular, easily replaceable and incorporate plug-in capability for their associated devices or PCBs. Assemblies must be provided with two guides for each plug-in PCB or associated device (except relays). The guides must extend to within 0.75 in. from the face of either the socket or connector and front edge of the assembly. If Nylon guides are used, attach the guides securely to the file or assembly chassis.

B. Locking Devices. All screw type fasteners must utilize locking devices or locking compounds except finger screws, which are captive.

C. PCB Design and Connectors. No components, traces, brackets or obstructions are to be within 0.125 in. of the board edge (guide edges). The manufacturer's name or logo, model number, serial number, and circuit issue or revision number must appear and be readily visible on all PCBs.

D. Model and Serial Numbers:

1. The manufacturer's model number, and circuit issue or revision number must appear on the rear panel of all equipment supplied (where such panel exists). In addition to any assignment of model numbers by the manufacturer, the TYPE number must be displayed on the front panel in bold type, at least 0.25 in. high.

2. A permanent label must be affixed to the inside near and center floor of the Type 2070 unit chassis when viewed from the front. The label must display the unit's serial number and be permanent and easy to read.

3. Workmanship. Workmanship must conform to the requirements of this specification and be in accordance with the highest industry standards.

4. Tolerances. The following tolerances must apply, except as specifically shown on the plans or in these specifications:

   a. Sheet Metal +/-0.0525 in.

   b. PCB +0 in., - 0.010 in.

   c. Edge Guides +/-0.015 in.

   d. Note: These dimensional tolerances do not apply to material gauge or thickness

2.05 ENGINEERING

A. Human Engineering. The equipment must be engineered for simplicity, ease of operation and maintenance.

1. Knobs must be a minimum of 0.5 in. in diameter and a minimum separation of 0.5 in. edge to edge.

2. PCBs must slide smoothly in their guides while being inserted into or removed from the frame and fit snugly into the plug-in PCB connectors. PCBs must require a force no less than 5 pounds-force or greater than 50 pounds-force for insertion or removal.

B. Design Engineering. The design must be inherently temperature compensated to prevent abnormal operation. The circuit design must include such compensation as is necessary to overcome adverse effects due to temperature in the specified environmental range. The design must take into consideration the protection of personnel from all dangerous voltages.

C. Generated Noise. No item, component or subassembly is to emit an audible noise level exceeding the peak level of 55 dBa when measured at a distance of one meter away from its surface, except as otherwise noted. No item, component or subassembly is to emit a noise level sufficient to interfere with processing and communication functions of the controller circuits.

2.06 PRINTED CIRCUIT BOARDS

A. Design, Fabrication and Mounting:

1. All contacts on PCBs must be plated with a minimum thickness of 0.00003 in. gold over a minimum thickness of 0.000075 in. nickel.

2. PCB design must be such that when a component is removed and replaced, no damage is done to the board, other components, conductive traces or tracks.

3. Fabrication of PCBs must be in compliance with Military Specification MIL-P- 13949, except as follows:

a. NEMA FR-4 glass cloth base epoxy resin copper clad laminates 0.0625 in. minimum thickness must be used. Inter-component wiring must be by laminated copper clad track having a minimum weight of 0.2 ounces per square foot with adequate cross section for current to be carried. All copper tracks must be plated or soldered to provide complete coverage of all exposed copper tracks. Jumper wires to external PCB components must be from plated- through padded holes and as short as possible.

b. All PCBs must conform to Section 3.3 of Military Specification MIL-P- 13949G Grade of Pits and Dents and be of Grade B quality (3.5.1.3) or better. The class of permissible bow or twist must be Class C (Table V) or better. The class of permissible warp or twist must be Class A (Table II) or better.

c. Omit Sections 4.2 through 6.6 of Military Specification MIL-P-13949G (inclusive) except as referenced in previous sections of this specification.

d. The mounting of parts and assemblies on the PCB must conform to IPC-2221B, except as follows:

(1) Semiconductor devices that dissipate more than 250 milliwatts or cause a temperature rise of 10 degrees C or more must be mounted with spacers, transipads or heat sinks to prevent contact with the PCB.

(2) When completed, remove all residual flux from the PCB.

(3) The resistance between any two isolated, independent conductor paths must be at least 100 Megohms when a 500 VDC potential is applied.

(4) All PCBs must be coated with a moisture resistant coating.

(5) Where less than 0.25 in. lateral separation is provided between the PCB (or the components of a PCB) and any metal surface, a 0.0625 in. (+/- 0.0005 in.) Thick Mylar (polyester) plastic cover must be provided on the metal to protect the PCB.

e. Each PCB connector edge must be chamfered at 30 degrees from board side planes. The key slots must also be chamfered so that the connector keys are not extracted upon removal of board or jammed upon insertion. The key slots must be 0.045 in. (+/-0.005 in.) for 0.1 in. spacing and 0.055 in. (+/-0.005 in.) for 0.156 in. spacing.

B. Soldering:

1. Hand soldering must comply with J-STD-001.

2. Automatic flow soldering must be a constant speed conveyor system with the conveyor speed set at optimum to minimize solder peaks or points. Temperature must be controlled to within +/- 8 degrees C of the optimum temperature. The soldering process must result in the complete coverage of all copper runs, joints and terminals with solder except that which is covered by an electroplating process. Wherever clinching is not used, provide a method of holding the components in the proper position for the flow process.

3. If exposure to the temperature bath is of such a time-temperature duration, as to come within 80% of any component's maximum specified time-temperature exposure, that component must be hand soldered to the PCB after the flow process has been completed.

C. Definitions. Definitions for the purpose of this section on PCBs must be taken from MIL-PRF-55110 and any current addendum.

D. Jumpers. Jumpers are not allowed unless called out in the specifications or approved by the City of Houston.

2.07 ELECTRICAL, ENVIRONMENTAL AND TESTING REQUIREMENTS

A. The framework of this section, along with the specific test requirements contained herein, is excerpted with modifications from NEMA TS2-2021 - Section 2 by permission of NEMA. Excerpt © 2002 AASHTO / ITE / NEMA. In the case where these requirements differ from the testing requirements in ATC Standard 5.2b, then apply ATC Standard 5.2b requirements ONLY to 1C modules.

B. General. This section establishes the limits of the environmental and operational conditions in which the Controller Assembly will perform. This section defines the minimum test procedures that may be used to demonstrate conformance of a device type with the provisions of the standard. These test procedures do not verify equipment performance under every possible combination of environmental requirements covered by this standard. Nothing in this testing profile must be construed as to relieve the requirement that the equipment provided must fully comply with these standards/specifications under all environmental conditions stated herein. The City of Houston may wish to extend the testing profile or introduce additional tests to verify compliance. (Authorized Engineering Information).

C. Inspection. A visual and physical inspection must include mechanical, dimensional and assembly conformance to all parts of this standard.

D. Testing Certification.

1. Design Acceptance testing must be performed with a fully loaded and functional Cabinet Assembly. Production testing must be performed as part of the City of Houston's procurement delivery procedures and that testing should be performed at the Major Unit level. (Authorized Engineering Information)

2. Certain portions of the test procedures contained in this standard my cause damage to the unit (e.g. protection devices may be aged) and are not recommended for routine Production testing. (Authorized Engineering Information)

E. Definitions of Major Units of the Cabinet Assembly. For the purpose of this section, "Major units of the Cabinet Assembly" must include the Controller Unit, Application Software for implementing the desired functionality, Cabinet Monitor Unit (CMU), Auxiliary Monitor Unit (AMU), Serial Interface Units (SIUs), Power Distribution Unit (PDA), Switch Packs, Flasher(s), and Detector(s).

F. Environmental and Operating Requirements. The requirements (voltage, temperature, etc.) of this section must apply in any combination.

1. Voltage and Frequency.

a. Operating Voltage. The nominal voltage must be 120 VAC, unless otherwise noted.

b. Operating Frequency. The operating frequency range must be 60 hertz (+/-3.0 hertz), unless otherwise noted.

2. Transients, Power Service. The Test Unit must maintain all defined functions when the independent test pulse levels specified below occur on the alternating- current power service.

a. High Repetition Noise Transients

(1) The test pulses must not exceed the following conditions:

(a) Amplitude: 300 Volts, both positive and negative polarity.

(b) Peak Power: 2500 watts.

(c) Repetition: 1 pulse approximately every other cycle moving uniformly over the full wave in order to sweep across 360 degrees of the line cycle once every 3 seconds.

(d) Pulse Rise Time: 1 microsecond.

(e) Pulse Width: 10 microseconds.

(f) This test is performed without protection in place or operational.

(g) This test is considered to be a minimum test requirement for the Test Unit complying with ANSI/IEEE C62.41. Regional conditions may warrant additional testing as described in ANSI/IEEE C62.41. (Authorized Engineering Information)

b. Low Repetition High Energy Transients.

(1) The test pulses must not exceed the following conditions:

(a) Amplitude: 600 Volts (+/-5 percent), both positive and negative polarity.

(b) Energy Source: Capacitor, oil filled, 10 microfarads (+/-10 percent), internal surge impedance less than 1 ohm.

(c) Repetition: 1 discharge every 10 seconds.

(d) Pulse Position: Random across 360 degrees of the line cycle.

(e) This test is performed with protection in place and operational. This test is considered to be a minimum test requirement for the Test Unit complying with ANSI/IEEE C62.41. Regional conditions may warrant additional testing as described in ANSI/IEEE C62.41. (Authorized Engineering Information)

c. Nondestructive Transient Immunity.

(1) The Test Unit (with protection in place and operational) must be capable of withstanding a high energy transient having the following characteristics repeatedly applied to the alternating current input terminals (no other power connected to terminals) without failure of the test specimen:

(a) Amplitude: 1000 Volts (+/-5 percent), both positive and negative polarity.

(b) Energy Source: Capacitor, oil filled, 15 microfarads (+/-10 percent), internal surge impedance less than 1 ohm.

(c) Repetition: Applied to the Test Unit once every 2 seconds for a maximum of three applications for each polarity.

(d) After the foregoing, the Test Unit must perform all defined functions upon the application of nominal alternating current power.

(e) This test is considered to be a minimum test requirement for the Test Unit complying with ANSI/IEEE C62.41 (100 Kilohertz Ring Wave, the 1.2/50 microseconds - 8/20 Combination Wave and the EFT Burst) at voltages and currents specified at "Location Category B2" and at "Test Severity" level III (i.e. up to 4.0 Kilovolts, open-circuit). Regional conditions may warrant additional testing as described in ANSI/IEEE C62.41. (Authorized Engineering Information)

d. Transients, Input-Output Terminals.

(1) The Test Unit (without protection in place or operational) must maintain all defined functions, when the test pulse occurs on the input- output terminals.

(a) Amplitude: 300 Volts, both positive and negative polarity.

(b) Pulse Source: 1000 ohms nominal impedance.

(c) Repetition: 1 pulse per second, for a minimum of 5 pulses per selected terminal.

(d) Pulse rise time: 1 microsecond.

(e) Pulse width: 10 microseconds.

(f) This test is considered to be a minimum test requirement for the Test Unit complying with ANSI/IEEE C62.41. Regional conditions may warrant additional testing as described in ANSI/IEEE C62.41. (Authorized Engineering Information)

e. Temperature and Humidity. The Test Unit must maintain all programmed functions when the temperature and humidity ambients are within the specified limits defined herein.

(1) Ambient Temperature.

(a) The operating ambient temperature range must be from -37 degrees C to +74 degrees C. The storage temperature range must be from -45 degrees C to +85 degrees C.

(b) The rate of change in ambient temperature must not exceed 18 degrees C per hour, during which the relative humidity must not exceed 95 percent.

(2) Humidity.

(a) The relative humidity must not exceed 95 percent non-condensing over the temperature range of -37 degrees C to +74 degrees C.

(b) Above +46 degrees C, constant absolute humidity must be maintained. This will result in the relative humidity shown in Table 1 for dynamic testing.

Table 1
AMBIENT TEMPERATURE VERSUS RELATIVE HUMIDITY AT BAROMETRIC PRESSURES (29.92 In. Hg.) (NON-CONDENSING)

Ambient Temperature/ Dry Bulb (in degrees C)	Relative Humidity (in percent)	Ambient Temperature/ Wet Bulb (in degrees C)
-37.0 to 1.1	10	-17.2 to 42.7
1.1 to 46.0	95	42.7
48.8	70	42.7
54.4	50	42.7
60.0	38	42.7
65.4	28	42.7
71.2	21	42.7
74.0	18	42.7

f. Test Facilities. All instrumentation required in the test procedures, such as voltmeters, ammeters, thermocouples, pulse timers, etc. must be selected in accordance with good engineering practice. In all cases where time limit tests are required, the allowance for any instrumentation errors must be included in the limit test.

(1) Variable Voltage Source: A variable source capable of supplying 20 amperes from 100 VAC to 135 VAC.

(2) Environmental Chamber: An environmental chamber capable of attaining temperatures of -37 degrees C to +74 degrees C and relative humidity given in Table 1.

(3) Transient Generators: Transient generators capable of supplying the transients outlined above.

G. Test Procedure: Transients, Temperature, Voltage, and Humidity

1. Test A: Placement in Environmental Chamber and Check-Out of Hook-Up

a. Place the test unit in the environmental chamber. Connect the test unit AC input circuit to a variable voltage power transformer, voltmeter, and transient generator. The transient generator must be connected to the AC input circuit at a point at least 25 feet from the AC power source and not over 10 feet from the input to the test unit.

b. Connect test switches to the appropriate terminals to simulate the various features incorporated into the test unit. Place these switches in the proper position for desired operation.

c. Verify the test hook-up. Adjust the variable-voltage power transformer to 120 VAC and apply power to the test unit. Verify that the test unit goes through its prescribed startup sequence and cycles properly in accordance with the operation determined by the positioning of test switches in item b.

d. Upon the satisfactory completion and verification of the test hook-up, proceed with Test B.

2. Test B: Transient Tests (Power Service)

a. Program the test unit to dwell. Verify the input voltage is 120 VAC.

b. Set the transient generator to provide high-repetition noise transients as follows:

(1) Amplitude: 300 Volts (+/-5 percent), both positive and negative polarity.

(2) Peak Power: 2500 watts.

(3) Repetition Rate: One pulse every other cycle moving uniformly over the full wave in order to sweep once every 3 seconds across 360 degrees of line cycle.

(4) Pulse Rise Time: 1 microsecond.

(5) Pulse Width: 10 microseconds.

c. Apply the transient generator output to the AC voltage input for at least 5 minutes. Repeat this test for at least two conditions of dwell for the test unit. The test unit must continue to dwell without malfunction.

d. Program the test unit to cycle through normal operations. Turn on the transient generator (output in accordance with item 2) for 10 minutes, during which time the test unit must continue to cycle without malfunction.

e. Set a transient generator to provide high-repetition noise transients as follows:

(1) Amplitude: 300 Volts (+/-5 percent), both positive and negative polarity.

(2) Source Impedance: Not less than 1000 ohms nominal impedance.

(3) Repetition: One pulse per second for a minimum of five pulses per selected terminal.

(4) Pulse Rise Time: 1 microsecond.

(5) Pulse Width: 10 microseconds.

(6) Program the test unit to dwell. Verify the input voltage is 120 VAC.

f. Apply the transient generator (output in accordance with item 5) between logic ground and the connecting cable termination of selected Field I/O input/output terminals of the test unit. A representative sampling of selected input/output terminations must be tested. The test unit must continue to dwell without malfunction.

g. Program the test unit to cycle. Turn on the transient generator (output in accordance with item 5) and apply its output to the selected Field I/O input/output terminations. The test unit must continue to cycle without malfunction.

h. Reinstall protection and set a transient generator to provide low-repetition high-energy transients as follows:

(1) Amplitude: 600 Volts (+/-5 percent), both positive and negative polarity.

(2) Energy Discharge Source: Capacitor, oil-filled, 10 microfarads.

(3) Repetition Rate: One discharge each 10 seconds.

(4) Pulse Position: Random across 360 degrees of line cycle.

i. Program the test unit to dwell. Verify the input voltage is 120 VAC.

j. Discharge the oil-filled 10-microfarad capacitor ten times for each polarity across the AC voltage input. Repeat this test for at least two conditions of dwell. The test unit must continue to dwell without malfunction.

k. Program the test unit to cycle through normal operations. Discharge the capacitor ten times for each polarity while the test unit is cycling, during which time the test unit must continue to cycle without malfunction.

l. During the preceding transient tests, the test unit must continue its programmed functions. The test unit must not skip normal program intervals/steps or portions thereof when in normal operation; place false inputs or produce false outputs while in dwell; disrupt normal sequences in any manner; or change parameters.

m. Nondestructive Transient Immunity:

(1) Turn off the AC power input to the test unit from the variable-voltage power source.

(2) Apply the following high-energy transient to the AC voltage input terminals of the test unit (no other power connected to terminals):

(a) Amplitude: 1000 V, both positive and negative polarity.

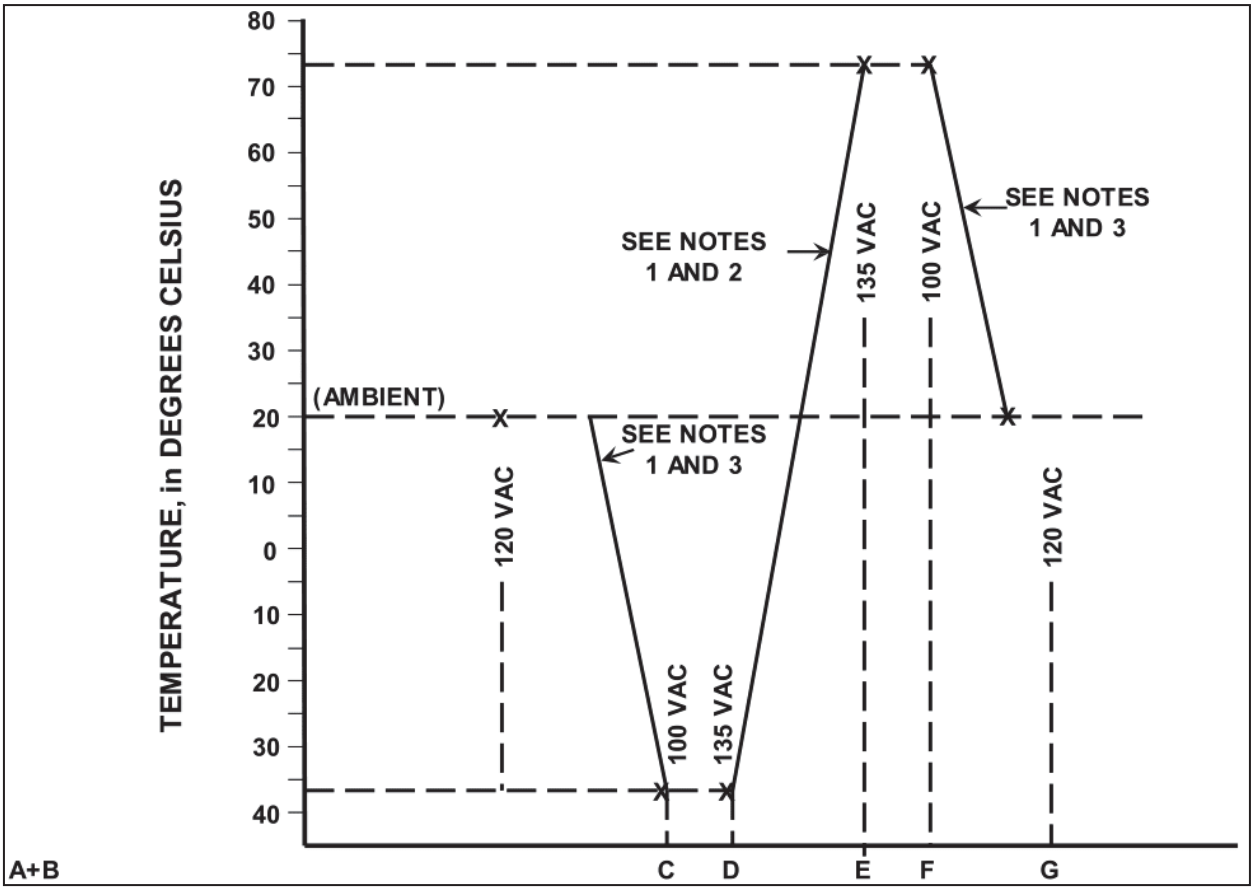
(b) Peak Power Discharge: Capacitor, oil-filled, 15 microfarads.

(c) Maximum Repetition Rate: Applied to the Cabinet Assembly once every 2 seconds for a maximum of three applications for each polarity.

(3) Upon completion of the foregoing, apply 120 VAC to the test unit and verify that the test unit goes through its prescribed startup sequence and cycles properly in accordance with the programmed functions. The first operation of the over-current protective device during this test is not considered a failure of the test unit.

NOTE-Test C through G follow the profile indicated in Figure 1 to demonstrate the ability of the test unit to function reliably under stated conditions of temperature, voltage, and humidity.

Figure 1
Test Profile



NOTES:

1. The rate of change in temperature must not exceed 18 degrees C per hour.
2. Humidity controls must be set in conformance with the humidity given in Table 1 during the temperature change between Test D and Test E.
3. If a change in both voltage and temperature are required for the next test, the voltage must be selected prior to the temperature change.

n. Test C-Low-Temperature Low-Voltage Tests

(1) Definition of Test Conditions

(a) Environmental Chamber Door: Closed.

(b) Temperature: -37 degrees C.

(c) Low Voltage: 100 VAC.

(d) Humidity Control: Off.

(2) Test Procedure: While at room temperature, adjust the input voltage to 100 VAC and verify that the test unit is still operable.

(a) With the test unit cycling through normal operations, lower the test chamber to -37 degrees C at a rate not exceeding 18 degrees C per hour. Allow the test unit to cycle for a minimum of 5 hours at -37 degrees C with the humidity controls in the off position. Then operate the test switches as necessary to determine that all functions are operable.

(b) Remove power from the test unit for a minimum period of 5 hours. Upon restoration of power, the test unit must go through its prescribed startup sequence and then resume cycling.

(c) With the test unit at -37 degrees C and the input voltage at 100 VAC, evaluate the following items against the respective Power Interruption Tests standards.

(d) On satisfactory completion of this test, proceed with Test D.

o. Test D-Low-Temperature High-Voltage Tests

(1) Definition of Test Conditions

(a) Environmental Chamber Door: closed.

(b) Low Temperature: -37 degrees C.

(c) High Voltage: 135 VAC

(d) Humidity Controls: Off.

(2) Test Procedure: While at -37 degrees C and with humidity controls off, adjust the input voltage to 135 VAC and allow the test unit to cycle for 1 hour. Then operate the test switches as necessary to determine that all functions are operable.

(3) With the test unit at -37 degrees C and the input voltage at 135 VAC (humidity controls off), evaluate the following items against the respective Power Interruption Tests standards.

(4) On satisfactory completion of this test, proceed to Test E.

p. Test E-High-Temperature High-Voltage Tests

(1) Definition of Test Conditions

(a) Environmental Chamber Door: Closed.

(b) High Temperature: +74 degrees C.

(c) High Voltage: 135 VAC.

(d) Humidity Controls: In accordance with the humidity given in Table 1.

(2) Test Procedure-With the test unit cycling, raise the test chamber to +74 degrees C at a rate not to exceed 18 degrees C per hour. Verify the input voltage is 135 VAC.

(3) Set the humidity controls to not exceed 95 percent relative humidity over the temperature range of +1.1 degrees C to +46 degrees C. When the temperature reaches +46 degrees C, readjust the humidity control to maintain constant absolute humidity; +42.7 degrees C wet bulb that results in the relative humidity shown in Table 1. Verify that the test unit continues to cycle satisfactory during the period of temperature increase and at established levels of relative humidity.

(a) Allow the test unit to cycle for a minimum of 15 hours at +74 degrees C and 18 percent relative humidity. Then operate the test switches as necessary to determine that all functions are operable.

(b) With the test unit at +74 degrees C and 18 percent relative humidity and the input voltage at 135 VAC, evaluate the following items against the respective Power Interruption Tests standards.

(4) On satisfactory completion of this test, proceed to Test F.

q. Test F-High-Temperature Low-Voltage Tests

(1) Definition of Test Conditions

(a) Environmental Chamber Door: Closed.

(b) High Temperature: +74 degrees C.

(c) Low Voltage: 100 VAC.

(d) Humidity Controls: 18 percent relative humidity and +42.7 degrees C wet bulb.

(e) Test Procedure: Adjust the input voltage to 100 VAC and proceed to operate the test switches to determine that all functions are operable. With the test unit at +74 degrees C and 18 percent relative humidity, +42.7 degrees C wet bulb, and the input voltage at 100 VAC, evaluate the following items against the respective Power Interruption Tests standards.

(f) On satisfactory completion of this test, proceed to Test G.

r. Test G-Test Termination

(1) Program the test unit to cycle.

(2) Adjust the input voltage to 120 VAC.

(3) Set the controls on the environmental chamber to return to room temperature, +20 degrees C (+/-5 degrees C), with the humidity controls in the off position. The rate of temperature change must not exceed 18 degrees C per hour.

(4) Verify the test unit continues to cycle through normal operations properly.

(5) Allow the test unit to stabilize at room temperature for 1 hour. Proceed to operate the test switches to determine that all functions are operable.

s. Test H-Appraisal of Equipment under Test

(1) A failure is defined as any occurrence that results in other than normal operation of the equipment. (See sub-section item b. below for details.) If a failure occurs, the test unit must be repaired or components replaced, and the test during which failure occurred must be restarted from its beginning.

(2) The test unit is considered to have failed if any of the following occur:

(a) If the test unit skips normal program intervals/steps or portions thereof when in normal operation, places false inputs, presents false outputs, exhibits disruption of normal sequence of operations, or produces changes in parameters beyond specified tolerances, or

(b) If the test unit fails to satisfy the requirements of Tests A to G, inclusive.

(3) An analysis of the failure must be performed and corrective action taken before the test unit is retested in accordance with this standard. The analysis must outline what action was taken to preclude additional failures during the tests.

(4) When the number of failures exceeds two, it must be considered that the test unit fails to meet these standards. The test unit may be completely retested after analysis of the failure and necessary repairs have been made in accordance with item 3).

(5) Upon completion of the tests, visually inspect the test unit. If material changes are observed which will adversely affect the life of the test unit, the cause and conditions must be corrected before making further tests.

(6) Upon satisfactory completion of all of the tests described, test the unit in accordance with Vibration Test.

t. Vibration Test.

(1) Purpose of Test. This test is intended to duplicate vibrations encountered by the test unit (individual major components) when installed at its field location.

(a) Fasten the test unit securely to the vibration test table prior to the start of the test.

(2) Test Equipment Requirements.

(a) Vibration table with adequate table surface area to permit placement of the test unit

(b) Vibration test consists of:

I. Vibration in each of three mutually perpendicular planes.

II. Adjustment of frequency of vibration over the range from 5 hertz to 30 hertz.

III. Adjustment of test table excursion (double amplitude displacement) to maintain a 'g' value, measured at the test table, of 0.5g; as determined by the following formula:

$g = 0.0511df2$
where
d = excursion, inches
f = frequency, hertz

(3) Resonant Search

(a) With the test unit securely fastened to the test table, set the test table for a double amplitude displacement of 0.015 inch.

(b) Cycle the test table over a search range from 5 hertz to 30 hertz and back within a period of 12.5 minutes.

(c) Conduct the resonant frequency search in each of the three mutually perpendicular planes.

(d) Note and record the resonant frequency determined from each plane.

I. In the event of more than on resonant frequency in a given plane, record the most severe resonance.

II. If resonant frequencies appear equally severe, record each resonant frequency.

III. If no resonant frequency occurs for a given plane within the prescribed range, 30 hertz must be recorded.

(4) Endurance Test

(a) Vibrate the test unit in each plane at its resonant frequency for a period of 1 hour at amplitude resulting in 0.5g acceleration.

(b) When more than one resonant frequency has been recorded, the test period of 1 hour must be divided equally between the resonant frequencies.

(c) The total time of the endurance test must be limited to 3 hours, 1 hour in each of three mutually perpendicular planes.

(5) Disposition of Equipment under Test

(a) Examine the test unit to determine that no physical damage has resulted from the vibration tests.

(b) Check the test unit to determine that it is functionally operable in all modes of its prescribed operation.

(c) The test unit may be removed from the test table. Upon satisfactory completion of the vibration test, proceed with the shock (impact) test.

u. Shock (Impact) Test

(1) Purpose of Test. The purpose of this test is to determine that the test unit is capable of withstanding the shock (impact) to which it may reasonably be subjected during handling and transportation in the process of installation, repair, and replacement. It is to be noted that the test unit is not, at this time, in its shipping carton.

(a) Fasten the test unit firmly to the specimen table. In each of its three planes the test, drop the unit from a calibrated height to result in a shock force of 10g.

(2) Test Equipment Requirements

(a) Shock (impact) test fixture equivalent to that suggested by the simplified sketch shown in Figure 2.

(b) The test table must have a surface area sufficient to accommodate the test unit.

(c) Calibrate the test table and the items tested as indicated. This shock test defines the test shock to be 10g (+/-1g).

I. Measure calibration of the test equipment for these shock tests by three accelerometers having fixed shock settings of 9g, 10g, and 11g. They must be Inertia Switch Incorporated ST-355, or the equivalent. Attach these devices rigidly to the test table.

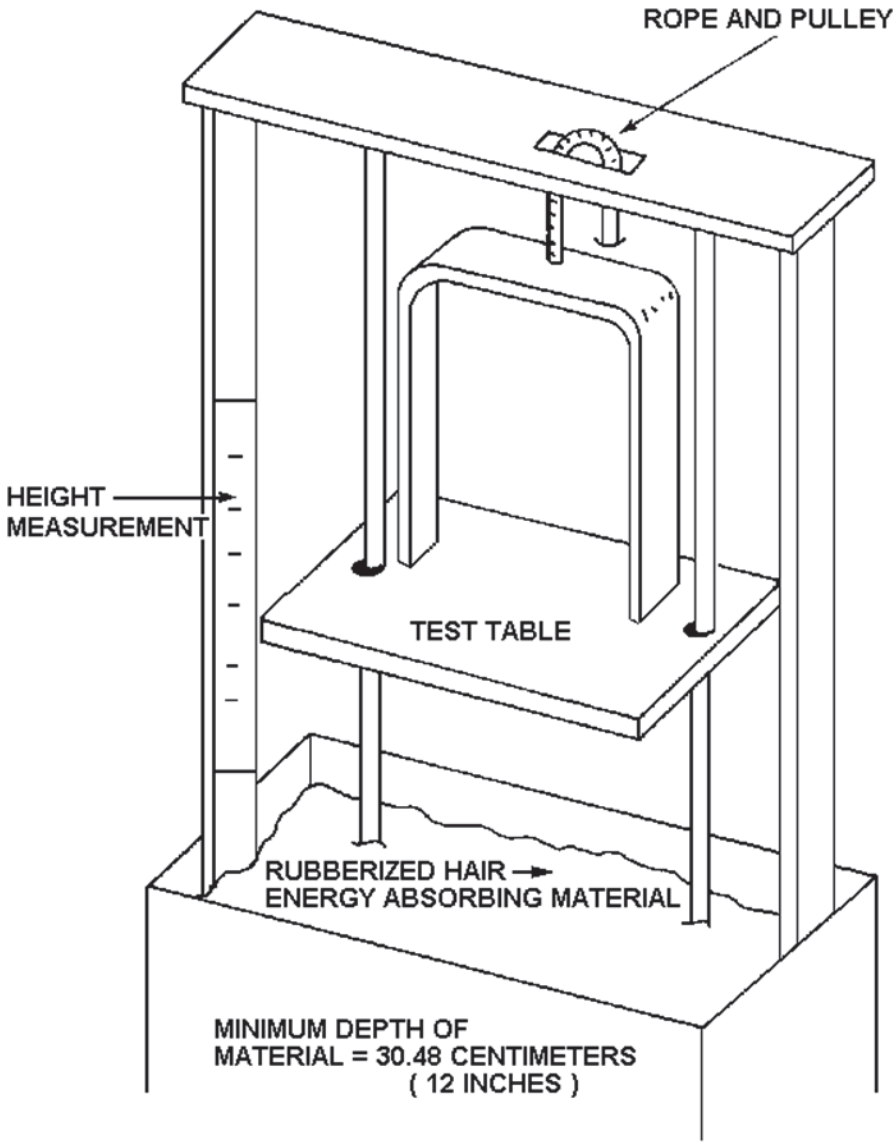


Figure 2
Shock Test Fixture

II. Calibration of the fixture for each item to be tested is as follows:

i. Place a dummy load weighing within 10 percent of the test unit on the table.

ii. Reset the three accelerometers and drop the test table from a measured height.

iii. Observe that the accelerometers indicate the following: Activate the 9g accelerometer; the 10g unit may or may not be actuated; the 11g unit must not be actuated.

III. Repeat calibration test (a) and (b) adjusting the height of the drop until, on ten successive drops, the following occurs:

i. The 9g unit is actuated ten times.

ii. The 10g unit is actuated between four to eight times.

iii. The 11g unit is not actuated on any of the ten drops.

(3) Test Procedure

(a) The calibration height of the drop for the particular item under test as determined in Test Equipment Requirements must be used in this procedure.

(b) Secure the test unit to the test table surface so that the test unit rests on one of its three mutually perpendicular planes.

(c) Raise the test table to the calibrated height.

(d) Release the test table from the calibrated height, allowing a free fall into the box of energy absorbing material below.

(e) Repeat the drop test for each of the remaining two mutually perpendicular planes, using the same calibrated height for each drop test of the same test unit.

(f) The observations of the accelerometer for the three tests of the test item are:

I. The 9g unit is actuated for all three tests. (Repeat the calibration if the unit is not actuated.)

II. The 10g unit may or may not be actuated in these tests.

III. The 11g unit is not actuated on any drop. (If the unit is actuated, repeat the calibration only if the test unit has suffered damage.)

(4) Disposition of Test Unit

(a) Check the test unit for any physical damage resulting from the drop tests.

(b) Check the test unit to determine that it is functionally operable in all modes of its prescribed operation.

(c) Satisfactory completion of all environmental tests, including the shock (impact) is required.

v. Power Interruption Test Procedures. Conduct the following power interruption tests at low input voltage (100 VAC) and high input voltage (135 VAC) at -37 degrees C, and +74 degrees C.

(1) Short Power Interruption. While the Test Unit is cycling through normal operations, remove the input voltage for a period of 475 milliseconds. Upon restoration of the input voltage, check to insure that the Test Unit continues normal operation as though no power interruption has occurred. Repeat this test three times.

(2) Voltage Variation. All circuits of the Test Unit must be subjected to slowly varying line voltage during which the Test Unit must be subjected to line voltage that is slowly lowered from a nominal 120 VAC line voltage to 0 VAC at a rate of not greater than 2 Volts per second. The line voltage must then be slowly raised to 100 VAC at which point the Test Unit must resume normal operation without operator intervention. Perform this test at both -37 degrees C and +74 degrees C, at a nominal 120 VAC line voltage. Repeat this test three times.

(3) Rapid Power Interruption. Subject the Test Unit to rapid power interruption testing of the form that the power is off for 350 milliseconds and on for 650 milliseconds for a period of 2 minutes. Perform power interruption through electromechanical contacts of an appropriate size for the load. During this testing, the controller must function normally and continue normal sequencing (operation) at the conclusion of the test. This test must be performed at both -37 degrees C and +74 degrees C, at a nominal 120 VAC line voltage. Repeat this test three times.

2.08 TYPE 2070 CONTROLLER UNIT

A. General

1. Module Descriptions. The Controller Unit is composed of the Type 2070 Unit CHASSIS, along with other modules and assemblies. The following is a list of Type 2070 versions, their interface rolls and composition:

Unit Version	Description
Type 2070LX Unit Type 2070LN Unit	LITE Unit mates to the 170 & ITS cabinets. It consists of: UNIT CHASSIS, 2070-1C CPU, 2070-2A (2B if NEMA CABINET), FI/O, 2070-3B FRONT PANEL and 2070- 4 B POWER SUPPLY

2. Unit Configuration. The Type 2070 Controller Unit Version defines the module composition to be delivered as follows:

No.	Item	Description	Composition	
			2070LN	2070LX
1	-	Unit Chassis	Y	Y
2	2070-1C	CPU Module	Y	Y
3	2070-2A	Field I/O Module for 170 type cabinet	-	Y
7	2070-2B	Field I/O Module for ITS & NEMA type cabinets	Y	-
5	2070-3B	Front Panel Display	Y	Y
6	2070-4B	Power Supply 3.5 AMP	Y	Y
7	2070-7A	Serial Communication	Y	Y

3. Metalwork. The CHASSIS Top and Bottom, Internal Structure Supports, Back Plane Mounting Surface, Module Plates, Power Supply Enclosure, and Front Panel must be made of 63-gauge minimum aluminum sheet. The CHASSIS Side panels must be 80-gauge minimum sheet.

4. Power Fail and Power Restoration Operation. It is noted that the Power Failure Power Restoration operations of this unit are specific to the requirements of the user. All associated modules are to comply to said operations.

5. Power Limitations. 2070 UNIT module / assembly power limitations are as follows:

Types	+5VDC	+12VDC ISO	+12VDC ser	-12 VDC ser
MCB	750 milliamperes	-----	-----	-----
TRANS BD	750 milliamperes	-----	-----	-----
2070-1C	1.0 amperes	250mA	-----	----
2070-2A FI/O	250 milliamperes	750 milliamperes	-----	-----
2070-2B FI/O	250 milliamperes	500 milliamperes	-----	-----
2070-3B FPA	500 milliamperes	-----	50 milliamperes	50 milliamperes
2070-7 All Comm	250 milliamperes	-----	50 milliamperes	50 milliamperes

B. Type 2070-1 CPU Module

1. Type 2070 - 1C Configuration. The TYPE 2070-1C CPU must be a single board module meeting the 2X WIDE board requirements. The module must be furnished normally resident in MOTHERBOARD Slot A5. The module must meet the following minimum requirements:

   a. The Model 2070-1C Module shall be provided with an Application Program Interface (API) compliant to the latest published ASHTO/ITE ATC API Standard. A copy of this API standard shall be provided separately at no additional cost upon request. At the time of this writing the latest published standard is API 5401 v2.17.

   b. ATC 5.2b, except / in addition to where noted below:

      (1) A processor with a minimum MIPS of 400 calculated using the Dhrystone v2.1 benchmark at 25°C.

      (2) A minimum of 64 megabytes (MB) of DRAM or equivalent volatile memory for application and OS program execution.

      (3) A minimum of 128 MB of FLASH for storage of OS Software and user applications.

      (4) Prior to 1 May 2017 a minimum of 1 MB of SRAM memory for non- volatile parameter storage; starting 1 May 2017 a minimum of 2 MB minimum of SRAM memory for non-volatile parameter storage.

      (5) The 1C card shall provide the standby power required for supporting the SRAM and RTC.

(6) A Utility Program shall be provided that would allow the user to upgrade (re-flash) the Boot Image for the Linux Kernel.

(7) A re-flash utility and the procedures for its use in PDF form.

(8) All Linux Software, except for loadable modules, shall comply with the GPL license as published by the Free Software Foundation.

(9) One USB 2.0 or greater compliant port.

(10) Two 10/100 Ethernet ports; Ethernet Ports shall be marked port 1 and port 2.

c. Host Board:

(1) Single board module meeting Caltrans 2x WIDE board requirements.

(2) Provides two DIN sockets and mounting standoffs for the connection of the 2070-1C engine Board.

(3) Not less than two Ethernet ports used to route ENET1 and ENET2 signals from Engine Board to the front panel.

(4) Datakey receptacle capable of housing 3.3 VDC 5.0.

(5) USB 2.0 or greater full speed port for memory.

d. Front panel:

(1) 2070 Standard 1x module.

(2) USB port.

(3) Data key socket.

(4) 256 bytes or greater SPI EEPROM.

(5) Two RJ45 Front Panel Ethernet jacks.

(6) 25 pin D Socket Type port.

e. Standard Features:

(1) Open source U-boot loader.

(2) ATC 5.2b standards compliment CPU Engine Board.

(3) Full support for all required ATC 5.2b software drivers.

(4) Compatible with the latest Caltrans QPL approved 2070E hardware. At the time of this writing the latest approved hardware specification is TEES 2009. Note: this does not require the 1C module to be on the Caltrans QPL, it requires that the 1C module be compatible with the other hardware on the Caltrans QPL.

(5) Compatible with legacy 2070s (TEES 2002 to present). The City of Houston operates 2070 controllers in NEMA TS1, 332 type, ITS, and other type cabinets.

(6) Capable of running multiple independent applications.

(7) Board - support toolchain package with all necessary libraries for 3rd party software development. A copy of this toolchain package shall be provided separately at no additional cost upon request.

(8) Standards based API library which allows applications to share front panel and field I/0 resources.

(9) Support SD card memory and provided with an industry standard SD card socket.

f. Operating system:

(1) Compliance with the ATC Standards v5.2b.

(2) Must be able to download software by USB.

(a) A dual option to download from Windows software over Ethernet is acceptable.

(3) SD card communication shall be addressed using SP4 for consistency with ATC standard 6.24.

C. Type 2070-2 Field I/O Module (FI/O)

1. Type 2070-2A Module. This module shall comply with the requirements in Specification ATC 5202 v03.04 section 3.10.

D. Type 2070-3 Front Panel Assembly

1. The Type 2070-3 Front Panel Assembly (FPA) shall comply with specification ATC 5203 section 3.11 selecting option 3B.

E. Type 2070-4 Power Supply Module

1. The Type 2070-4A Power Supply Module shall comply with standard ATC 5202 v03.04 section 3.12.

F. Unit Chassis

1. General

a. The Chassis consists of the metal housing, Serial Motherboard, Back-plane Mounting Surface, Power Supply Module Supports, slot card guides, Wiring Harnesses, and Cover Plate(s).

b. All external screws must be countersunk and be Phillips flat head stainless steel type.

c. The housing must be treated with clear chromate and the slot designation labeled on the back-plane mounting surface above the upper slot card guide.

d. The Chassis must be cooled by convection only. The top and bottom pieces of the housing must be slotted for vertical ventilation.

2. Serial Motherboard. Serial Motherboard must function as support for its connectors, A1 to A5 and FP, and as the interface between the CPU and the dedicated modules/Front Panel carrying both serial communications, logic, and power circuits. The PCB must be multi-layered, with one layer plane assigned to DC Ground.

a. A wiring harness PS2 must be provided between the Type 2070-4 Power Supply and the Motherboard PCB (provide strain relief). Test points must be provided on the FPA side of the Motherboard for PS2 lines.

b. A wiring harness FP must be provided, linking the Motherboard with the FPA.

G. Details: reference standard ATC 5202 v03.04 Appendix A for figures and pinouts on 2070 modules.

2.09 TYPE 2070 PERIPHERAL EQUIPMENT

A. General Notes:

1. The 2070-7x modules must provide circuitry to disable its Channel 2 and EIA- 232 control lines (TX, RX, RTS, CTS, and DCD) when a ground true state is present at Connector A1, Pin B21 (C50 Enable). The disable lines must be pulled up on this module.

2. Line drivers/receivers must be socket mounted or surface mounted.

3. Isolation circuitry must be opto- or capacitive-coupled isolation technologies. Each module's circuit must be capable of reliably passing a minimum of 1.0 megabits per second.

4. The communications modules must be "Hot" swappable without damage to circuitry or operations.

B. Type 2070-7A Async Serial Communications Module

1. Circuitry. Two circuits, designated CIRCUIT #1 and CIRCUIT #2, must be provided. Their functions are identical, except for the CPU Serial Communications Port and external connector (CIRCUIT #1 to SP1 [or SP3] and Connector C21S and CIRCUIT #2 to SP2 [or SP4] and Connector C22S).

2. 2070-7A. Each circuit must convert its EIA-485 signal lines (RX, TX, RTS, CTS and DCD) to / from board TTL Level Signals; isolate both signal and ground; and drive / receive external EIA-232 devices via C21 / C22 Connectors. Connectors must be DB-9S type.

3. Indicators. Each circuit signal TX and RX line must have an LED Indicator mounted on the front plate and labeled to function.

2.10 NEMA MODULE

A. The 2070-8 module shall comply with standard ATC 5202 v03.04 section 3.20.

2.11 METALS

A. All sharp edges and corners must be rounded and free of any burrs.

B. Aluminum. Sheet must be 63 gauge American Standard (0.060-in.) minimum thick Type 3003-H14 or Type 5052-H32 ASTM Designation B209 aluminum alloy. Rod, Bar and Extruded must be Type 6061-T6, or equal.

C. Stainless Steel. Sheet must be annealed or one-quarter-hard complying with the ASTM Designation: A666 for Type 304, Grades A or B, stainless steel sheet.

D. Cold Rolled Steel. Sheet, Rod, Bar and Extruded must be Type 1018/1020.

1. Plating. All cold roll steel must be plated. All plating must be either cadmium plating meeting the requirements of Federal Specification QQ-P- 416C, Type 2 Class l or zinc plating meeting the requirements of ASTM B633-85 Type II SC4.

2.12 MECHANICAL HARDWARE

A. All bolts, nuts, washers, screws, hinges and hinge pins must be stainless steel unless otherwise specified.

2.13 ELECTRICAL ISOLATION

A. Within the circuit of any device, module, or Printed Circuit Board (PCB), electrical isolation must be provided between DC logic ground, equipment ground and the AC- conductor. They must be electrically isolated from each other by 500 megohms, minimum, when tested at the input terminals with 500 VDC.

2.14 DAUGHTER BOARDS

A. Keyboards and LCD/LED Displays are considered daughter boards. Daughter boards must be mechanically secured with a minimum of four spacers/metal screws. Connectors must be either Flat Cable or PCB Headers. Components are to be mounted under the daughter board.

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 16732

UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM FOR TRAFFIC SIGNAL CABINETS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnish, install, and make fully operational an Uninterruptable Power Supply (UPS) system at designated locations as shown on the plans and as detailed in accordance with these specifications. Use the same manufacturer and model for each Uninterruptable Power Supply (UPS). The Uninterruptable Power Supply provides reliable power to a traffic signal intersection (vehicle and pedestrian) in the event of utility failure or interruption. The UPS system shall also act as a power conditioner and/or voltage regulation device.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 16130 – Advanced Transportation Controller (ATC) Cabinet Assembly

C. Section 16730 – Intelligent Transportation System (ITS) Controller Cabinet Assembly

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. This item will be measured as each unit furnished, installed, made fully functional and tested in accordance with these special specifications or as directed by the Engineer. The UPS system will include, but is not limited to an automatic bypass switch, power transfer relay, an inverter/charger, batteries, battery charge management device, wiring, external cabinet, all mounting hardware, manufacturer's operation manual, required testing results, manufacturers technical specification, and the cost of all materials, training, warranty, equipment, and all accessories necessary to the complete installation of the unit.

2. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Uninterruptable Power Supply". This price will include all equipment described under this item with automatic bypass switch, power transfer relay, an inverter/charger, batteries, battery charge management device, wiring, external cabinet, mounting hardware; all documentation and testing and will also include the cost of furnishing all labor, materials, software, warranty, training, equipment, and incidentals.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. IEEE/ANSI C.62.41- Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits

B. TXDOT Special Specification 6006 – Electric Components

C. UL 1449 – Surge Protective Devices

1.05 SUBMITTALS

A. Operation and maintenance manuals shall be provided. The operation manual shall include a block diagram schematic of all systems hardware components. The manual shall include instructions for programming and viewing software features. The manual shall include all uploading/downloading (communications protocol) requirements via R232 port and Ethernet port.

B. Board level schematics shall be provided when requested.

C. Board level schematics shall be provided when requested.

D. Manufacturers' cut sheets / specifications and software for all equipment proposed under these specifications shall be submitted to the City of Houston's Traffic Operations Division's ITS Group located at Houston TranStar (713-881-3179) prior to construction.

1.06 QUALITY ASSURANCE

A. TESTING

1. City of Houston reserves the right to do testing on UPS systems to ensure quality assurance before installations and random sampling of units being provided to the City. UPS systems that fail will be removed from the Prequalified Products List (QPL).

2. City of Houston QPL testing procedures will include the following:

a. UPS system shall comply with all the criteria of this specification.

b. Event logging for fault/alarm conditions.

c. System will demonstrate one or more of the operation methods described in Article 2.01.H.

d. UPS system will operate at 700 watt load (minimum 4 hours), system will transfer to flash mode and operate at 350 watt load (minimum 2 hours) under battery power and at ambient temperature +251zC, total length of test 6 hours.

e. All component of the system shall be tested in environmental chamber (temperature ranges from -301zC to 741zC).

B. EXPERIENCE REQUIREMENTS

1. Meet the following requirements, as a minimum, for Contractor or designated subcontractors involved in the installation and testing of the UPS system:

2. Three years' experience in the installation of UPS equipment. Two installed systems where UPS systems are installed and the systems have been in continuously satisfactory operation for at least two (2) years. Submit as proof, photographs or other supporting documents, and the names, addresses and telephone numbers of the operating personnel who can be contacted regarding the system.

3. Provide necessary documentation of subcontractor qualifications pursuant to contract award.

1.07 WARRANTY

A. All components of the UPS system will be warranted by the manufacturer for five years following the acceptance of the system by City of Houston. The warranty will include the specific installation characteristics for the geographic region and project limits.

B. Batteries shall be warranted for full replacement for 5 years. Batteries shall be defined as bad, if they are not able to deliver 80% of battery rating.

PART 2 PRODUCTS

2.01 MATERIALS

Provide an Uninterruptable Power Supply (UPS) unit that meets the following requirements.

A. GENERAL REQUIREMENTS

1. The UPS system shall be capable of operating a signalized intersection (700 watt load) for 4 hours of full runtime when utility power is disabled and under ambient temperature of 251zC. The UPS system shall switch the intersection to flash mode when approximately 40% of the battery charge is remaining, via relay contact connection points on the front panel of the unit. The UPS system shall operate the intersection in the flash mode of the operation (350 watt load) for an additional 2 hours. Depending on the type of traffic signal cabinet, the UPS system shall be rated for a minimum load capacity of:

a. 1,100 watts for an ATC Cabinet 356 version, or

b. 2,000 watts for an ATC Cabinet 350 version, unless the City specifies otherwise.

2. Provide equipment that utilizes the latest available techniques for design and construction with a minimum number of parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality.

3. Design the equipment for ease of maintenance. Provide component parts that are readily accessible for inspection and maintenance. Provide test points that are for checking essential voltages and waveforms.

B. DISPLAYS, CONTROLS, DIAGNOSTICS AND MAINTENANCE

1. The UPS system shall include a front panel display. All applicable programmable functions of the operational methods described in this specification shall be viewable through the front panel display.

2. All events described in Operations Section shall be viewable from the front panel display.

3. The UPS system software shall be programmable from the front panel of the inverter/charger by means of a keyboard or momentary buttons allowing the user to step through menu driven software.

4. A 10/100 Ethernet port shall be provided on the front panel of the inverter/charger.

5. UPS system software shall be provided for the operational needs of the UPS system. The user/operator shall be able to access all system software via the Ethernet port and RS232 port on the front panel of the inverter/charger. The user shall be able to read logged events and/or change programmable parameters from the keyboard, laptop, or local area network via Ethernet port.

6. System software shall be upgradable via the RS232 and Ethernet ports on the front panel of the inverter/charger.

7. All upgrades for software shall be provided for hardware components for the duration of the warranty period at a minimum.

C. INVERTER/CHARGER

Provide an inverter/charger that has the following features:

1. When utility line voltage is out of normal operating range (typical 100V AC to 135V AC), the inverter/charger shall provide voltage regulation and/or power conditioning to the inverter line voltage using one or more of the methods described in Article 2.01.H of this specification. When utility line voltage is present, it shall act as a charging device for the batteries.

2. Operating temperature range for both the inverter/charger unit and power transfer relay shall be -34oC to 74oC.)

3. When battery power is used, the UPS system output voltage shall be between 110V AC and l25V AC, pure sine wave output, :S 3% THD, 60Hz + 3Hz.

4. As a minimum the inverter/charger shall be rated for either 1,100 watts or 2,000 watts, depending on the UPS system selected, of continuous power from the unit.

D. AUTOMATIC BYPASS SWITCH

Provide an automatic bypass switch that has the following features:

1. The automatic bypass switch shall be provided as a separate unit external to the inverter/charger unit. The automatic bypass switch shall be 2 position and rated at a minimum of 240V AC/30 amp. A UPS supply breaker rated at 240V AC/30 amps shall be provided for the 120V AC input to the inverter/charger.

2. When the automatic bypass switch is in the “on” position and the supply breaker is “on”, the UPS system is connected to utility line voltage and its output is connected to the cabinet service panel. If the utility line voltage is deactivated, the UPS system will automatically switch over to battery power.

3. When the automatic bypass switch is in the “off” position, and the supply is “on”, utility line power is provided to the cabinet service panel and the inverter/charger allowing equipment to be tested without interrupting power to the traffic signal load.

4. When the automatic bypass switch is “off” and the supply breaker is “off”, the utility line voltage will feed power directly to the traffic signal cabinet service panel and power to the inverter/charger will be deactivated allowing the user to service UPS equipment.

E. BATTERIES

Provide batteries for the Uninterruptable Power Supply System that have the following features:

1. Individual batteries shall be 12V type rated for at least 165 minutes of runtime, and shall be easily replaced and commercially available for purchase as common off the shelf equal.

2. Batteries shall be sized and rated to operate at 700 watt load for 4 hours (normal operation) followed by a 350 watt load (flash operation) for 2 hours.

3. Battery configurations shall consist of 12V batteries arranged in one of the following arrangements: 48V, 60V, 72V, 84V, 96V.

4. Batteries shall be deep discharge sealed prismatic valve regulated acid (VRLA) AGM or Gel cell batteries.

5. Batteries shall operate over a temperature range of -34oC to 74oC.

6. Batteries shall not be charged when battery temperature exceeds 50oC + 3oC.

7. Batteries shall indicate maximum recharge data, recharging cycles, and manufacture defaults on the inverter. Batteries shall not allow the recharging process to exceed the batteries maximum values.

8. Battery interconnect wiring shall connect to the inverter unit via modular harness with red and black cables. Harness shall have battery ring lug at the battery end of the cables that are .40" in diameter and connect to batteries using a ¼" – 20 UNC bolt that is ¾" in length.

9. Batteries shall have maintenance free threaded inserts sized to fit a ¼" – 20 UNC bolt that ¾" in length.

10. Insulated covers shall be provided at the connection points of the batteries to prevent accidental shorting.

11. Battery harness and cabling shall be a minimum of 6ft in length

12. Batteries weighing more than 50 pounds shall be provided with a handle or hand strap allowing the user to carry or move the battery without the use of other equipment.

F. BATTERY MONITORING SYSTEMS

Provide a temperature compensated battery charging system and a temperature sensor that have the following features:

1. The UPS system shall use a temperature compensated battery charging system. The charging system shall compensate over a range of 2.5 to 4mV/1zC per cell.

2. The temperature sensor shall be used to monitor the temperature and regulate the charge rate of the batteries. Unless required otherwise by the plans the temperature sensor wire shall be as follows:

    a. Temperature sensor wire shall be a minimum of 8 feet in length.

    b. Should the temperature sensor fail, the inverter/charger shall not allow the UPS system to overcharge the batteries. The UPS system shall provide an alarm should the temperature sensor fail.

    c. Recharge time for the batteries to 80% or more of full battery charge capacity shall not exceed 20 hours at 701zF.

d. Batteries shall not be charged when the battery temperature exceeds 501zC + 31zC.

e. The UPS system shall monitor battery strings within a system and set a fault indicator if the battery voltage falls below normal operating voltages.

G. EXTERNAL UPS SYSTEM CABINET[1]

Applicable only to the ATC Cabinet 356 version - Provide an external cabinet to house all of the UPS system components that has the following features:

1. The external cabinet shall be NEMA Type 3R all aluminum with stainless steel hardware, or equal, approved by the City of Houston Traffic Signal Maintenance Shop. The external cabinet shall be sized to house all of the UPS system components including batteries and designed to mount to the side of the traffic signal cabinet. Dimensions of the external cabinet shall not exceed 56" height x 26" width x 18" depth. The cabinet shall be mounted in a manner that does not obstruct pedestrian travel on adjacent sidewalk.

2. The cabinet shall be provided with one door in front that will provide access to the cabinet. The door shall be provided with three hinges with non-removable stainless steel pins, or a full-length piano hinge with stainless steel pins spot welded at the top of the hinge. The hinges shall be mounted so that it is not possible to remove them from the door or cabinet without first opening the door.

3. The cabinet door shall be fitted with a Number 2 Corbin lock and a cast aluminum or chrome plated steel handle with a 16mm (minimum) diameter shaft (or equivalent cross-sectional area for a square shaft) and a three point latch. The lock and latch design shall be such that the handle cannot be released until the lock is released. One key shall be provided for each cabinet. A gasket shall be provided to act as a permanent dust and weather resistant seal at the cabinet door facing. The gasket material shall be of a nonabsorbent material and shall maintain its resiliency after long term exposure to the outdoor environment. The gasket shall have a minimum thickness of 6.25mm. The gasket shall be located in a channel provided on the cabinet or on the door(s). An "L" bracket is acceptable in lieu of this channel if the gasket is fitted snugly against the bracket to insure a uniform dust and weather resistant seal around the entire door facing. Any other method is subject to written purchaser approval during inspection of an order.

[1] For the ATC Cabinet 350 version, the UPS system components (including batteries) shall be housed in, facing the front, the right rack cage of the traffic cabinet housing. Refer to Specifications Section 16730 – Intelligent transportation System (ITS) Controller Cabinet Assembly and Section 16130 – Advanced Transportation Controller (ATC) Cabinet Assembly.

4. The intake for the vent system shall be on the lower section of the cabinet front door and filtered with a washable, metal air filter. The filter shall be securely mounted so that any air entering the cabinet must pass through the filter. The cabinet opening for intake of air shall be large enough to use the entire filter. The air intake and exhaust vent shall be screened to prevent entry of insects. The screen shall have opening no larger than 8.1mm². The total free air opening of the exhaust vent shall be large enough to prevent excessive back-pressure on the fan.

5. The external cabinet must contain a fan mounted in the top of the cabinet. The fan must be 48Vdc and thermostat controlled. It must turn on when the inside temperature of the cabinet reaches or exceeds 49oC (120oF) and turn back off once the inside temperature of the cabinet returns to 32oC (89oF).

6. The external UPS system cabinet shall include a red LED mounted on the top of the cabinet that is visible from the street. This indicator shall be connected to light the LED "on" to allow maintenance to know when the intersection is running off UPS power. When the intersection is operating on utility line voltage the LED will be "off" (not illuminated).

H. OPERATION

The UPS system shall operate in one or more of the following methods:

1. Line Interactive (Buck and Boost) Method

   a. When the buck and boost functions are enabled they shall set the upper and lower control limit allowable for the utility line voltage. If the utility line voltage fails within the parameters set by buck and boost, then the UPS system shall continue to operate the intersection under utility line power. If the utility line voltage fluctuates above or below the buck and boost values, the UPS system shall raise or lower the voltage by approximately 10%-15% of the utility line voltage in an attempt to bring the voltage back into the upper and lower control limits set by buck and boost. Buck and boost shall have preset manufacturer defaults.

   b. If the utility line voltage falls above or below the functional capabilities of buck and boost, then the UPS system shall transfer power from the utility line voltage and the inverter/charger shall operate the intersection from battery power converting DC voltage to AC.

2. Continuous Operating Mode, Double Conversion Method

a. Using the continuous operating mode buck and boost functions are disabled and the UPS system operates continuously converting the utility line voltage, 120V AC, to DC voltage, then back to 120V AC, supplying the cabinet with inverter line power. Should the utility line voltage fail, the UPS system will continue to supply inverter line power to the cabinet via the UPS system.

3. General Operation Requirements

a. The UPS system shall be capable of providing 1,100 watts or 2,000 watts active output capacity, with a minimum of 80% inverter efficiency. The inverter/charger shall be capable of operating at a 1,100 watt or 2,000 watt continuous load, depending on the intersection needs.

b. When the batteries are fully charged, ensure the UPS system provides power to run an intersection and all peripherals for a minimum of 4 hours of semi- actuated runtime (700 watt load), then switch to flash mode for a minimum of 2 hours of flash runtime (350 watt load).

c. When the system is running on battery power, the UPS system shall allow the user to select a voltage (typically 48V) at which the transition from normal operating loads (700 watts) to flash mode (350 watts) will occur via a set of relay contacts or connection points on the front panel of the inverter/charger.

d. The transfer time allowed, from disruption of normal utility line voltage to stabilized inverter line voltage from the batteries, shall be less than 65 milliseconds. The same allowable transfer time shall also apply when switching from inverter line voltage to utility voltage.

e. The UPS system shall bypass utility line voltage, whenever the utility line voltage is outside the manufacturer’s defaults or a user programmed voltage range + 5V AC.

f. When the utility line power has been restored to a normal operating voltage for more than 30 seconds, the UPS system shall transfer from battery back to utility line mode. The UPS shall be equipped to prevent a malfunction feedback to the cabinet or from feeding back to the utility service.

g. The UPS system shall be compatible with ATC/ITS models, NEMA, and Model 170/2070, controller and cabinet components for full runtime operation.

h. For an ATC Cabinet 356 version, the UPS system shall be shelf mounted within its own side mounted external cabinet. For an ATC Cabinet 350 version, the UPS system shall be housed in the traffic signal cabinet. The bypass switch can be mounted inside the traffic signal cabinet or in the side mounted external cabinet along with the batteries.

i. The interconnection cables shall be no less than 10 feet in length. Relay contact wiring for relay contact closures shall be no less than 6 feet long of #10 AWG wire. Wire size shall be sized accordingly to manufacturer recommendations for any cable lengths greater than 10 feet.

j. The UPS system shall have lightning surge protection compliant with IEEE/ANSI C.62.41, latest revision and meeting all current UL 1449 standards.

k. The UPS system and batteries shall be easily replaced and provided with all needed hardware and software. The UPS system shall not require any special tools for installation.

l. The UPS system shall operate with an automatic “fail safe” mode. Should a breaker trip on the inverter/charger and/or the power transfer relay, the unit will automatically default to utility line power and bypass the UPS system.

m. The UPS system shall be capable of logging up to 100 events. Events shall date and time stamp faults with the AC line voltage and UPS battery voltage. At a minimum, the following conditions shall be recorded as an event:

(1) The UPS system shall record utility line voltage occurrences whenever the line voltage falls above or below the upper and lower control limits or manufacturer preset defaults. When this condition occurs, it shall be record as an event.

(2) Whenever the UPS system automatically switches to battery power this shall be recorded as an event.

(3) Whenever the UPS system returns to utility line power from battery power, this shall be recorded as an event.

(4) The UPS system shall be capable of self-monitoring and record failure of any UPS system components as an event.

I. ELECTRONIC COMPONENTS

1. Provide this item in accordance with TXDOT Special Specification 6006 – Electric Components.

J. MECHANICAL COMPONENTS

1. Provide external screws, nuts and locking washers that are stainless steel; no self-tapping screws will be used. Provide parts made of corrosion resistant material, such as plastic, stainless steel, anodized aluminum or brass. Protect materials from fungus growth and moisture deterioration. Separate dissimilar metals by an inert dielectric material.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Manufacturer Services

1. Ensure that a manufacturer's technical representative is available on site to assist the technical personnel at each installation site and with UPS equipment installation and communication system configuration.

2. Do not execute the initial powering up of the UPS equipment without the permission of the manufacturer's representative.

END OF SECTION

SECTION 16733

FIELD HARDENED ETHERNET SWITCH

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This Item governs the furnishing and installation of a Hardened Ethernet Switch (HES):

1. At designated locations as shown on the plans, a0073 detailed in accordance with these specifications, and as directed by the Engineer.

2. With various port configurations based on 10/100 mbps and Gigabit Ethernet standards for both copper and fiber optic connectivity.

3. Including at least two (2) fiber ports and six (6) copper ports.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. No separate payment will be made for Hardened Ethernet Switch. Include payment in related unit price work.

B. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. Electromagnetic Interference Standards

B. EN 55022 – EMC Standard

C. EN 60950-1 – Information Technology Equipment

D. EN 61000-4-2 – Test Standard for Electrostatic Discharge (ESD) Immunity

E. EN 61000-4-3 – Immunity to Radiated, Radio-frequencies.

F. EN 61000-4-4 – Electrical Fast Transient (EFT)/Burst Transients Immunity

G. EN 61000-4-5 - Testing and Measurement Techniques – Surge Immunity Test

H. EN 61000-4-6 – Immunity to Conducted Disturbances, Induced by Radio Frequency Fields

I. EN 61000-4-8 – Power Frequency Magnetic Field Immunity Test

J. EN 61000-6-2 – Generic Standards – Immunity for Industrial Environments

K. Federal Communications Commission Standards

L. IEC 60068-2-6 – Sinusoidal Vibration Testing

M. IEC 60068-2-27 – Shock Testing

N. IEC 60255-21-1 - Electrical relays - Part 21: Vibration, Shock, Bump and Seismic Tests on Measuring Relays and Protection Equipment - Section One: Vibration Tests

O. IEC 60255-21-2 - Electrical relays - Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment - Section Two: Shock and bump tests

P. IEC 60950-1- Information Technology Equipment, Safety

Q. IEEE 802.1D – Spanning Tree Protocol

R. IEEE 802.1p – Quality of Service (QOS)

S. IEEE 802.1Q – Virtual Local Area Network (VLAN)

T. IEEE 802.1w - Rapid Spanning Tree Protocol

U. IEEE 802.1x – Port-based Network Access Control (PNAC)

V. IEEE 802.3u – Ethernet

W. IEEE 802.3x – Flow Control

X. NEMA TS2 – Traffic Controller Assemblies with NTCIP Requirements

Y. NFPA 70 – National Electric Code

Z. RFC 783 – TFTP Protocol

AA. UL 508 – Standard for Safety for Industrial Control Equipment

PART 2 PRODUCTS

2.01 MATERIALS

A. General Requirements.

1. Provide:

a. All HES of the same manufacturer.

b. All new equipment in strict accordance with the details shown on the plans and in the specifications.

c. High-performance and hardened Ethernet switch supporting standard OSI Layer 2 and 3 functionality.

d. Support to directly connect to existing networks configured in ring and mesh fault tolerant topologies enabling applications to operate reliably, and with low latency.

e. All equipment licenses, where required, for any software or hardware in the system.

f. Ensure compatibility between routers along same corridors regardless of brand name

g. Ensure software parameters and settings stay retained in the event of power disruption

B. Adherence to Standards.

1. The Ethernet Switch shall support the following protocols and regulatory standards: Product Safety:

a. UL508, EN60950-1, IEC60950-1

b. EMI

c. FCC Part 15, Class A

d. EN55022

2. IMS:

a. EN61000-6-2

b. EN61000-4-2 (ESD Standards)

c. EN61000-4-3 (Radiated RFI Standards)

d. EN61000-4-4 (Burst standards)

e. EN61000-4-5 (Surge Standards)

f. EN61000-4-6 (Induced RFI Standards)

g. EN61000-4-8 (Magnetic Field Standards)

3. Environmental Test Compliance:

a. IEC60255-21-1/IEC60068-2-6 Fc (Vibration Resistance)

b. IEC60255-21-2/IEC60068-2-27 Ea (Shock)

c. NEMA TS2 Environmental Requirements for Traffic Control Equipment

d. IEEE 802.3u 100 Megabit Ethernet

e. IEEE 802.3x Flow Control

f. IEEE 802.1Q Virtual Local Area Network (VLAN) Tagging & MSTP

g. IEEE 802.1D Spanning Tree Algorithm

h. IEEE 802.1w Rapid Spanning Tree Algorithm

i. IEEE 802.1p Quality of Service (QOS), 8-level transmission priorities

j. IEEE 802.1x Security

4. Protocols:

a. a – Ring for High Speed Redundancy Recovery <15ms

b. Telnet with SSH

c. IP Multicast Filtering through Internet Group Management Protocol (IGMP) Snooping V1 (RFC 1112), V2 (RFC 2236)

d. IGMP Snooping allows Multicast Packets Filtering

e. Subscribed packets are forwarded to the subscriber

f. Unsubscribed packets are dropped at the switch

g. NTP support

h. Data Storm Control

5. Miscellaneous Standards:

a. IEEE 802.3: 10BASE-T

b. RFC783: TFTP

c. FCC

2.02 EQUIPMENT

A. Physical Design / Installation Requirements.

Supply all HES with a physical design that conforms to the following requirements:

1. Must be compatible for DIN-Rail (Top hat type 35mm), Rack Mount, or Wall Mount.

2. Provide a minimum of two built-in 100 MB full-duplex switched single-mode fiber ports as indicated on the plans.

3. Provide a minimum of six switched 10/100 MB copper (RJ 45) ports, independently auto negotiating.

4. Designed with an operating system that allows individual ports to be configured for port mirroring, speed, duplex, auto-negotiation, and flow control. Design the operating system to provide for broadcast storm frame filtering with user defined thresholds.

5. Designed with an operating system allows for the collection of statistics on a per port basis and provides for full support of RMON statistics, history, alarms, and event groups.

6. Designed with an operating system that provides port security to prevent unknown devices from gaining access to the network. In case of unauthorized attempts to access the network, shutdown the port for a period of time and SNMP trap and generate an alarm.

B. Electrical and Mechanical Requirements. Provide the following functionality and features:

1. Port Configurations

   a. 8 Ports 10/100TX + 2 Port 1000SX/LX, MM/SM

   b. 6 Ports 10/100TX + 2 Ports 100FX, MM/SM +2 Port 1000SX/LX, MM/SM

2. Drives up to 100 m of Category 3, 4, or 5 unshielded twisted-pair (UTP) cable at 10 Mbps; or 100 m of Category 5, 5e or 6 UTP cable at 100 Mbps

   a. 100FX Ports

3. Drives up to:

   a. Minimum of 8K Media Access Control (MAC) addresses

4. Frame buffer memory: 160 packet buffers, 1536 bytes each (240 Mbits)

5. Port Mirroring

6. MAC Based Port Trunking (2 Groups Allowed)

7. Group 1 Up To 4 Ports FE, and Group 3 Up To 2 Ports GE
8. Switching method store-and-forward
9. Non-blocking full wire speed forwarding rate
    a. 14,880 pps @ 10 Mbps
    b. 148,800 pps for 100 Mbps
    c. 1,488,000 pps for 1000 Mbps
10. Provide RJ-45 ports that auto-negotiate operation at 10 Mbps and 100Mbps
11. Packet-Processing
    a. Switching Latency: < 15 microsecond (100Mbps)
    b. Priority queues: 2
    c. Ring sizes: Up to 80 switches
12. Port Configuration Specifications
    a. Port configuration information may be obtained from the NMS.
    b. 10/100 T/TX ports (Copper Twisted Pair)
    c. RJ-45 female connector
    d. Automatic and user-selectable speed setting (10/100 mbps)
    e. Automatic and user-selectable half/full duplex setting
    f. Rate Controlled 2Mbps to 100Mbps @ 0.5 Mbps Increments

100 Mbps Fiber Optic Port Specification Table

Typical Distance *	Nominal Wavelength	Fiber Type	Connector
2km	1300 nm	Multi-Mode**	SC or LC with SFP
20 km	1310 nm	Single Mode	SC or LC with SFP
40 km	1310 nm	Single Mode	SC or LC with SFP

* Distance numbers are standard designations used by the Ethernet industry and should not be used as factors in fiber optic network design. Optical budgets are minimum guaranteed values that should be used for network design.

** Multi-Mode fiber optic cable may be 62.5 or 50 micron core diameter.

2.03 UNIT MANAGEMENT CAPABILITIES

A. Hyper Text Transport Protocol (HTTP)/Web Browser device configuration interface

B. Command Line Interface (CLI)

C. Telnet device configuration interface (CLI)

D. Access through SSH Encryption Protocol Optional by Enabling it via CLI

E. Allow multiple simultaneous management sessions or automatically terminate existing session when a new session is requested

F. Simple Network Management Protocol (SNMP) version 1, 2 & 3 device status, diagnostic, and alarm monitoring and remote configuration

G. Remote Monitoring (RMON) network monitoring in compliance to standard RFC2819: RMON MIB

H. LED indicators: One LED for power, three LEDs per port for link, Tx, and Rx activity.

2.04 POWER SUPPLY

A. The Ethernet Switch shall be designed to operate with the following power requirements:

1. Terminal Block voltage between 12 VDC and 48 VDC

2. External Universal Power Supply Optional

3. Input Voltage: 85 to 240 VAC (auto-ranging).

4. Input Frequency: 47 to 60 Hz (auto-ranging).

5. Power Consumption: 20 watts (max).

6. Fast Transient Protection / Burst Standards: Compliant with IEEE C37.90.1 or EN61000- 4-4

2.05 MECHANICAL

A. Enclosure must meet or exceed 20-gauge steel or IP30 aluminum casing suitable for:

1. Stand-alone

2. Shelf

3. Pedestal

4. Wall mounting.

B. Permanently and clearly identify the enclosure with:

1. Name

2. Model number

3. Serial number

4. Any information required to facilitate equipment maintenance.

C. Dimensions shall not exceed the following maximums:

1. Height: 3” (76.2 mm)

2. Width: 8” (203.2 mm)

3. Depth: 10” (254 mm)

4. Weight: 5 lb. (2.27 kg)

2.06 WIRING

A. Meet all requirements of the National Electric Code for all wiring external to the HES switch.

B. Cut all wires to proper length before assembly. Do not double back any wire to take up slack.

C. Neatly lace wires into cable with nylon lacing or plastic straps.

D. Secure cables with clamps.

E. Provide service loops at all connections.

2.07 TRANSIENT SUPPRESSION

A. Provide diodes or other protective devices across the coils of all DC relays, solenoids and holding coils for transient suppression.

2.08 POWER SERVICE PROTECTION

A. Provide readily accessible, manually resettable or replaceable circuit protection devices (such as circuit breakers or fuses) for equipment and power source protection, such that no wire, component, connector, PC board or assembly is subjected to sustained current in excess of their respective design limits upon the failure of any single circuit element of wiring.

2.09 FAIL SAFE PROVISION

A. The equipment shall be designed such that it does not cause or contribute toward the failure of any other unit of equipment.

2.10 CONNECTORS AND HARNESSES

A. Make external connections by means of connectors.

B. Provide keyed connectors to preclude improper hookups.

C. Color code and / or appropriately mark all wires to and from the connectors.

D. Provide connecting harnesses of appropriate length and terminated with matching connectors for interconnection with the HES switches.

E. Uniquely color code patch fibers with mixed connectors for easy identification.

F. Plate all pins and mating connectors with not less than 20 microns of gold.

G. Cover all connectors utilizing solder type connections with a piece of heat shrink tubing securely shrunk to insure that it protects the connection.

2.11 ENVIRONMENTAL REQUIREMENTS

A. The Ethernet Switch shall be designed to operate in the following environmental conditions and shall meet or exceed:

1. -40ºC to 75ºC operating temperature range

2. -40ºC to 85ºC storage temperature range

3. 10% to 95% operating relative humidity (non-condensing)

4. Altitude: Operating 10,000 ft, Storage 15,000 ft

PART 3 EXECUTION

3.01 CONSTRUCTION METHODS

A. Provide equipment that utilizes the latest available techniques for design and construction with a minimum number of parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality. The equipment shall be designed for ease of maintenance, with all component parts being readily accessible for inspection and maintenance. Provide test points for checking essential voltages and waveforms.

1. Provide external screws, nuts and locking washers that are made of corrosion resistant material, such as plastic, stainless steel, anodized aluminum or brass.

2. No self-tapping screws.

3. Protect materials from fungus growth and moisture deterioration.

4. Separate dissimilar metals by an inert dielectric material.

END OF SECTION

SECTION 16735

FIBER OPTIC SPLICE ENCLOSURE

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Fiber Optic splice enclosures.

1.02 RELATED SECTIONS

A. Section 01270 - Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. This item will be measured by each “Fiber Optic Splice Enclosure” installed, connected and tested.

2. Payment for the work performed and materials furnished in accordance with this item and will be paid for at the unit price bid for “Fiber Optic Splice Enclosure”. This includes testing; connecting; and for materials, equipment, mounting hardware, labor, tools, documentation, warranty, training and incidentals.

3. Refer to Section 01270 - Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ASTM G 21 – Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi

B. ASTM G 155 - Standard Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials

C. Bellcore GR-769-CORE – Requirements for Fiber Optic Splice Closures and Terminals

D. National Electric Safety Code

1.05 SUBMITTALS

A. Provide all submittals identified in these specifications no later than two (2) weeks following award of contract.

B. Documentation. Submit manufacturer’s cut sheets to ensure that the specifications are met.

PART 2 PRODUCTS

2.01 MATERIALS

A. Description. Furnish and install underground and aerial splice enclosures. The enclosures shall meet the size and capacity requirements of the project plans.

B. Materials. Ensure materials and construction methods conform to the current NEC and National Electrical Safety Code.

1. Splice Trays.

a. General Requirements. Accept single mode fibers and meet the following requirements:

(1) Completely re-enterable

(2) Accommodate up to eight buffer tubes, expandable to 24 buffer tubes

(3) Hold up to 48 splices expandable to 288 splices

(4) Hold buffer tubes in place with channel snaps

(5) Stackable tray design

b. Technical Requirements. Splice Tray organizer will be made of molded polycarbonate plastic with a clear PVC cover. The tray retainers, inserts, and fiber tube will be made of polypropylene/EPDM. Test splice tray, tray cover, cable ties, splice inserts, and tube according to Bellcore GR-769-CORE one day chemical resistance test.

2. Optical Fiber Organizers.

a. Store splice trays in such a way as to protect and support cable splices within an environmentally protected area, an outside plant entrance point within a basement junction box, etc. Store splices in all configurations for up to four cables. Accept a minimum of four splice trays and offer bonding and grounding hardware as required from project to project. Use a one piece cable strapping system for easy storage.

PART 3 EXECUTION

3.01 INSTALLATION GUIDELINES

A. Use Locations

1. Underground vault

2. Communications Service Box

3. Manhole

4. Aerial mounted on messenger

5. Hub building

B. Design Requirements. Aerial application requires proper mounting hardware and shall be mounted using messenger cable. Ensure re-entry does not cause damage to drop cables or their jackets. Splice enclosures must withstand the most severe conditions of moisture, vibration, impact, cable stress and flex temperature extremes. If requested by the Engineer, provide the factory test procedures and their results of the minimum specifications listed below, which are the minimum requirements for any underground or aerial splice enclosure. Splice Enclosures shall be compatible and securely mounted in Communications Service Boxes used by City of Houston.

1. Allow for cable entry or re-entry in butt configuration, using mid-span cable breakout and splicing methods. Only one (1) cable per entry port is allowed. Use cable addition kits when all existing ports in butt configuration are in use. No inline cable entry into splice enclosure is allowed. Enclosure to meet the following requirements:

   a. Rigid non filled case,

   b. Withstand compression up to 200 pounds,

   c. Made of molded plastic,

   d. Two entrance ports on each end, and

   e. Port plugs allowing for in-line or butted splices.

3.02 TESTING REQUIREMENTS FOR SPLICE ENCLOSURES.

	TEST	PROCEDURE	RESULTS
Environmental Requirements	UV Resistance	ASTM-G155 for 740 hours	No loss in material strength
	Fungus Resistance	ASTM-G21	Zero rating
	Water Immersion	20 foot depth for 7 days	No water intrusion
	Freeze/Thaw	Ten 28 hour freeze/thaw cycle from 104 F (40 C) to 158 F (70 C)	No loss in material strength
	Salt Fog	30 days	No damage to metallic parts
	Acidified Saltwater	90 days in a salt/sulfuric acid bath (sulfuric acid, 0.2N sodium hydroxide)	No damage to metallic parts
	Chemical Immersion	24 hours at 100 F in Kerosene	No loss in material strength (Closure Body Material)
	Gasket Material	Sulfuric acid, 0.2N sodium hydroxide, gasoline, wasp spray	Weight change less than 10%
Mechanical Requirements	Compression Set	100 C for 22 hours	<22%
	Impact Torsion	100 ft-lb at 104 F (40 C) and 0 F (18 C) 10 twists at 104 F (40 C) and 0 F (18 C)	No mechanical damage No mechanical damage or loss of seal
	Bending	25 bends at 104 F (40 C) and 0 F (18 C)	No mechanical damage or loss of seal
	Drop Compression	Drop from 30 inches at 104 F (40 C) and 0 F (18 C) 300 lbf for 15 min. at 104 F (40 C) and 0 F (18 C)	No mechanical damage No mechanical damage
	Cable Pullout	100 lbf for 30 min.	No cable movement
Electrical Requirements	Current Surge	300 amps/10 secs.	No damage to bonding hardware
	Bond Clamp Retention	20 lbf for 1 min.	No bond clamp movement

END OF SECTION

SECTION 16736

FIBER DISTRIBUTION UNIT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Primary Fiber Distribution Units (PFDU) and Secondary Fiber Distribution Units (SFDU)

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement. This Item shall be measured by the number of primary or secondary fiber distribution units furnished and installed.

2. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" shall be paid.

a. "Primary Fiber Distribution Unit" Per Unit

b. "Secondary Fiber Distribution Unit" Per Unit

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 SUBMITTALS

A. Documentation

1. Submittals of catalog sheets, engineering drawings and specifications for all hardware items to be used on a project shall be provided to the Engineer for approval prior to commencement of work.

2. Submittal includes catalog sheets, engineering drawings and specifications for all hardware items for engineer's approval.

B. Provide the Engineer with all submittals identified in these specifications no later than two (2) weeks following award of the contract.

PART 2 PRODUCTS

2.01 MATERIALS

A. Primary Fiber Distribution Units

1. PFDU. Utilize hardware within the primary hubs in support of the hub distribution system and the primary network. This point in the system allows the distribution of signals directly to the network electronics via a jumper cord/patch cord cable management system.

2. The PFDU is characterized by a modular, medium density construction.

3. Termination method for PFDU shall be field termination of all inbound cable and patch cord connectivity to all outbound cables and network electronics.

4. PFDU shall be mountable within a 19-inch rack or bay and have a typical dimension of 8-inch high by 19-inch wide by 18-inch deep.

5. PFDU hardware shall be easily adaptable for bay routing of patch cords and cable. Design hardware to allow for the side-by-side termination of all fibers without violating minimum bend radius requirements.

6. Each PFDU connector capacity shall be 144 for SC connections, or 72 for ST connections if specified on plans.

7. All adapters used within the Network shall be compatible with single mode SC connectors unless otherwise specified on the plans. Fiber Optic Adapters shall be SC type unless otherwise specified in the plans. No plastic adapters shall be allowed.

8. All PFDU hardware that shall be accessible by unauthorized personnel shall be lockable with an interior key lock.

9. All PFDU Housing’s shall be made with front and rear locking options.

B. Secondary Fiber Distribution Unit

1. Typically, the final distribution point within the network and located in the Controller Cabinet. These shall be modular junction panels capable of being mounted on top of the pre-installed power strips in the cabinet.

2. The SFDU shall be a modular design, 1 unit tall, 19-inch mountable, with 16 pre-drilled adapter ports minimum. The SFDU shall have twelve pre-installed SC bulkheads, and a minimum of 4 open holes.

3. The SFDU shall be capable of being mounted on top of the pre-installed power strips in the cabinet. The left side power strip occupies 3/8” between the racks. The right side power strip occupies 7/8” between the racks.

4. All adapters used within the Network shall be compatible with single mode SC connectors, unless otherwise specified on the plans. No plastic adapters shall be allowed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Furnish and install Primary Fiber Distribution Units (PFDU) and Secondary Fiber Distribution Units (SFDU) in the individual traffic cabinets and communications closets within buildings as shown on plans.

END OF SECTION

SECTION 16737

COMMUNICATION SERVICE BOX

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Standard, off-street buried communication service boxes with lids and aprons to be utilized for support of communications cable installations.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Payment for this item will be measured by each "Communication Service Box" installed.

2. Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "Communication Service Box" of the type and size specified. This price is full compensation for excavating and backfilling; constructing, furnishing, and installing the communication service boxes and concrete aprons when required; and equipment, labor, materials, tools, and incidentals necessary to complete the work.

3. Refer to Section 01270 – Measurement and payment for unit price procedures.

1.04 REFERENCES

A. ASTM C 497 – Standard Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections or Tile

B. ASTM C 857 –Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures

C. ASTM D 543 - Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D. ASTM D 570 - Standard Test Method for Water Absorption of Plastics

E. ASTM D 635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

F. ASTM D 790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

G. ASTM D 2444 - Standard Practice for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)

H. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials

I. ASTM E 662 - Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials

J. ASTM G 21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi

K. ASTM G 155 - Standard Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials

L. ASTM G 154 - Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Materials

M. NFPA 70 – National Electric Code

N. Western Underground Committee Guide 3.6 – Non-Concrete Enclosures

PART 2 PRODUCTS

2.01 MATERIALS

A. General Requirements.

1. Ensure the communication service box is capable of supporting burial in off-street areas where occasional, non-deliberate heavy vehicle loads may be experienced.

2. Sustaining light vehicle loads in applications such as parking lots or driveways, and does not deteriorate when buried in various types of soils with varying moisture content.

B. Functional Requirements.

Ensure that the communication service box is capable of the following applications:

1. Ensure box withstands 600 lb. per square foot applied over the entire sidewall with less than ¼ -inch deflection per foot length of box.

2. Ensure box or extension is footed with a minimum of 1-1/4-inch flange.

3. Ensure box and cover withstand a test loading of 20,000 lb. over a 10-inch by 10- inch area centered on the cover with less than ½-inch deflection. Meet Western Underground Standards 3.6. Supply certification by an independent laboratory or factory testing documentation witnessed and certified by a professional engineer licensed in Texas.

4. Manufacture box and cover from polymer concrete reinforced with two layers of continuous strands of woven or stitched borosilicate fiberglass cloth. Construct the polymer concrete from catalyzed polyester resin, sand, and aggregate. Ensure a minimum compressive strength of 11,000 psi. Polymer concrete containing chopped fiberglass or fiberglass reinforced plastic is not acceptable.

5. Pulling of fiber optic cable interconnected with conduit.

6. Provide cable racks for storage of cable service loops within minimum bend radius limits of 10 inches (250mm).

7. Provide storage of splice enclosures.

8. Provide attachment bracket kit for splice enclosure mounting to prevent splice enclosure from lying on the bottom of the communication service box.

9. Provide access to cable and equipment after installation to support maintenance.

10. Accommodate a degree of security of cable and equipment from vandalism and theft by requiring an access tool.

11. Provide modular additions of conduits through punchouts or other means from four sides.

12. Provide protection of cable and devices from run-over by light vehicles and non- deliberate heavy vehicles without damage to the communication service box or enclosed cables and devices.

13. Support National Electrical Code requirements for grounding of shielded metallic strength cables as deemed necessary by the communications installation design.

14. Support water drainage of any invasive water.

C. Specifications. Communication service box material will comply with ASTM standards. The following applicable ASTM specifications are defined below:

Specification/ Test Method	Title/Subject	Applicability
ASTM C-497	Load testing of Pipe and Conduit	Compliant
ASTM C-857	Structural Loading for Underground Precast Structures	Compliant
ASTM D-543, Section 7	Chemical Resistance Test	Compliant
ASTM D-570, Section 5.0, 6.1, 6.5	Water Absorption	Compliant
ASTM D-635	Flammability Test	Compliant
ASTM D-790	Flexural Property	Compliant
ASTM D-2444	Impact Resistance Test	Compliant
ASTM E-84	Surface Burning Characteristics	Compliant
ASTM E-662	Specific Optical Density	Material Samples tested for Compliance
ASTM G-21	Fungus Growth	Material Samples tested for Compliance
ASTM G-155	Sunlight Exposure of Non-Metallic Materials	Compliant
ASTM G-154	Sunlight Exposure	Material Samples tested for Compliance

D. Environmental Requirements.

1. Galvanic Corrosion. Ensure communication service box material does not contain dissimilar metals which support galvanic corrosion nor any chemicals which, when in contact with non-corrosive metals used in the splice enclosure construction would cause metal deterioration.

2. Ice and Snow. Ensure communication service box will not be damaged by ice covering the lid at a thickness of two inches (50mm) nor a snow load of four feet (1.2m) for a period of four weeks.

2.02 SAFETY REQUIREMENTS

A. Human Safety.

1. Ensure communication service box is free from chemicals that are harmful to humans and is not constructed with sharp edges.

2. Lid will have a minimum coefficient of friction of 0.5. The lid will not be constructed to cause slippage of a person walking across the covered communication service box during wet conditions.

3. Lid installation and removal tools will comply with normally recognized industry safety standards.

B. System Safety. Communication service box material will contain no chemicals that may damage normal communications wire line, optical cable, splice enclosures or other equipment normally used in outdoor communications network installation. Also, communication service box will not reflect any light.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. Requirements. Construct for in-ground installation ensuring a flush fitting with sidewalks and grass areas, using light weight, high strength materials.

1. Lid Requirements. Ensure lid is exposed to the environment and in public view.

a. Include locking devices which are non-corrosive and require removal using a special access tool/key.

b. Include provisions for lifting and removal using a maintenance tool.

c. Lids shall be secured with tamper resistant standard Penta-Head Stainless Steel bolts.

d. Traffic-bearing.

e. Blend into the environment, providing an acceptable appearance.

f. Perform its intended function without failure for a minimum of 20 years of exposure to the environment as defined in this specification.

2. General Requirements. Communications service box dimensions will be per plan drawings. a. Knockouts. Locate and configured as shown on plan drawings.

a. Provide two (2) conduit knockouts of minimum 4-inch size on each wide dimension side of the communication service box close to the bottom edge, allowing adequate material for structural integrity.

b. Provide one (1) knockout of 4-inch minimum on each shorter dimension side of the communication service box for conduit penetrations.

B. Drainage. Construct communication service box without a bottom, allowing drainage via a bottom trench fill of 6 to 8 inches of gravel or crushed rock.

C. Splice Enclosures and Mounting Kit. Include a kit for providing mounting for a splice enclosure per plan drawing.

1. Design with sidewall mounting provisions on the longest width for a splice enclosure.

2. Include brackets allowing attachment of a cylindrical splice enclosure using nylon ties in the splice enclosure mounting kit.

3. Include in mounting provisions preformed holes for screw seat inserts with inserts included as part of the mounting kit, or screw seats molded into the communication service box sidewall.

4. Support of 18 pounds is required for splice enclosure brackets.

D. Concrete Apron. Provide a concrete apron (typically 10” wide x 6” to 8” deep) surrounding the ground box. The apron shall include necessary reinforcing steel as required in the City of Houston Communication Details.

END OF SECTION

SECTION 16739

BLUETOOTH SPECIFICATION
(Anonymous Wireless Address Matching Device)

PART 1 GENERAL

1.01 DESCRIPTION

A. Furnish anonymous wireless address matching (AWAM) device as detailed in this specification and as directed. Provide all equipment required to interface with an existing/proposed infrastructure as subsidiary.

B. Ensure after the setup, there are no external tuning controls of any kind, which will require an operator.

C. Furnish all new equipment and component parts of the latest proven design and manufacture, and in an operable condition at the time of delivery and installation. Provide all parts that are of high quality workmanship.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement. This Item will be measured as each unit furnished, installed, and tested.

2. Payment. The work performed and the materials furnished in accordance with this Item measured as provided under “Measurement” will be paid for at the unit price bid for “Bluetooth Equipment”.

3. The stand alone enclosure will be bid as a separate item if needed: AWAM Device Enclosure.

4. Refer to Section 01270 – Measurement and Payment for unit price procedure.

1.04 REFERENCES

A. TxDOT Special Specification 6005 - Testing, Training, Documentation, Final Acceptance, and Warranty

1.05 WARRANTY

A. Provide warranty in accordance with TxDOT Special Specification 6005, “Testing, Training, Documentation, Final Acceptance, and Warranty”.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide all AWAM devices from the same manufacturer. At a minimum, this item shall include:

1. AWAM Device
2. Antenna
3. Surge Protection

2.02 MATERIALS

A. Provide design to prevent reversed assembly or improper installation of connectors, fasteners, etc. Design each item of equipment to protect personnel from exposure to high voltage during equipment operation, adjustments, and maintenance.

B. Include licenses for all equipment, where required, for any software or hardware in the AWAM system.

C. Ensure the AWAM device is a rack mount device and will plug into a NEMA TS1, TS2, 170 or 2070 card rack assembly. The AWAM device shall draw power from the edge connector of the card rack assembly. The AWAM device shall also have the ability to function as a shelf mount unit with the addition of a stand alone enclosure.

D. The AWAM processor shall include the field software and accompanying use license to enable direct collection of MAC addresses from passing vehicles containing devices capable of being discovered by the process. It must communicate directly to the host application on the TranStar network by Ethernet-based methods in a format consistent with the existing travel time monitoring host software currently in use at Houston TranStar. At a minimum, the field software should provide the timestamp that the MAC address was read, the location of the device, and the MAC address itself or an equivalent anonymized version of it. The AWAM device shall accept new software revisions via BAT E-Z flash memory cards or equivalent. Software configuration changes shall be able to be made both pre and post installation. The AWAM device shall contain BAT reidentification algorithms and filtering or equivalent.

E. The Bluetooth discovery process shall operate in an asynchronous mode such that all MAC addresses gathered are individually time-stamped when they are detected, rather than operate in a batch process of discovery. The field processor and software must provide the ability to anonymize MAC addresses using methods and format consistent with the existing travel time monitoring host software currently in use at Houston TranStar. The field software must produce individual, non-duplicative, MAC addresses with ability to 'push' to the travel time monitoring server using User Datagram Protocol (UDP) in near real-time. In addition, the controller must be remotely accessible using secure IP networking (for example, SSH) for management purposes. The management interface should allow for the setting of software parameters, viewing system logs, starting and stopping the software and rebooting the controller.

2.03 AWAM DEVICE PERFORMANCE

A. Ensure the AWAM device provides a minimum of 85% MAC address reads when tested per the test procedure as outlined in this document.

2.04 AWAM DEVICE COMMUNICATIONS

A. Ensure the AWAM device is capable of communicating via Ethernet through the existing city network.

2.05 PROCESSOR FEATURES

A. 200Mhz ARM9 CPU

B. 32MB SDRAM

C. PC/104 expansion bus

D. Compact Flash socket

E. 1 USB 2.0 ports

F. 10/100 Ethernet

G. 1 serial ports

H. 20 DIO Pins

I. Battery backed real-time clock

J. Debian Linux OS

2.06 MECHANICAL SPECIFICATIONS

A. Mechanical Specifications. Size: 8.3 in. x 4.5 in. x 1.2 in.

2.07 ELECTRICALSPECIFICATIOS

A. Power Requirements: 8-30VDC, 3 Watts

2.08 ENVIRONMENTAL SPECIFICATIONS

A. Environmental Specifications. Fanless Operating Temperature: -20°C to +75°C

2.09 BLUETOOTH SPECIFICATIONS

A. Ensure the Bluetooth adapter is integrated into the AWAM device as a separate daughter board to the main processor board. External plug-in Bluetooth adapters will not be accepted. Bluetooth adapter shall have at minimum the following features:

1. Bluetooth 2.0+EDR Class 1
2. Working distance 300m
3. USB 2.0 interface
4. Maximum transfer rate of 3 Mbps (EDR)
5. Frequency Range of 2.402~2.480GHz
6. Transmit Output Power of +19dBm (+6dBm EDR) E.I.R.P.
7. Antenna connector: RP-AMA
8. Bluetooth Profiles DUN, FAX, LAP, SPP, HID, HCRP, FTP,OPP, A2DP, AVRCP, GAVDP, HSP, HFP,PAN, BIP
9. Regulatory Approvals: FCC, CE, TELEC, KCC, Bluetooth SIG

2.10 ANTENNA SPECIFICATIONS

1. Antenna shall have at minimum the following features:
2. Frequency: 2400-2500 MHz
3. Gain: 5dBiImpedance: 50 0.
4. Finish: Matte Black
5. Radiator Material: Copper
6. Polarization: Linear
7. Connector: N Male
8. VSWR: 1.9 : 1 Max
9. Radiate Pattern: Omni-directional

10. Operating Temperature: -30° C to 90° C

2.11 SURGE PROTECTION SPECIFICATIONS

A. Surge protection shall have at minimum the following features:

1. Gas discharge tube
2. Bi-directional protection
3. Passes DC power
4. Body: Aluminum
5. Connector: N-female to N-female
6. Size: 3.2 in. x 1.6 in. x 0.8 in.
7. Frequency: 0-3 GHz
8. Max Discharge Current: 5 kA
9. Impedance: 50 0.
10. Operating Temperature: -55° C to 85° C

PART 3 EXECUTION

3.01 TESTING

A. Perform testing in accordance with TxDOT Special Specification 6005, “Testing, Training, Documentation, Final Acceptance, and Warranty”.

B. AWAM device shall conform to the device performance requirements listed in section 2.03. when subjected to the following test procedure:

1. 10 Trial Vehicle Runs
2. Sites Connected to Transtar Server to Verify Recordings
3. The vehicles used for the testing shall have 2 Bluetooth devices with discovery mode enabled. The MAC addresses will be recorded at the server connected to the AWAM device process controller prior to the commencement of the test.
4. The passing percentage (%) shall be computed using the following formula to find a weighted average percentage: ((Total Positive Readings from the Antenna Runs (n) / Total runs (T)) x 100

END OF SECTION

SECTION 16740

SINGLE MODE FIBER OPTIC CABLE SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Single Mode Fiber Optic Cable System.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Measurement. This Item will be measured by the foot of cable furnished, installed, spliced, connected, terminated, stored, and tested.

B. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Fiber Optic Cable System" of the type, and number of fibers as applicable. This price is full compensation for furnishing and installing all cable (including patch cables and Ethernet cables); for relocating or removing cables as required; for pulling through conduit or duct; testing; for installing cable along messenger cable; for minor relocation of messenger cable on poles; splicing; connecting; and for materials, equipment, labor, tools, documentation, warranty, training and incidentals.

C. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. ANSI/ICEA S-87-640 – Standard for Optical Fiber Outside Plant Communications Cable

B. ASTM D 210 – Standard Specification for Bone Black Pigment

C. ASTM D 882 – Standard Test Method for Tensile Properties of Thin Plastic Sheeting

D. ASTM D 1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

E. ASTM D 2261 – Standard Test Method for Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant-Rate-of-Extension Tensile Testing Machine)

F. GR-20-CORE (Bellcore (Telcordia)) Issue 10 – Optical Fiber and Optical Fiber Cable

G. National Electric Safety Code

H. Rural Utilities Service (RUS), 7CFR 1755.900 – Filled Fiber Optics Cable

I. TIA 586 – Commercial Building Cabling for Telecommunications

J. TIA/EIA 598-B – Standard Optical Fiber Cable Color Coding

K. TIA 492-CAAA – Detail Specification for Class Iva Dispersion-Unshifted Single-Mode Optical Fibers

L. TIA 604 – Fiber Optic Connector Intermateability

1.05 SUBMITTALS

A. Documentation Submittal Checklist for Fiber Optic Specifications. This is a summary of the submittals included in this Specification.

1. Fiber Optic Cable Technician Qualifications

a. Submit documentation to ensure that Fiber Optic Cable Technician meets all requirements stated in Article 1.06.A.1.

2. Fiber Optic Cable Manufacturer

a. Manufacturer ISO-9001 and TL 9000 Certification. Proof of compliance with Bellcore (Telcordia) GR-20-CORE, Issue No. 1 TL 9000. Documentation for each cable indicating that the cable is listed by the Rural Utilities Service (RUS), 7CFR 1755.900 or PE-90 if in transition to RUS. Manufacturing Site testing procedures and results.

3. Cable Documentation

a. Current Catalog Cut Sheet. Manufacturer’s production cable cross section drawings. Manufacturer’s confirmation letter listing the optical field cables. Current RUS “Listing Letter”. Letter of certification for GR-20-CORETL 9000 compliance. Manufacturer’s installation procedures and technical support information.

4. Packaging and Shipping of Fiber Optic Cable

a. Submit manufacturer’s test results documented in accordance with GR-20-CORE Issue 10. Attenuation for each fiber in the cable in units of dB/km at both 1310 nm and 1550 nm.

5. Optical Fiber Materials

a. Documentation that cable meets all requirements of Article 3.01.B.3 and manufacturer’s SOP for installation.

6. Pull Tape

    a. Manufacturer's cut sheets for pull tape.

7. Underground Marking Tape

    a. Manufacturer cut sheets and documentation necessary to ensure that tape meets all specifications under Article 3.01.B.5.

8. Underground Cable Marking Posts and Discs

    a. Manufacturer's cut sheets for proposed posts and discs.

9. Fiber Optic Connectors

    a. Manufacturer's cut sheets for fiber optic connectors for proposed use.

10. Patch Cords

    a. Submit catalog sheets, engineering drawings and specifications for patch cords for approval.

11. Equipment Racks and Bays

    a. Manufacturer's cut sheets for equipment racks and bays for proposed use.

12. Testing

    a. Submit OTDR, Optical Power Meter, end-to-end attenuation, and ping tests performed on as-built cable system.

B. Provide the Engineer all submittals identified in the specification no later than two (2) weeks following award of the contract. Do not purchase cable for use on this project prior to receiving written approval of submittals for fiber optic cable by the Engineer. Additional details about submittals can be found in the specific equipment sections below. Refer to Submittal Checklist for Fiber Optic Specifications at the end of this specification.

C. Submittal Requirements for Fiber Optic Cable Manufacturers. Submit documentation for the fiber optic cable manufacturer that documents, as a minimum, the following information:

1. Manufacturer ISO-9001 and TL 9000 Certification.

2. "Proof of Compliance" with (Bellcore (Telcordia)) GR-20-CORE, Issue No. 2 TL9000.

3. Documentation for each cable, indicating that the cable is listed by the Rural Utilities Service (RUS), 7CFR 1755.900 or, if cable is in transition to RUS and be fully compliant with ANSI/ICEA S-87-640.

4. Manufacturing Site Testing Procedures. The Engineer reserves the right to require verification of any or all of the manufacturer's test procedures and those test results. When required by the Engineer, the cable manufacturer issuing the test data as verification of testing will conduct this testing, and/or the testing will be performed in the presence of the Engineer or Engineer's Agent.

D. Submittals for Fiber Optic Cable.

1. Documentation will consist of catalog sheets, engineering drawings, and maintenance procedures for all fiber optic cables to be used on this project. As a minimum, fiber optic cable submittals will include the following information:

a. Current Catalog Cut Sheet

b. Manufacture's production cable cross section drawings

c. Manufacture's confirmation letter listing the optical fiber cable(s)

d. Current RUS "Listing Letter" for said cable manufacturer

e. Cable manufacturer's installation procedures and technical support information associated with the cable proposed for use.

2. Submit manufactures cut sheets for all fiber optic cable to be used.

E. Submit documentation for the optical fiber that sufficiently documents that, optical fiber meets all criteria specified in Article 3.01.B. Provide the manufacturer's Standard Operating Procedure (SOP) for installation of this cable.

F. Submit manufacturer cut sheets for pull tape to be used on this project.

G. Submit manufacturer cut sheets and all applicable documentation necessary to establish that the specifications are met for the underground marking tape to be used on this project.

H. Submit manufacturer cut sheets for underground marking posts and discs to be used on this project.

I. Submit manufacturer cut sheets for fiber optic connectors to be used on this project.

J. Submittals for Patch Cords

1. Submit catalog sheets, engineering drawings and specifications for patch cords for approval prior to commencement of work.

K. Submit all manufacturer's cut sheets for equipment racks and bays.

L. Submittals for Fiber Optic Aerial Storage System

1. Submit catalog sheets, engineering drawings and specifications for a Fiber Optic Aerial Storage System to the Engineer for approval prior to commencement of work.

M. Submittals for Fiber Optic Technician Qualifications

1. Submit to the Engineer all documentation necessary to demonstrate that all fiber optic technicians providing services on this contract meet the minimum requirements established in Article 1.06.A.1, prior to the start of construction. Written approval of the technicians submitted for review by the Engineer is required prior to beginning any work on the fiber optic cable plant. Address any deficiencies noted by the Engineer prior to beginning any work on the fiber optic cable plant.

N. Test Procedures. Submit test procedures and data forms for the pre-installation, post-installation, subsystem, and system integration test for approval. Test procedures will require approval before performing tests. Submit one (1) copy of the data forms containing data and quantitative results, as well as an authorized signature. Submit a copy of the OTDR and Power Meter Test results as an electronic copy; supply original software packages and PC for OTDR results interpretation.

O. Submittals for Installation

1. Submit documentation including all OTDR, optical Power Meter Tests, and end-to- end attenuation tests performed on the as-built cable system. Submit three (3) units each of the hardware components/equipment required for the OTDR and the power meter tests to Engineer.

1.06 QUALITY ASSURANCE

A. Training Requirements for Technicians

1. Fiber Optic Cable Technician Qualifications

a. Work To Be Performed By Fiber Optic Technicians

(1) Any task requiring the opening of the fiber optic cable jacket, installation of fiber optic connectors, fusion splicing together of two fibers, or the testing of any fiber optic cable, drop cable, or patch cords will be performed by Fiber Optic Technicians that have been pre-approved by the Engineer.

b. Minimum Requirements for Fiber Optic Technicians

(1) Certifications – All fiber optic technicians will maintain Fiber Optic Installer Certification by the Electronic Technical Association (ETA) or approved equal. It should be noted that approved fiber optic technicians will maintain all certifications on their person at all times while working on the subject project.

(2) Training – All fiber optic technicians will be able to demonstrate their participation in at least one of the following:

c. Attendance and successful completion of at least one four day "Installation of Fiber Optic Products School" conducted by a major manufacturer of fiber optic products within one calendar year of the commence work date of this project. Said course outline will be submitted for review by the Engineer in order to determine if the course content is adequate to address the work requirements established in Article 1.06.A.1.a.

d. Demonstration of attendance and successful completion of an independent generic four (4) day school that encompasses all aspects of outside plant fiber optic technician certification within one calendar year of the commence work date of this project. Said course outline will be submitted for review by the Engineer in order to determine if the course content is adequate to address the work requirements established in Article 1.06.A.1a.

(1) Work History for Fiber Optic Technicians – All Fiber Optic Technicians who will perform work on this project will be able to demonstrate a minimum of three (3) years work experience, with a minimum of eighteen (18) months continuous work experience during this timeframe.

(2) Work experience will be any work activity involving those work elements described in Article 1.06.A.1a.

PART 2 PRODUCTS

2.01 MATERIALS

A. General Requirements. Provide new corrosion resistant materials that comply with the details shown on the plans and the requirements of this item.

1. Provide splicing kits, fiber optic cable caps, moisture/water sealants, connectors, patch cords, aerial cable storage systems, and accessories to complete the fiber optic communication system. Furnish equipment for installation, splicing, and testing.

B. Cable Requirements. Furnish fiber optic cable suitable for underground conduit and aerial environment.

1. Do not purchase cable for use on this project prior to receiving written approval of submittals for fiber optic cable by the Engineer, as established in Section 1.05.

2. All fiber optic cable(s) supplied and utilized on this project will be from a single manufacturer.

3. Optical fiber and cable manufacturer shall be vertically integrated.

4. The optical fiber shall be a matched clad design manufactured by the outside vapor deposition process.

5. Manufacturers proposing to supply fiber optic cable for this project will be Certified ISO- 9001 and TL 9000 Certified.

6. Fiber optic cable manufacturer proposed for this project will demonstrate, as a prerequisite, engagement in the production of each and every fiber optic cable(s) specified herein, for a continuous period of twenty years.

7. All cables supplied for this project will be produced utilizing the construction processes noted herein and warranted by manufacturer. Ensure that all proposed fiber optic cable is compatible with existing equipment/infrastructure.

2.02 SOURCE QUALITY CONTROL

A. Perform tests in accordance with testing requirements in this Item. All optical fibers within each cable will be factory tested by the manufacturer for continuity and to establish the attenuation of each fiber prior to shipping. Testing will be conducted and the results documented in accordance with GR-20-CORE (Bellcore (Telcordia)) Issue 10. This testing will be conducted immediately prior to shipping while the fiber is on the reel and the results will be provided with each cable reel and affixed within the reel wrapping. An additional copy of the test documentation will be provided to the Engineer under separate cover. As a minimum, the results provided in these reports will indicate attenuation for each fiber in the cable in units of dB/km at both 1310 nm and at 1550 nm.

1. Test Methods.

a. Optical Time Domain Reflectometer (OTDR) Tests. Use the OTDR to measure fiber optic cable for overall attenuation (signal loss dB/km), fiber cable length, and identify fiber optic cable anomalies such as breaks. Perform four (4) OTDR tests. They are as follows:

(1) Acceptance test

(2) Pre installation test

(3) Post termination test

(4) Final end to end test

2. OTDR Settings:

a. Use the file name of the fiber scan to indicate the location or direction the test was run from, as well as the fiber number being tested.

b. Set the “A” cursor at the beginning of the fiber trace and set the “B” cursor at the end of the fiber trace. The distance to cursor “B” indicates the length of the fiber cable segment being measured.

c. Match the index of refraction to the index of the factory report.

d. Set the loss indicator to dB’s/km for the acceptance test.

e. The reflectance is automatically set internally by the OTDR.

f. Set the pulse width at a medium range. Change the pulse width to a slow pulse width when an anomaly occurs on the fiber trace so that it can be examined closely.

g. Set the average to medium speed. Change the average to slow speed when an anomaly appears on the fiber trace to allow for closer examination of the anomaly.

h. Set wavelength at 1310 nm and 1550 nm for singlemode cable so the cable is tested at both windows for each type of cable.

i. Show all settings on test result fiber scans.

3. Optical Power Meter Test. Use the optical power meter test to check fiber optic cable for fiber optic cable anomalies such as breaks causing dB loss.

a. Test single mode fiber optic cable at both 1310 nm and 1550 nm. In order to evaluate results solely for the fiber optic cable, initially calculate loss from connector to connector and subtract this value when testing the fiber optic cable.

4. Pre-Installation Tests. Test and record the fiber optic cable at the site storage area prior to installation.

    a. Test each optical fiber in the cable from one end with an OTDR compatible with wavelength and fiber type. Check testing for length, point discontinuity, and approximate attenuation. Record each measurement by color, location, and type of fiber measured. Perform a measurement from the opposite end of that fiber in case a measurement cannot be made from one end. Wait for notification if loss per km exceeds manufacturer's test data by more than 0.5 dB/km or point discontinuity greater that 0.2 dB.

    b. Perform this test within three (3) days from receipt of the fiber optic cable. Test overall attenuation (dB/km), total cable length, anomalies, or cable problems. Test cable at both windows (1310 nm and 1550 nm for single mode cable). Compare factory test results against test results and return to manufacture if different. If identical, document the test results. Deliver documentation for future reference.

5. Post Installation Tests. Immediately perform the post installation test after the fiber optic cable has been installed. Re-test and re-record each optical fiber in the cable after installation, before termination, for loss characteristics. Test both directions of operations of the fiber.

    a. Test cable for overall attenuation, cable segment length, and damage. Use the same OTDR settings for Post Installation Test as the Pre-Installation Test. Replace any cable segment that is damaged during the test and document test results. Deliver tests results for future reference.

6. Post Termination Test. Perform the post termination test as the cable is terminated or spliced, whether there is termination of fiber cable to fiber cable or fiber cable to equipment. Check attenuation, fusion or termination point problems, and overall fiber cable segment. Determine if the attenuation and quality of the termination meets the specification; if not, repeat the termination until it meets specification requirements. Test the fiber segment for attenuation and anomalies after termination acceptance. Document and submit test results as stated in this Item after fiber segment acceptance.

    a. Test the splices at 1310 nm for single-mode and provide printouts of the splice tests. Take tests in both directions and record the average.

    b. Use a launch reel of the same type of fiber to test the fusion splices on pigtails.

c. Use the same OTDR settings for Post Termination Test as the Post Installation Test and Pre-Installation Test, except move the “B” cursor to the middle of the termination or splice point. After the termination, return “B” cursor to the end of the fiber segment and measure overall length and attenuation. Conduct Power Meter Test after termination of cable is completed.

7. Subsystem Tests. Perform Network Subsystem Tests after integration to the fiber optic network. Test the capability of the fiber optic cable to transmit video and digital information. Complete and submit approved data forms for review and rejection or acceptance.

   a. Correct and substitute components in the subsystem if the Subsystem Tests fail and repeat the tests.

   b. Prepare and submit a report if a component was modified as result of the Subsystem Test failure. Describe in the report the failure and action taken to remedy the situation.

8. Final End to End Test and ping test. Perform Final End to End Test on the entire system with both the OTDR and Power Meter after fiber cable segments of the system are terminated. Also, perform a ping test between all controllers and switches on the system. A report of successful pings shall be submitted to the City of Houston engineer / project manager. The City of Houston must be present during the ping test.

   a. Perform the Final End to End Test:

      (1) Measure the overall fiber cable system length.

      (2) Measure the overall system attenuation, and

      (3) Check for anomalies.

   b. Document and submit results as stated in this Item, after test acceptance.

PART 3 EXECUTION

3.01 INSTALLATION

A. Description. Furnish and install single mode fiber optic cable as shown on the plans.

B. Materials.

1. Cable. Single Mode Fiber Optic Cable

a. All fiber optic cable will be loose tube telecommunications grade designed for high speed transmission of voice, data, and video communications. The cable will combine a loose tube fiber with a UV rated outer (MDPE) jacket and be designed for duct and aerial installations. The maximum pulling tension shall be 2700 N (608 lbf) during installation (short term) and 890 N (200 lbf) long term installed. The cable shall withstand a minimum compressive load of 220 N/cm. The Cable and fiber manufacturer shall be the same company to ensure long-term reliability of the cabled fiber and to ensure the availability of fully integrated technical support. Cable shall be Corning Cable Systems part number U4-T_1_ _ D20.

b. Buffer Tube Requirements.

(1) Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be either 2.5 mm or 3.0 mm. Each buffer tube shall contain up to 12 fibers. The fibers shall not adhere to the inside of the buffer tube. Each fiber shall be distinguishable by means of color coding in accordance with TIA/EIA-598-B, "Optical Fiber Cable Color Coding." The fibers shall be colored with ultraviolet (UV) curable inks. Buffer tubes containing fibers shall be color coded with distinct and recognizable colors in accordance with TIA/EIA-598-B, "Optical Fiber Cable Color Coding." Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be 1 mm. The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrinkback requirements of 7 CFR 1755.900. Each buffer tube shall contain a water-swellable yarn or water blocking element for water-blocking protection. The water-swellable yarn or water blocking element shall be non- nutritive to fungus, electrically non-conductive, and homogeneous. It shall also be free from dirt or foreign matter. This yarn or element will preclude the need for other water-blocking material; the buffer-tube shall be gel-free.

c. Cable Construction

(1) The central member shall consist of a dielectric, glass reinforced plastic (GRP) rod (optional steel central member). The purpose of the central member is to provide tensile strength and prevent buckling. Tensile strength shall be provided by the central member, and additional dielectric yarns as required.

(2) The central member shall be overcoated with a thermoplastic when required to achieve dimensional sizing to accommodate buffer tubes/fillers. Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation, or "S-Z", stranding process. Water swellable yarn(s) shall beapplied longitudinally along the central member during stranding. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed. Fillers shall be placed so that they do not interrupt the consecutive positioning of the buffer tubes. In dual layer cables, any fillers shall be placed in the inner layer. Fillers shall be nominally 2.5 mm or 3.0 mm in outer diameter. Two polyester yarn binders shall be applied contrahelically with sufficient tension to secure each buffer tube layer to the dielectric central member without crushing the buffer tubes. The binders shall be non- hygroscopic, non-wicking, and dielectric with low shrinkage. For single layerables, a water swellable tape shall be applied longitudinally around the outside of the stranded tubes/fillers. The water swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter. For dual layer cables, a second (outer) layer of buffer tubes shall be stranded over the original core to form a two layer core. A water swellable tape shall be applied longitudinally over both the inner and outer layer. The water swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter. The dielectric yarns shall be helically stranded evenly around the cable core.

d. Cable Jacket

(1) Non-armored cables shall be sheathed with medium density polyethylene (MDPE). The minimum nominal jacket thickness shall be 1.3 mm. For reduced diameter (RD) cables, the minimum norminal jacket thickness shall be 1.4mm. Jacketing material shall be applied directly over the tensile strengthmembers (as required) and water swellable tape. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus. The MDPE jacket material shall be as defined by ASTM D1248, Type II, Class C, Category 4 and Grades J4, E7 and E8.The cable jacket shall contain no metal elements and shall be of a consistent thickness.

e. Trunk Cable.

(1) Single mode fiber optic trunk cable will be utilized to connect the network data loop to all drop cables via the fusion splice process. Each cable will have traceability of each fiber back to the original fiber manufacturer's fiber number and parameters of the fiber. The optical fibers will meet all optical fiber specifications as listed in Article 3.01.B.3.a.

(2) The fiber count for each trunk cable will be as indicated in the project drawings.

f. Drop Cable.

(1) Single mode fiber optic drop cable will be utilized to connect the trunk cable to field equipment via fusion splicing. Each cable will have traceability of each fiber back to the original fiber manufacturer's fiber number and parameters of the fiber. The optical fibers will meet all optical fiber specifications as listed in Article 3.01.B.3.a.

(2) The fiber count for each drop cable will be as indicated in the project drawings.

(3) A fan-out kit will be required within the Secondary Fiber Distribution Unit (SFDU) on the terminal end of each drop cable that is utilized for this project. The fan-out kit will be installed in a climate controlled environment. Ensure that the length of all drop cables, not indicated by drawings, is adjusted for field conditions. Additional costs caused by failure to establish the lengths of any and all drop cables in the field will be at the Contractor's expense.

(4) Color Coding of Buffer Tubes.

(5) Buffer tubes containing fibers shall be color coded with distinct and recognizable colors in accordance with EIA-TIA-598-B, "Optical Fiber Cable Color Coding ".

g. Fiber Optic Cable Jacket Marking.

(1) Cable jackets shall be marked with the manufacturer's name, month and year of manufacture, sequential meter or foot markings, a telecommunication handset symbol as required by Section 350G of the National Electrical Safety Code (NESC), fiber count, and fiber type. The actual length of the cable shall be within -0/+1% of the length markings. The print color shall be white, with the exception that cable jackets containing one or more coextruded white stripes, which shall be printed in light blue. The height of the marking shall be approximately 2.5 mm.

(2) If the initial marking fails to meet the specified requirements (i.e., improper text statement, color, legibility, or print interval), the cable may be remarked using a contrasting alternate color. The numbering sequence will differ from the previous numbering sequence, and a tag will be attached to both the outside end of the cable and to the reel to indicate the sequence of remarking. The preferred remarking color will be yellow, with the secondary choice being blue.

(3) All loose tube fiber optic cable, for each length of cable, will be marked with the following legend:

(a) Manufacture Name

(b) "OPTICAL CABLE"

(c) Year of Manufacture.

(d) "CITY OF HOUSTON"

(e) Number of Fibers

(f) "SM FOC – CALL CITY OF HOUSTON 311"

2. Packaging and Shipping of Fiber Optic Cable.

a. Requirements.

(1) The cable will be packaged, wound on spools or reels. Each package will contain only one continuous length of cable. The packaging will be constructed so as to prevent damage to the cable during shipping and handling.

(2) When the cable length creates a reel weight exceeding 800 pounds, the manufacturer will be required to supply the cable on a large wooden reel, the reel will be lagged with wooden staves. The cable will be covered with a thermal wrap. The outer end of the cable will be securely fastened to the reel head so as to prevent the cable from becoming loose in transit. The inner end of the cable will project a minimum of ten feet into a slot in the side of the reel or into a housing on the inner slot of the drum, in such a manner to make it available for testing. An arbor hole of 1-1/2 inch minimum is required.

(3) Finally, end seals will be applied to each end of the cable to prevent moisture from entering the cable.

(4) Reels will be permanently marked with an identification number that can be used by the manufacturer to trace the manufacturing history of the cable and the fiber.

(5) Each reel will be plainly marked to indicate the direction in which it should be rolled to prevent loosening of the cable on the reel.

3. Optical Fiber Materials. Optical fiber will be glass and consist of a germania-doped silica core surrounded by concentric silica cladding. The fiber will be a matched clad design manufactured by the Outside Vapor Deposition (OVD) process. All fibers will be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical and environmental requirements of these specifications.

a. The optical fiber utilized in the manufacture of all fiber optic cable for this project will be produced by one manufacturer. The optical fiber characteristics will be in accordance with Article 3.01.B.3.a.

b. Optical Requirements.

(1) Only dispersion unshifted single mode fiber as specified by EIA 492-CAAA, Class 4a will be utilized in the manufacture of all cable for this project.

(2) All fibers will be coated with a dual layer acrylate protective coating. The coating will be mechanically or chemically strippable without damaging the fiber.

(3) Each optical fiber will be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN / m 2).

(4) The required optical fiber grade will reflect the maximum individual fiber attenuation, to guarantee the required performance of every fiber in the cable at 23 5 C on the original shipping reel.

(5) The optical fiber will comply with all optical and mechanical requirements over a storage temperature range of –50 C to +70 C, an installation temperature range of –40 C to +70 C, and an operating temperature range of-30 C to +70 C.

PARAMETERS	SINGLE MODE
Type	Step Index
Core Diameter	8.3 µm (Nominal)
Cladding Diameter	125 µm ± 1 µm
Core to Cladding Diameter	0.5 µm
Coating Diameter (OSP)	245 µm ± 5 µm
Cladding-Noncircularity	1.0%
Proof Tensile Test	100 kpsi (0.7 GN/m2)
Max Attenuation:	
@ 1310 nm (SM)	0.4 dB/km
@ 1550 nm (SM)	0.3 dB/km
Chromatic Dispersion	
Zero Dispersion	1302/1322 nm
Zero Dispersion Slope	0.089 ps/(nm^2•Km)
Maximum Dispersion	<3.5ps/(nm^2•Km) for 1285-1330 nm :S 18ps/(nm^2•Km) for 1550 nm
Cut-Off Wavelength	1260 nm

c. Color Coding of Individual Optical Fibers. Individual optical fibers will be color coded in accordance with EIA-TIA-598-B, “Optical Fiber Cable Color Coding”. The fibers will be colored with ultraviolet (UV) curable inks.

4. Pull Tape. Pull Tape is required. No pull ropes, twine, or pull strings will be used on this project for the purpose of installation. Further, if the plans and specifications indicate pull tape for future use do not substitute pull ropes, twine or pull strings for pull tape.

a. Requirements. Pull tape will be prefabricated woven polyester tape made from low friction, high abrasion resistant yarns providing a low coefficient of friction. Pull tapes will be prelubricated. Pull tapes will be printed with sequential footage markings for accurate measurement. Pull tapes will be ½ inch wide and have a minimum tensile strength of 1,250 pounds.

5. Underground Marking Tape. Underground marking tape will be used in all areas where trenching is utilized to install underground conduit. Use marking tape in conjunction with marking posts and marking discs.

a. Requirements. The technical specifications of underground marking tape are identified below, along with applicable testing methods necessary to establish that a cable submitted for approval meets these specifications.

TEST PROPERTY	THRESHOLD SPECIFICATION	REQUIREMENTS
Standard Weight	ASTM D2103	20 lbs/100 feet
Thickness – Overall	ASTM D210	4 mil
3 in. Tensile Break – MD	ASTM D882	35 lbs/ft
3 in. Tensile Strength – MD	ASTM D882	4 kpsi
3 in. Tensile Break – TD	ASTM D882	38 lbs/ft
3 in. Tensile Strength – TD	ASTM 882	5 kpsi
Elongation – MD – MD	ASTM 882	530 %
Elongation – TD – TD	ASTM 882	660 %
Tear Strength	ASTM D2261	1.5 lbs/ft

b. Labeling Requirements for Underground Marking Tape. Underground marking tape will be a 3-inch wide, tear resistant, corrosion resistant elastic PVC orange tape, imprinted with the legend “SM FOC – CALL CITY OF HOUSTON 311”. This legend will be printed every three (3) feet in black letters.

6. Underground Cable Marking Post and Marking Discs. Underground cable marking posts will be used everywhere feasible and practical in all areas where fiber optic cable is installed in underground conduit. This is the preferred method of marking, since it is very visible. Marking posts should be placed every 500 feet in urban area, and every 1000 feet in suburban areas, as well as at every intersection corner and every change in direction. Exception would be locations like downtown where all surfaces are paved, where discs would be more practical. Use marking discs set in concrete or pavement where the use of marking posts is not feasible and practical, i.e., areas such as downtown where everything is paved and for aesthetics.

a. Requirements. Technical specifications of underground marking posts are identified below.

(1) Line Markers will be made from ultraviolet-stabilized High Density Polyethylene (HDPE)

(2) Minimum 3-1/2" O.D. tubular design

(3) Text will be hot-stamped into the fittings with an extra u-v clear coat.

(4) Crossing casing vents will be used to help maintain atmosphere conditions.

(5) Line markers will require no maintenance after installation.

7. Fiber Optic Connectors

a. Requirements.

(1) Fiber Optic Connectors will be field installed, SC compatible for single mode applications or ST compatible if specified as such on the plans. Ensure that all connectors are the same as the manufacturer's cable.

(a) Connectors will be compliant with TIA/EIA 604 and have a tensile strength of 10 pounds, with 0.2 dB change.

(b) Durability will be 0.3 dB change for 500 rematings per FOTP – 21.

(2) Fiber Optic Connectors will not exceed the maximum loss listed below for each connector type:

Connector Type	Installation	Max. Loss
SC™ Single Mode	Field	0.50 dB (Insertion)
SC™ Single Mode	Field	-40 dB (+18 C to +26 C) Reflectance

Connector Type	Installation	Max. Loss
ST™ Single Mode	Field	0.50 dB (Insertion)
ST™ Single Mode	Field	-40 dB (+18 C to +26 C) Reflectance

8. Fiber Optic Adapters

a. Requirements.

(1) Fiber Optic Adapters will be SC type. If ST type adapters are specified on the plans ensure compatibility with ST style connectors.

SC

Body Parts	Metal or ceramic
Sleeve	Zirconia
Testing	TIA/EIA 604 and TIA 586 B.3 compliant

ST

Body Parts	Brass or Nickel Plated Brass
Body Construction	Precision-machined
Sleeve	Zirconia
Panel Thickness	0.06” minimum to 0.13” maximum
Withdrawal Force	200-600 grams
Testing	TIA/EIA 604 compliant
Durability	2' 500 cycles per EIA 455-21

(2) Adapter unit will include Nut, lockwasher, and dust cap.

C. Patch Cords

1. Requirements. All fiber patch cords will meet National Electric Code (NEC) jacketing requirements for this project’s application and will have outer jacket coloration of yellow for single mode patch cords. All duplex patch cords will be of a zip cord design and will have connector boots of two (2) colors, namely white or off- white for one leg of the duplex cord (non-printed zip leg) and red for the opposite leg (printed zip leg) or the duplex cord.

   a. Connector losses will not exceed those established in Article 3.01.B.7.a.2).

   b. No splices of any type are allowed within an assembly. Each assembly is to be fully tested and those test results placed on a test tag for each mated pair of connectors.

   c. Connectors will then be attached to one end of each pair within the assembly. Each assembly will be individually packaged within a plastic bag with the submitted manufacturer’s part number marked clearly on the outside of said bag. Label each installed patch cord as directed by the Engineer.

D. Equipment Racks and Bays. Install equipment racks and bays at designated locations as shown on the plans, as detailed in accordance with these specifications, and as directed.

1. Requirements. Provide all new equipment in strict accordance with the details shown on the plans and in the specifications.

    a. At the "head end" and hubs all distribution hardware, network electronics, video equipment, VDS processors, and all controllers and miscellaneous electronics will be mounted within a 7 feet high by 24 inch wide bay or cabinet for 19 inch wide mounting rack(s). Each installed and populated individual rack segment will be identified as a "bay". The primary structure material of each rack will be factory painted steel. Each rack will be field attachable to one another in a modular configuration. The frames themselves will be equipped with components that will allow for the field management of cables, jumpers and pigtails as may or may not be used in the interconnect system. All these components will be manufactured in such a way as to meet all fiber bend radius requirements. Above and below each rack will be an enclosed fiber management system allowing for proper field cross connect management. All rack ends will be sealed with "end caps" thus protecting any patch cords, cable, or pig tails which may be routed at that location. Between each rack will be mounted jumper management rings or loops that allow for the efficient management, routing, and protection of all cable patch cords/jumpers, or pig tails used within the rack system to interconnect the network electronics. Additionally, management troughs will be mounted at the top and bottom of each rack and ten made continuous as bays are attached.

E. Fiber Optic Cable Aerial Storage System. Install a Fiber Optic Cable Aerial Storage System at designated locations as shown on the plans, as detailed in accordance with these specifications, and as directed.

1. Requirements. Provide all new equipment in strict accordance with the details shown on the plans and in the specifications.

    a. Aerial Location. Used to store, and protect the minimum bend radius, of a surplus length of fiber cable at splice points, or for future expansion along aerial messenger span fiber optic cable installations.

        (1) The storage units will be a snowshoe type, designed to maintain the minimum bending radius of the fiber optic cable indicated in the fiber optic cable specifications.

        (2) The snowshoe storage units will be constructed of aluminum with continuous welds at crossbars and ends.

        (3) Each snowshoe storage unit will be double coated with a baked on, polyester powder coat finish.

        (4) Design snowshoe with 12" radius with a channel width (I.D.) of 1.25".

(5) Tie eyelets will accommodate both stainless steel and tie wrap securing methods.

(6) To counteract wind loading, aerial fiber optic cable storage units should be installed as close to span support poles as feasible.

(7) Do not install snowshoe above a roadway or driveway.

(8) All installation hardware including stainless steel mounting bolts, stainless nuts and washers are included.

(9) Ensure quantity of fiber optic cable stored is per plan drawings.

3.02 CONSTRUCTION

A. Install fiber optic cable without changing the optical and mechanical characteristics of the cables.

1. Perform all work in a workmanlike manner and meet the highest industry standards, and in accordance with the requirements of the latest editions of the NEC and National Electrical Safety Code.

B. Installation

1. Installation Methods

a. Install fiber optic cable and communication equipment in accordance with the manufacturer's recommended practices.

b. Install fiber optic cable on poles or in conduits as specified in the plans. In conduits, if required, relocate existing cable to allow new fiber optic cable routing in conduits. When pulling the cable, do not exceed the bending radius. Ensure a minimum bend radius with no load at 10 x fiber optic cable diameter. Minimum bend radius at maximum stringing tension is 20 x fiber optic cable diameter. Use rollers, wheels, or guides that have radii greater than the bending radius. Provide separate grooved rollers for each cable when simultaneously pulling multiple cables. Use a lubricating compound to minimize friction. Use fuse links and breaks. Measure the pulling tension. Do not exceed a pulling tension of 2700 N (600 lbf).

c. Seal conduits with a two (2) part urethane after installing cable.

d. Bury an approved copper tracer wire directly inside the conduit for the entire length of the conduit as directed by the field engineer. Ensure tracer wire is continuous between communication service boxes.

2. Fusion Splicing

   a. Fusion splicing is the only approved splicing method.

   b. Fusion splicing consists of aligning the cores of two clean (stripped of coating), cleaved fibers or a group of such fibers (mass splice) and fusing the ends together with an electric arc. The fiber ends are positioned under a microscope or a high resolution video monitor and then aligned using various precision movement micro- positioners (commonly stepping motors or piezoelectric devices). High voltage electrodes contained in the splicer conduct an arc across the fiber ends as the fibers are moved together, thus fusing the fibers together. Optimum core alignment will be verified prior to splicing and splice estimated devices and profile alignment algorithms. Fusion splicing equipment will provide the operator with reference estimated splice loss measurements. Further, it will automatically align fibers, determine cleave quality and fuse the fibers. No splice will result in a loss of more than 0.03 dB, as measured by an Optical Time Domain Reflectometer (OTDR) bi- directionally.

   c. Maintain records of the OTDR measurements and submit this documentation to the City of Houston for review and final approval of the fiber optic cable plant. Perform optical power meter test on the single mode fiber at 1310 nm and 1550 nm. All testing requirements are detailed in Article 2.02.A.

END OF SECTION

SECTION 16741

VIDEO COLOR QUAD UNIT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnish and install Video Color Quad Unit as shown on the plans, and as detailed in this Specification.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement: This Item will be measured as each unit furnished, installed, made fully operational and tested in accordance with these Specifications or as directed by the Engineer.

2. Payment: The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for “Video Color Quad Unit”. This price is full compensation for furnishing all equipment described under this Item with all cables and connectors, all documentation and testing; and shall include the cost of furnishing all labor, materials, training, warranty, equipment, and incidentals.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. NFPA 70 – National Electric Code

B. TxDOT Special Specification 6005 - Testing, Training, Documentation, Final Acceptance, and Warranty

C. TxDOT Special Specification 6006 - Electronic Components

PART 2 PRODUCTS

2.01 MATERIALS

A. General Requirements. All materials furnished, assembled, fabricated, or installed under this Item will be new, corrosion resistant, and in strict accordance with the details shown on the plans and in this Specification.

B. Functional Requirements. Furnish and install, at the locations shown on the plans, Video Quad Unit to combine four (4) analog video inputs into a single screen video display output.

1. Provide the video color quad unit that allows up to 4 video camera signals to be displayed simultaneously on a single monitor screen divided into 4 blocks. Ensure each of 4 images in the quad display mode are refreshed and appear in real time with no motion loss due to multiplexed display images. Ensure the quad unit is able to use virtually any 2:1 interlace type camera. Ensure the quad unit allows sequential display of quad page and each camera at full screen on live display monitor port. Ensure the unit supports remote control of functions through an RS-232 serial port.

    a. Ensure the Color Quad Video Generator meets the following minimum requirements:

        (1) Operating power may be 120 V AC or 12 V DC with adapter

        (2) Operating temperature range from 32 - 110°F

        (3) Video input four 1.0 V p-p composite video

        (4) Monitor output 1.0 V p-p composite video

        (5) Monitor output DB-15 SVGA

2. Wiring and Connectors. Ensure coaxial cable is used for making video connections between devices in the Traffic Signal Controller. Ensure the cables are the RG-59 type with a nominal impedance of 75 ohms. Ensure all cables have a polyethylene dielectric with copper braid shield having a minimum of 95% shield coverage and not greater than 3.4 dB attenuation per 100 ft. at 100 MHz. Video connectors shall be BNC die crimp type. Ensure coax braid is neatly trimmed before crimping the connector to insure no possibility of contact between braid and inner connector. Ensure there are no nicks in the center conductor. Ensure crimps are mechanically secure and made in such a way that no braid is left exposed or protrudes from the connector. Ensure the center pin is gold plated and installed with the tip of the center pin flush with the front edge of the connector.

a. Ensure cables are neatly dressed and bundled with nylon cable ties. Ensure each cable is marked with a unique identification number at a point 6 in. from each end of the cable. Ensure numbering is done by applying adhesive plastic tape with machine printed black figures on white background. Thermal, or inked ribbon, computer printed labels are not satisfactory. Ensure identification is read upright when holding the cable horizontally with the connector to the left. Ensure the finished identification number is protected with a piece of clear shrinkable tubing shrunk tightly over the label and extending at least 1/4 in. either side of the label. Ensure each cabinet or rack contains a typed list showing the cabinet identification and the numbers, description, source and destinations of all cable in that cabinet. Ensure the cable list is heat laminated to protect it from moisture and dirt. Ensure the system schematic is clearly identify all cables by number.

3. Interconnect Harness and Accessories. Provide all interconnect harnesses and accessories needed for a completely integrated system. Ensure these cables/harnesses are properly labeled on either end of the cable assemble. Provide cables which consist of but not be limited to:

a. RS232 cables

b. Video coaxial cables with BNC connectors

2.02 ELECTRICAL REQUIREMENTS

A. Power Requirements. Ensure the Video Quad Unit meets all of its specified requirements when the input power is 115 ± 20 volts AC, 60 ± 3 Hz. Ensure the maximum power required does not exceed 600 watts.

1. Ensure the equipment operation is not be affected by transient voltages, surges, and sags normally experienced on commercial power lines.

B. Wiring. Ensure all wiring meets the requirements of the National Electric Code. Ensure all wires are cut to proper length before assembly. Ensure no wire is doubled back to take up slack. Ensure wires are neatly laced into clamps. Ensure cable slack is provided to facilitate removal and replacement of assemblies, panels and modules.

C. Transient Suppression. Ensure all DC relays, solenoids, and holding coils have diodes across the coils for transient suppression.

D. Power Service Protection. Ensure the equipment contains readily accessible, manually resettable or replaceable circuit protection devices (such as circuit breakers or fuses) for equipment and power source protection.

E. Fail Safe Provision. Ensure the equipment is designed such that the failures of the equipment will not cause the failure of any other unit or equipment.

2.03 MECHANICAL REQUIREMENTS

A. Connector and Harness. Ensure all external connections are made by means of connectors. Ensure the connectors are keyed to preclude improper hookups. Ensure all wires to and from the connectors are color coded and appropriately marked. Ensure pins and mating connectors are corrosion resistant.

2.04 ENVIRONMENTAL DESIGN REQUIREMENTS

A. Ensure the equipment meets all its specified requirements during and after subjecting to any combination of the following conditions:

1. Ambient temperature range of 32ºF to 110ºF.

2. Relative humidity up to 90% non-condensing.

PART 3 EXECUTION

3.01 GENERAL

A. Ensure the equipment design and construction utilizes the latest available techniques with a minimum number of parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality.

B. Ensure the equipment is designed for ease of maintenance. Ensure all component parts are readily accessible for inspection and maintenance. Ensure test points are provided for checking essential voltages and waveforms.

C. Electronic Components. Ensure all electronic components comply with TxDOT Special Specification 6006, "Electronic Components."

D. Mechanical Components. Ensure all external screws, nuts, and locking washers are stainless steel. Ensure no self-tapping screws are used unless specifically approved.

1. Ensure all parts are made of corrosion resistant material, such as plastic, stainless steel, anodized aluminum or brass.

2. Ensure all materials used in construction are protected from fungus growth and moisture deterioration.

3. Ensure dissimilar metals are separated by an inert dielectric material.

3.02 TESTING, TRAINING, DOCUMENTATION AND WARRANTY

A. Perform testing, training and provide documentation, warranty in accordance with Article 2, TxDOT Special Specification 6005, "Testing, Training, Documentation, Final Acceptance, and Warranty."

END OF SECTION

SECTION 16742

VIDEO DETECTION SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This specification sets forth the minimum requirements for a Video Imaging Vehicle Detection System (VIVDS) that monitors vehicles on a roadway via processing of video images and provides detector outputs to a traffic controller or similar device.

B. A video detection system for a single intersection shall consist of the following components: variable focal length color camera, VIVDS processor(s), and all associated equipment required to setup and operate in a field environment including one color video monitor, connectors, communication cable, and camera mounting hardware.

C. The system software shall be able to detect either approaching or departing vehicles in multiple traffic lanes. A minimum of 4 detector outputs per video processor module card and each output shall have a minimum of 48 detection zones. Each zone and output shall be user definable through interactive graphics by placing lines and/or boxes in an image on a video monitor. The user shall be able to redefine previously defined detection zones.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement. This item shall be measured by each intersection including four (4) color cameras, mounted including fittings, conductors, brackets, appurtenances, video processor(s), cables, cabinet & communication interfaces, programming, communications software, and other associated equipment required for installation.

2. Payment. This item shall be paid by each installation at an intersection.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. MIL-C-26482 – Military Specification: Connectors, Electrical, (Circular, Miniature, Quick Disconnect, Environment Resisting), Receptacles and Plugs

B. NEMA TS1 - Traffic Control Standards

C. NEMA TS2 – Traffic Controller Assemblies with NTCIP Requirements

D. NEMA TS4 – Hardware Standards for Dynamic Message Signs (DMS) with NTCIP Requirements

E. NFPA 70 – National Electric Code

1.05 WARRANTY

A. All material, workmanship and labor furnished shall be covered by Supplier(s)/Manufacturer(s) guarantee and/or warranty for a minimum period of twenty-four (24) months. Warranty period shall begin the day the video detection system is activated by the City of Houston, either as new order or warranty repair. The City of Houston's preference is for all non-warranty service to be charged a singular flat rate.

B. Successful bidder shall bear all expenses connected with return of any material, which the City deems necessary to return for adjustments during warranty period.

C. Successful bidder shall bear all labor cost associated with warranty items and maintenance in a timely manner; the quality of timely service is determined by the City's Traffic Engineer and shall not exceed twenty-four (24) hours from the Time of Notification (TON) to initial field response by the successful bidder or their representative. In essence, the successful bidder shall provide maintenance and field service (i.e. trouble calls) during the warranty period.

D. Supplier(s)/Manufacturer(s) shall make all engineering data, diagrams, software changes or improvements, which increases performance of equipment purchased under this bid, available to the City of Houston at no additional cost.

E. Supplier(s)/Manufacturer(s) shall have field engineers or technicians available on request to assure satisfactory initial operation, and to consult with City's Traffic Engineer, or City’s Traffic Engineer representative, on any special circuitry that may be required in certain applications.

PART 2 PRODUCTS

2.01 MATERIALS

A. VIVDS PROCESSOR AND RACK-MOUNTED INTERFACE UNIT

1. The VIVDS processor is an electronic unit that converts the video image provided by the cameras, generates vehicle detection for defined zones and collects vehicular data as specified.

2. The VIVDS processor may be housed in either the cabinet or camera housing. While not required, the City of Houston prefers that the VIVDS processor unit to fit inside each camera housing. The processor can fit directly into NEMA TS1 and TS2 type racks as well as Type 170/2070 input files. The video output from the unit shall be in color with active detection zones overlaid on full motion video.

3. The VIVDS processor unit shall be designed to operate reliably in the adverse environment found in the typical roadside traffic cabinet. It shall meet the environmental requirements set forth by the latest NEMA (National Electrical Manufacturers Association) TS1 and TS2 standards as well as the environmental requirements for Type 170, Type 179 and 2070 controllers. Operating temperature shall be from -25°F to +160°F at 0% to 95% relative humidity, non-condensing.

4. The VIVDS shall have a modular electrical design. The VIVDS shall be powered by 89- 135 VAC, 60 Hz single-phase. Power to the VIVDS shall be from the transient protected side of the AC power distribution system in the traffic control cabinet in which the VIVDS is installed. If the VIVDS processor is located in the controller cabinet, then, the system shall be powered by 12-24 VDC and draw less than 2 amperes.

5. The field communications wiring between each camera and the traffic controller cabinet shall be either 18 AWG, 6 twisted-wire-pair with an overall shield or coaxial cable. While not required, the City prefers the twisted-wire-pair.

6. The VIVDS Processor System (VPS) at each intersection shall be able to be networked using a 2-TWP interconnect back to the Master Cabinet for future communication to, Houston TranStar, the traffic management center.

7. Serial communications to the field setup computer shall be through an RS-232 serial port. This port shall be able to download the real-time detection information needed to show detector actuations. A connector on the front of the VIVDS processor unit shall be used for serial communications.

8. The VIVDS processor unit software and/or the supervisor software shall include diagnostic software to allow testing the VIVDS functions. This shall include the capability to set and clear individual detector outputs and display the status of inputs to enable setup and troubleshooting in the field.

B. VIDEO DETECTION CAMERA

1. The video detection system shall use medium resolution, color image sensors as the video source for real-time vehicle detection. The cameras shall be approved for use with the VIVDS processor unit by the supplier of the VIVDS. As a minimum, each camera shall provide the following capabilities:

a. Images shall be produced with a Charge Coupled Device (CCD) sensing element with horizontal resolution of at least 380 lines and vertical resolution of at least 350 lines. Images shall be output as a video signal conforming to RS 170A or CCIR.

b. Useable video and resolvable features in the video image shall be produced when those features have luminance levels as low as 0.1 lux at night.

c. Useable video and resolvable features in the video image shall be produced when those features have luminance levels as high as 10,000 lux during the day.

2. The camera and lens assembly shall be housed in an environmental enclosure that provides the following capabilities:

a. The enclosure shall be waterproof and dust-tight to the latest NEMA-4 specifications.

b. The enclosure shall allow the camera to operate satisfactorily over an ambient temperature range from -25°F to +160°F while exposed to precipitation as well as direct sunlight.

c. The enclosure shall allow the camera horizon to be rotated in the field during installation.

d. The enclosure shall include a provision at the rear of the enclosure for connection of power and video signal cables fabricated at the factory. The input power to the environmental enclosure shall be nominally 120 or 240 VAC 50/60 Hz and the power consumption shall be 35 watts or less under all conditions.

e. A thermostatically controlled heater shall be at the front of the enclosure to prevent the formation of ice and condensation, as well as to assure proper operation of the lens's iris mechanism. The heater shall not interfere with the operation of the camera electronics, and it shall not cause interference with the video signal.

f. The enclosure shall be light-colored or unfinished and shall include a sun shield to minimize solar heating. The front edge of the sunshield shall protrude beyond the front edge of the environmental enclosure and shall include provision to divert water flow to the sides of the sunshield. The amount of overhang of the sun shield shall be adjustable to block the view of the horizon to prevent direct sunlight from entering the lens. Any plastics used in the enclosure shall include ultra violet inhibitors.

g. The total weight of the image sensor in the environmental enclosure with sunshield shall be less than 20 lbs.

h. When operating in the environmental enclosure with power and video signal cables connected, the image sensor shall meet FCC class B requirements for electromagnetic interference emissions.

3. The video output of the cameras shall be isolated from earth ground. All video connections for the cameras to the video interface panel shall also be isolated from earth ground. Connections for both video and power shall be made to the image sensor using waterproof, quick disconnect connectors.

4. Camera mounting hardware shall allow for vertical or horizontal mounting to the camera enclosure.

5. Each camera enclosure shall be equipped with a water-proof connector mounted to the rear bulkhead of the camera enclosure. The connector on the rear of the camera enclosure and the mating connector on the end of the cable shall conform to the MIL-C-26482 Series 1 standard. To guarantee that the cable connector and backshell form a waterproof connection, each backshell shall be filled with an epoxy-potting compound. After the potting compound has set up, the backshell shall be covered with a shrink tubing boot that extends down about 2 inches onto the outer jacket of the cable and filled with epoxy potting compound, also. After the potting compound has set up, the shrink boot shall be heated to form a 100% waterproof connection between the cable connector and the cable.

2.02 FUNCTIONAL CAPABILITIES

A. VIVDS Processor Unit

1. The VIVDS shall provide real-time vehicle detection (within 112 milliseconds (ms) of vehicle arrival). The VIVDS processor unit shall be capable of simultaneously processing information from various video sources, including CCTV video image sensors and video tape players. The video sources may be, but are not required to be, synchronized or line- locked. The video shall be processed at a rate of 30 times per second by the VIVDS processor unit.

2. The system shall be capable of providing twenty-four (24) or more detector outputs from up to eight (8) camera/video processor units. The VIVDS processor system should provide compressed color video through the DB-9 RS-232 data stream with active detection zones overlaid.

3. Detection zones shall be provided that are sensitive to the direction of vehicle travel. The direction to be detected by each detection zone shall be user programmable. The VIVDS processor unit shall compensate for minor camera movement (up to 2% of the field of view at 400 ft.) without falsely detecting vehicles. The camera movement shall be measured on the unprocessed video input to the VIVDS processor unit. The camera shall operate while directly connected to VIVDS Processor Unit. Once the detector configuration has been downloaded or saved into the VIVDS processor unit, the video detection system shall operate with the monitoring equipment (monitor and/or laptop) disconnected or on-line.

4. The camera/processor unit shall be provided with count, presence, directional presence, speed, stopped vehicles, and queue types of detection zones. An adjustable cycle timer shall be available for dealing with stopped vehicles. The Windows software shall be able to display the traffic parameters on the screen of an SVGA monitor on a per vehicle basis for each detection station by lane. It shall also be possible to view and sort the stored data for selected time intervals. When the monitoring equipment is directly connected to the VIVDS processor unit, it shall be possible to view vehicle detections in real-time as they occur on the field setup computer's color VGA display or the video monitor.

B. Vehicle Detection

1. The video detection system shall provide flexible detection zone placement anywhere within the combined field of view of the image sensors. Preferred presence detector configurations shall be lines or boxes placed across lanes of traffic or lines placed in-line with lanes of traffic. A single detector shall be able to replace one or more conventional detector loops. Detection zones shall be able to be fully overlapped. In addition, detection zones shall have the capability of implementing "AND" and "OR" logical functions including presence, extension and delay timing. These logical functions may be excluded if provisions are made to bring each detector separately into the controller and the controller can provide these functions.

2. Placement of detection zones shall be by means of a graphical interface using the video image of the roadway. The monitor shall show images of the detection zones superimposed on the video image of traffic while the VIVDS processor is running.

3. The detection zones shall be created by using the mouse or keypad to draw detection zones on the monitor. The detection zones shall be capable of being sized, shaped and overlapped to provide optimal road coverage and detection. It shall be possible to save the detector configurations on disk to download detector configurations to the VIVDS processor unit and to retrieve the detector configuration that is currently running in the VIVDS processor unit.

4. The mouse or keypad shall be used to edit previously defined detector configurations so as to fine-tune the detection zone placement size and shape. Once a detection configuration has been created, the system shall provide a graphic display of the new configuration on its monitor. While this fine-tuning is being done, the detection shall continue to operate from the detector configuration that is currently called for.

5. When a vehicle occupies a detection zone, the detection zone on the live video shall indicate the presence of a vehicle, thereby verifying proper operation of the detection system. With the absence of video, the card shall have an LED that will indicate proper operation of the detection zones.

6. Detection zones shall be provided that is sensitive to the direction of vehicle travel. The direction to be detected by each detection zone shall be user programmable.

7. The video detection system shall reliably detect vehicle presence in the design field of view. The design field of view shall be defined as the sensor view when the image sensor is mounted 24 ft. or higher above the roadway, when the camera is adjacent (within 15 ft.) to the edge of the nearest vehicle travel lane, and when the length of the detection area is not greater than 10 times the mounting height of the image sensor. Within this design field of view, the VIVDS processor unit shall be capable of setting up a single detection zone for point detection (equivalent to the operation of a 6 ft. by 6 ft. inductive loop). A single camera, placed at the proper mounting height with the proper lens, shall be able to monitor up to and including 5 traffic lanes simultaneously.

8. Detection accuracy of the video detection system shall be comparable to properly operating inductive loops. Detection accuracy shall include the presence of any vehicle in the defined detection zone regardless of the lane, which the vehicle is occupying. Occlusion produced by vehicles in the same or adjacent lanes shall not be considered a failure of the VIVDS processor unit, but a limitation of the camera placement. Detection accuracy (a minimum of 95%) shall be enforced for the entire design field of view on a lane by lane and on a time period basis.

9. Equipment failure, either camera or VIVDS processor unit, shall result in constant vehicle detection on affected detection zones.

PART 3 EXECUTION

3.01 INSTALLATION

A. The cabling shall comply with the National Electric Code, as well as local electrical codes. Cameras may acquire power from the luminaire if necessary.

B. The video detection system shall be installed by supplier factory certified installers and as recommended by the supplier and documented in installation materials provided by the supplier. Proof of factory certification shall be provided.

3.02 FIELD QUALITY CONTROL

A. The supplier shall maintain an adequate inventory of parts to support maintenance and repair of the video detection system. These parts shall be available for delivery within 30 days of placement of an acceptable order at the supplier's then current pricing and terms of sale for said parts.

B. The supplier shall maintain an ongoing program of technical support for the video detection system. This technical support shall be available via telephone, or via personnel sent to the installation site upon placement of an acceptable order at the supplier's then current pricing and terms of sale for on site technical support services.

C. A factory-authorized representative shall provide installation or training support.

D. All product documentation shall be written in the English language.

E. The supplier of the video detection system shall supervise the installation and testing of the system. A factory certified representative from the supplier shall be on-site during installation. Up to 2 days of training shall be provided to personnel of the City of Houston in the operation, setup and maintenance of the video detection system. Instruction and materials shall be provided for a maximum of 20 persons and shall be conducted at a location selected by the City.

END OF SECTION

SECTION 16746

VIDEO MANAGEMENT SOFTWARE

PART 1 GENERAL

1.01 DESCRIPTION

A. Furnish and install video management software that provides display, selection, and control functions for a camera system and video encoders/decoders as shown on the plans and as detailed in the specifications.

1.02 RELATED SECTION

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly, but will be considered subsidiary to bid items of the Contract.

B. Refer to Section 01270 – Measurement and Payment for unit price procedures

1.04 REFERENCES

A. TxDOT Special Specification 6005 - Testing, Training, Documentation, Final Acceptance and Warranty

1.05 SUBMITTALS

A. Client Manual. Provide a client manual that clearly outlines the steps necessary to operate the software. Include in the Client Manual screen captures taken directly from the software to illustrate the instructions. Include in the Client Manual a table of contents and an index.

B. Server Manual. If a server is utilized, provide a Server Manual that clearly outlines the steps necessary to configure the software. Include in the Server Manual screen captures taken directly from the software to illustrate the instructions. Include in the Server Manual a table of contents and an index.

C. Driver Application Notes. Provide each device driver with Driver Application Notes that document configuration and operation of the driver and its devices. Provide Driver Application Notes that clearly outline the steps necessary to configure the software. Include in the Driver Application Notes screen captures taken directly from the software to illustrate the instructions. Include in the Driver Application Notes a table of contents.

PART 2 PRODUCTS

2.01 MATETRIALS

A. General Requirements. Furnish and install only new, materials under this Item in strict accordance with the details shown on the plans and in the specifications.

1. Provide software that is a graphical user interface based program designed for CCTV camera system integration, control, and automation. If a server is required, provide the server version of this software along with a Microsoft Windows Server. Install the client version of this software on the operator workstation as shown on the plans.

2. Design the software system for ease of future expansion by providing the capability to support a minimum of 100 CCTV cameras, including associated video encoders and a minimum of 16 decoders. Provide software with the capability of recognize and support the different data protocols of future video input and transmission, of multiple manufacturers.

B. Functional Requirements. Design the Video Management software system so as to provide the following:

1. Operating System. Provide software that operates on Windows 2003 Server and Windows XP Professional.

2. Architecture.

a. Components. Provide software comprised of the following components: server application (if required), client application, and device driver applications (including camera PTZ and encoder/decoder control).

(1) Ensure the various software components are able to be started in any order.

(2) Provide software that allows clients, servers, and device drivers to be added at any time during or after initial configuration.

(3) Provide software that allows equipment from different manufacturers to be combined.

(4) Ensure that the unexpected or unplanned termination of a component does not cause any other component to fail.

(5) Client application shall run on existing TranStar HP z600 workstations. It shall utilize external video decoder for all video display, and shall not utilize software video decoding.

(6) If servers are required, they shall be provided under this item and shall conform to TranStar specifications. TranStar servers are HP DL380 G5 or 6, with Win 2003 Enterprise, or Standard OS.

b. Support Applications - Furnish a configuration interface that provides the ability to add, remove, and modify devices controlled by any configured device driver. Ensure the software provides a configurable arbitration system that eliminates CCTV resource conflicts and allows users to take exclusive control of specific devices.

(1) Furnish software that provides user-definable on-screen labels for each device.

(2) Furnish a client application that provides multi-monitor support.

c. Common Interface. Ensure the same interface is used to control equipment from different manufacturers. Ensure the same interface is also used to retrieve archived video from different devices, no matter what type of device the video was recorded on.

(1) Ensure a particular custom window is capable of displaying IP and analog video, and ensure the client interface is capable of displaying IP and analog video simultaneously in different custom windows.

(2) Ensure support of IP video encoders/decoders supported by Houston TranStar.

(3) Ensure support of PTZ protocols supported by Houston TranStar.

d. Device Driver Applications. Provide device drivers capable of communicating with any device via direct serial, IP, or modem pool. Provide multiple device drivers that are able to share all or a portion of a modem pool.

(1) Ensure each device driver is unique to the type of equipment it controls.

(2) Allow the addition of a new device driver with no require modification to the client or server application.

(3) Provide device drivers that can run anywhere on the network, not necessarily located where the server is installed.

(4) Provide device drivers that have the capability of running as a Windows Service or as an executable.

e. CCTV Equipment. Provide device drivers for proposed cameras, encoders and decoders, to be installed as part of this project.

(1) Make camera advanced functions such as on-screen displays, patterns, and presets available through the driver interface.

f. Encoders/Decoders. Provide device drivers for proposed video encoders and decoders.

2.02 DOCUMENTATION, TRAINING, TESTING AND WARRANTY

A. Provide documentation, testing, training and warranty in accordance with the TxDOT Special Specification 6005, “Testing, Training, Documentation, Final Acceptance and Warranty.”

PART 3 EXECUTION – NOT USED

END OF SECTION

SECTION 16747

PERMANENT COUNT STATION
Radar Vehicle Sensing Device (RVSD)

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Description: Furnish and install overhead radar vehicle sensing device (RVSD) system as shown in the plans, as detailed in the special specifications and as directed.

B. Ensure after the setup, there are no external tuning controls of any kind, which will require an operator.

C. All equipment provided shall be compatible with existing City of Houston infrastructure.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement. This Item will be measured as each unit complete in place.

2. Payment. The work performed and material furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Radar Vehicle Sensing Device." This price is full compensation for furnishing all equipment described under this Item with all cables, connectors, mounting assemblies, interface devices; all documentation and testing; all labor, materials, tools training, warranty, equipment, and incidentals.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures

1.04 REFERENCES

A. Federal Communications Commission (FCC), CFR 47, Part 15, section 15.245

B. Federal Communications Commission (FCC), CFR 47, Part 15, section 15.249

C. MIL-C-26482 – Military Specification – Connectors, Electrical, (Circular, Miniature, Quick Disconnect, Environment Resisting), Receptacles and Plugs

D. NEMA 250 – Enclosures for Electrical Equipment (1,000 Volts Maximum)

E. NEMA TS2 – Traffic Controller Assemblies with NTCIP Requirements

F. NFPA 70 – National Electric Code

G. TxDOT Special Specification 6005 - Testing, Training, Documentation, Final Acceptance and Warranty

H. TxDOT Special Specification 6006 - Electronic Components

1.05 SUBMITTALS

A. Provide necessary documentation of contractor or subcontractor qualifications pursuant to contract award.

B. Documentation Requirements. Provide documentation in accordance with TxDOT Special Specification 6005, "Testing, Training, Documentation, Final Acceptance, and Warranty".

1. Provide documentation ensuring emissions from the RVSD equipment are not harmful to the public.

2. Provide additional test reports, for each of the following requirements:

a. NEMA 4X Testing. The RVSD enclosure must conform to test criteria set forth in the NEMA 250 Standard for Type 4X enclosures. Provide third party enclosure test results for each of the following specific Type 4X criteria:

(1) External Icing (NEMA 250 Clause 5.6)

(2) Hose-down (NEMA 250 Clause 5.7)

(3) 4X Corrosion Protection (NEMA 250 Clause 5.10)

(4) Gasket (NEMA 250 Clause 5.14)

b. NEMA TS2-1998 Testing. The RVSD must comply with the applicable standards stated in the NEMA TS2-1998 Standard. Provide third party test results for each of the following specific tests:

(1) Shock pulses of 10g, 11 ms half sine wave

(2) Vibration of .5 Grms up to 30 Hz

(3) 300 V positive/negative pulses applied at 1 pulse per second at minimum and maximum DC supply voltage

(4) Cold temperature storage at -49°F for 24 hours

(5) High temperature storage at +185°F for 24 hours

(6) Low temp, low DC supply voltage at -30°F and 10.8 VDC

(7) Low temp, high DC supply voltage at -30°F and 26.5 VDC

(8) High temp, high DC supply voltage at 165°F and 26.5 VDC

(9) High temp, low DC supply voltage at 165°F and 10.8 VDC

1.06 QUALITY ASSURANCE

A. Experience Requirements. The contractor or subcontractor involved in the installation and testing of the RVSD must, as a minimum, meet the following experience requirements:

1. Two years continuous existence offering services in the installation of RVSD systems.

2. Two installed RVSDs where systems have been in continuously satisfactory operation for at least 1 year. Submit as proof, photographs or other supporting documents, and the names, addresses and telephone numbers of the operating personnel of the business or agency owning the system who can be contacted by the City of Houston regarding the system.

1.07 WARRANTY

A. Provide a warranty in accordance with TxDOT Special Specification 6005, “Testing, Training, Documentation, Final Acceptance and Warranty.”

1.08 MAINTENANCE

A. Performance Maintenance. Provide RVSD that does not require cleaning or adjustment to maintain performance. Ensure it does not rely on battery backup to store configuration information. Ensure the RVSD, once calibrated, does not need recalibration to maintain performance over entire operational temperature range unless the roadway configuration changes. Provide remote connectivity to the RVSD to allow operators to change the unit’s configuration, update the unit’s firmware programming and recalibrate the unit automatically from a centralized facility.

PART 2 PRODUCTS

2.01 MATERIAL

A. Ensure the RVSD will automatically configure the maximum number of lanes shown on the plans by determining lane boundaries, concrete or metal barriers and detection thresholds. Ensure sensor will automatically configure the number of lanes in the presence of barriers, medians and work zones. Ensure sensor will automatically calibrate vehicle speed, detection levels, sensitivity, and vehicle direction. Ensure the RVSD detects vehicle volume, speed occupancy, and direction in all weather conditions without performance degradation. Ensure the RVSD is remote accessible; provides multiple connectivity options for integration into the existing system, and supports the communications protocols identified in article 2.01.K “Communication”.

B. Provide the RVSD that automatically tunes out stationary objects, such as traffic barriers and retaining walls, prior to completing the configuration. Provide documentation on the auto- configuration and auto-calibration processes.

C. Provide an RVSD that does not cause interference or alter the performance of any known equipment.

D. Furnish all new equipment and component parts in an operable condition at the time of delivery and installation.

E. Provide design to prevent reversed assembly or improper installation of connectors, fasteners, etc. Design each item of equipment to protect personnel from exposure to high voltage during equipment operation, adjustments, and maintenance.

F. Include licenses for all equipment, where required, for any software or hardware in the RVSD system.

G. Provide all RVSD from the same manufacturer.

H. Provide RVSD firmware that is upgradeable by external local or remote download.

I. Sensor Performance. Ensure the RVSD provides accurate, real-time volume, average speed, occupancy, and vehicle direction data. Ensure the RVSD provides user configurable settings for a collection interval from 20 sec. to 15 min. and polling intervals from 20 sec. to 1 hr. Ensure the detections are correctly categorized into a minimum of 8 user definable length-based classifications. Ensure vehicle detections occur at a range of 9 ft. to 250 ft. simultaneously from the RVSD. Ensure the RVSD unit or accompanying field equipment provides a minimum of 3 hours of local storage for detection interval settings of 20 seconds to 15 minutes in local storage to reduce data loss during communications outages.

    1. Ensure the RVSD operates in side-fire mode. When operating in side-fire mode, a single RVSD must simultaneously detect traffic in the maximum number of lanes as shown on the plans.

2. Ensure the RVSD maintains accurate performance in all weather conditions, including rain, freezing rain, snow, wind, dust, fog and changes in temperature and light. Ensure RVSD operation continues in rain or snow up to 4 in. per hour, and the device will not experience degraded performance when encased in 1/2 in. of ice.

3. Ensure volume data is accurate within 5% of actual for any direction of travel in nominal conditions. Ensure individual lane accuracy is within 10% of actual during nominal conditions. Nominal conditions exist when traffic is flowing at speeds greater than 10 miles per hour, with less than 10% truck traffic per lane and at least 30% of each vehicle visible above roadway barriers for true sensor detection.

4. Ensure per vehicle speed data is accurate within 5 MPH for 90% of measurements. Provide true speed detection via dual radar speed trap without the requirement to enter average vehicle lengths for the speed calculation.

5. Ensure occupancy data is accurate within 20% of the actual occupancy for any lane when occupancy is less than 30%. For example, if the actual occupancy in a lane is 20%, the measured occupancy must be between 16% and 24%.

6. Ensure classification data is accurately determined for 90% of detected vehicles.

7. Ensure the RVSD automatically configures vehicle direction and that vehicle direction is accurately determined for 90% of wrong-way vehicles. This data shall be available simultaneously and in addition to other data as called for in this specification.

8. Provide test data, using methods required in article 3.03.A., demonstrating or proving performance.

J. Cabling. Supply the RVSD with a connector cable of the appropriate length for each installation site.

1. Ensure the connector meets the MIL-C-26482 specification. Provide an environmentally sealed shell backshell that offers excellent immersion capability, and is designed to interface with the appropriate MIL-C-26482 connector. Encase all conductors that interface with the connector in a single jacket and ensure the outer diameter of this jacket is within the backshell's cable O.D. range to ensure proper sealing. Ensure the backshell has a clampbar style strain relief with enough strength to support the cable slack under extreme weather conditions. Provide the MIL-C-26482 connectors that provide contacts for all data and power connection.

2. If communication is conducted over the RS-485 or RS-232 bus, the communication cable must be Belden 9331, or an equivalent cable with the following specifications:

a. Shielded, twisted pairs with a drain wire

b. Nominal Capacitance Conductor to Conductor @ 1Khz <= 26pF/Ft

c. Nominal Conductor DC Resistance @ 68°F <= 15 ohms/1000Ft

d. Single continuous run with no splices allowed

e. Terminated only on the two farthest ends of the cable

K. Communication. Ensure that the RVSD provides communication options that include RS- 232, RS-485 or TCP/IP. Provide a RVSD which has the ability to support a variety of baud rates from 9600 to 115200.

1. Ensure the RVSD provides built in RS-232, RS-485 and an internal serial communication port. Each communication port must support all of the following baud rates: 9600, 19200, 38400, 57600 and 115200. Additionally, the RS-232 port must be full-duplex and must support true RTS/CTS hardware handshaking for interfacing to various communication devices.

2. Data Packets. The RVSD must produce interval data packets containing, as a minimum:

a. One or more detection zones

b. Collection interval durations

c. Sensor ID

d. 32-bit time stamps indicating end of collection interval

e. Total volume by detection zone

f. Average speed in each detection zone during the collection interval. Speed value units must be selectable as either miles per hour or kilometers per hour

g. Occupancy in each detection zone during the collection interval, reported in 0.1% increments

h. A minimum of 8 vehicle classifications reported as number of vehicles of each classification identified in each detection zone during the collection interval

i. Volume in up to 15 user-defined speed bins

j. Volume for both directions of traffic

k. Average headway in seconds

l. Average gap in seconds

m. 85th percentile speed in either miles per hour or kilometers per hour

n. Vehicle count for correct and wrong-way vehicles in separate correct and wrong-way bins

3. Data Packets. The RVSD must produce event (per vehicle) data packets containing, as a minimum:

a. Sensor ID

b. Lane Assignment

c. Per vehicle speed value in either miles per hour or kilometers per hour. Wrong-way vehicles shall show a negative speed value

d. Vehicle length

e. Classification using up to 8 user defined classes

f. 32-bit time stamps indicating end of collection interval

g. Range

L. Operating System Software. Provide the RVSD to also include graphical user interface software that displays all configured lanes and provides visual representation of all detected vehicles. The graphical interface must operate on current City of Houston core operating system software. The software must automatically select the correct baud rate and serial communication port from up to 15 serial communication ports. The software must also operate over a TCP/IP connection and support a dial-up modem connection.

1. The software must give the operator complete control over the configuration process.

2. The operator must have the ability to save the configuration information to a file or reload the RVSD configuration from a file using the graphical user interface software.

3. Using the installation software, the operator must be able to:

a. change the baud rate on the sensor by selecting baud rates from a drop-down list

b. add response delays for the communication ports to allow for communication stabilization.

c. switch between data pushing and data polling, and

d. change the RVSD's settings for Flow Control from none to RTS/CTS and vice versa.

4. The operator must be able to upload new firmware into non-volatile memory of the RVSD over any supported communication channel including TCP/IP networks.

M. Software. Provide any and all programming and software required to support the RVSD system. Install the programming and software in the appropriate equipment at the time of acceptance testing. Complete and pass acceptance testing using a stable release of the programming and software provided.

1. Provide software update(s) free of charge during the warranty period.

N. Manufacturing Requirements. Ensure the assembly of the units adheres to industrial electronic assembly practices for handling and placement of components.

1. The RVSD must undergo a rigorous sequence of operational testing to ensure product functionality and reliability. Include the following tests:

a. Functionality testing of all internal subassemblies

b. Unit level burn-in testing of 24 hours duration or greater

c. Final unit functionality testing prior to shipment

2. Provide test results and all associated data for the above testing, for each purchased RVSD by serial number. Additionally, maintain and make available manufacturing data for each purchased RVSD by serial number.

3. Externally, the RVSD must be modular in design to facilitate easy replacement in the field. Ensure the total weight of the RVSD does not exceed 5 lbs.

4. Ensure all external parts are protected against corrosion, fungus growth and moisture deterioration.

O. FCC. Ensure the RVSD has Federal Communications Commission (FCC) certification. Display the FCC-ID number on an external label. Ensure each RVSD is Federal Communications Commission (FCC) certified under CFR 47, Part 15, section 15.245 or15.249 as a field disturbance sensor. Display this certification on an external label on each device according to the rules set out by the FCC.

1. Provide the RVSD system that is FCC certified under Part 15, Subpart C, Section 15.245 or 15.249 for low-power, unlicensed, continuous radio transmitter operation. Assure that the RVSD system will not cause harmful interference to radio communication in the area of installation. If the operation of the RVSD system causes harmful interference, correct the interference at the Contractor's expense.

2. Provide the RVSD that transmits in the 10.50 – 10.55 GHz or 24.00 – 24.25 GHZ frequency band and meets the power transmission and frequency requirements specified under sections15.245 and 15.249 of CFR 47 across the operating temperature of the device and over time as the sensor ages.

3. Provide documentation proving compliance to all FCC specifications.

P. Power Requirements. Provide the RVSD that operates either at 12 VDC to 28 VDC or at 12 VAC to 24 VAC from a separate power supply to be provided as part of the bid item and ensure it does not draw more than 10 watts of power each.

1. Provide the separate power supply or transformer that operates from 115 VAC ±10%, 60 Hz ±3 Hz.

2. Provide equipment operations that are not affected by the transient voltages, surges and sags normally experienced on commercial power lines. Check the local power service to determine if any special design is needed for the equipment. The extra cost, if required, must be included in the bid of this item.

Q. Wiring. Provide wiring that meets the requirements of the National Electric Code. Provide wires that are cut to proper length before assembly. Provide cable slacks to facilitate removal and replacement of assemblies, panels, and modules. Do not double-back wire to take up slack. Lace wires neatly into cable with nylon lacing or plastic straps. Secure cables with clamps. Provide service loops at connections.

R. Transient Suppression. Provide DC relays, solenoids and holding coils that have diodes or other protective devices across the coils for transient suppression.

S. Power Service Protection. Provide equipment that contains readily accessible, manually re- settable or replaceable circuit protection devices (such as circuit breakers or fuses) for equipment and power source protection.

1. Provide and size circuit breakers or fuses such that no wire, component, connector, PC board or assembly must be subjected to sustained current in excess of their respective design limits upon the failure of any single circuit element or wiring.

T. Fail Safe Provision. Provide equipment that is designed such that the failures of the equipment will not cause the failure of any other unit of equipment. Ensure automatic recovery from power failure will be within 15 sec. after resumption of power.

U. Mechanical Requirements. Enclose the RVSD in a Lexan polycarbonate, ultraviolet resistant material. The unit must be classified as watertight according to the NEMA 250 Standard.

1. Provide the RVSD that will withstand a drop of up to 3 ft. without compromising its functional and structural integrity.

2. Do not use silicone gels or any other material for enclosure sealing that will deteriorate under prolonged exposure to ultraviolet rays. Ensure the overall dimensions of the box, including fittings, do not exceed 14 in. x 11 in. x 4 in. Ensure the overall weight of the box, including fittings, does not exceed 5 lbs.

3. Coat all printed circuit boards with a clear-coat moisture and fungus resistant material (conformal coating).

4. Ensure external connection for telecommunications and power be made by means of a single military style multi-pin connector, keyed to preclude improper connection.

   a. Modular Design. Provide equipment that is modular in design to allow major portions to be readily replaced in the field. Ensure modules of unlike functions are mechanically keyed to prevent insertion into the wrong socket or connector.

      (1) Identify modules and assemblies clearly with name, model number, serial number and any other pertinent information required to facilitate equipment maintenance.

   b. Connectors and Harnesses. Provide external connections made by means of connectors. Provide connectors that are keyed to preclude improper hookups. Color code and appropriately mark wires to and from the connectors.

      (1) Provide connecting harnesses of appropriate length and terminated with matching connectors for interconnection with the communications system equipment.

      (2) Provide pins and mating connectors that are plated to improve conductivity and resist corrosion. Cover connectors utilizing solder type connections by a piece of heat shrink tubing securely shrunk to insure that it protects the connection.

   c. Environmental Requirements. Provide RVSD capable of continuous operation over a temperature range of –35°F to +165°F and a humidity range of 5% to 95% (non- condensing).

PART 3 EXECUTION

3.01 GENERAL

A. Provide equipment designed and constructed with a minimum number of parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality.

1. Design the equipment for ease of maintenance. Provide component parts that are readily accessible for inspection and maintenance. Provide test points that are for checking essential voltages and waveforms.

3.02 INSTALLATION

A. Mounting and Installation. Install the RVSD according to manufacturer's recommendations to achieve the specified accuracy and reliability.

1. Verify, with manufacturer assistance, the final RVSD placement if the RVSD is to be mounted near large planar surfaces (sound barrier, building, parked vehicles, etc.) that run parallel to the monitored roadway.

2. Include, at a minimum, radar detector unit, enclosures, connectors, cables, junction box, mounting equipment and hardware, controller interface boards and assemblies, local and remote software, firmware, power supply units and all other support, calibration, and test equipment for the RVSD system.

3. Furnish the RVSD with bracket or band designed to mount directly to a pole or overhead mast-arm or other structure. Ensure the mounting assembly has all stainless steel, or aluminum construction, and supports the load of the RVSD. Incorporate for the mounting assembly a mechanism that can be tilted in both axes, then locked into place, to provide the optimum area of coverage. Ensure the mounting bracket is designed and installed to prevent sensor re-positioning during 80 mph wind conditions.

4. Proper placement, mounting height and orientation of the RVSD systems must conform to the manufacturer's published requirements for the system provided. Install the RVSD units as shown on the plans. Analyze each proposed pole location to assure that the RVSD installation will comply with the manufacturer's published installation instructions. Advise the Engineer, before any trenching or pole installation has taken place, of any need to move the pole from the location indicated in the plans in order to achieve the specified detector performance. Confirm equipment placement with the manufacturer before installing any equipment.

5. Ensure alignment, configuration and any calibration of the RVSD takes less than 15 minutes per lane once mounting hardware and other installation hardware are in place. Install RVSD units such that each unit operates independently and that detectors do not interfere with other RVSD units or other equipment in the vicinity.

B. Electronic Components. Provide electronic components in accordance with TxDOT Special Specification 6006, "Electronic Components".

C. Mechanical Components. Provide external screws, nuts and locking washers that are stainless steel. Provide parts made of corrosion resistant material, such as plastic, stainless steel, anodized aluminum or brass. Protect materials from fungus growth and moisture deterioration. Separate dissimilar metals by an inert dielectric material.

3.03 FIELD QUALITY CONTROL

A. Testing. Perform testing in accordance with TxDOT Special Specification 6005, "Testing, Training, Documentation, Final Acceptance, and Warranty." Test all RVSD to ensure that they comply with all FCC specifications.

1. Ensure the RVSD meets functional performance requirements of article 2.01.I (Sensor Performance) by the following methods:

2. Verify volume accuracy by performing a manual count on each lane of detection. When compared to the manual counts, the sensor counts must meet performance requirements as stated in article 2.01.I.

3. Verify speed accuracy with laser speed gun. Vehicle speeds should be collected and compared to the per vehicle speed measurement generated by the RVSD. When compared to the speeds collected via laser, the sensor speed data must meet performance requirements as stated in article 2.01.I.

4. Verify direction accuracy by ensuring that all lanes are configured with the correct directionality. Following this configuration, reverse the direction on one lane and verify that the number of vehicles detected in that lane are correctly placed in the wrong-way detection bin. When compared to the manual counts for this lane, the wrong-way sensor counts must meet the performance requirements as stated in article 2.01.I.

B. Support. Ensure installers and operators of the RVSD are fully trained in the installation, auto-configuration and use of the device.

1. The manufacturer must train installers and operators to correctly perform the tasks required to ensure accurate RVSD performance. The amount of training necessary for each project will be determined by the manufacturer (not less than 4 hours) and must be included, along with training costs, in the manufacturer's quote. In addition, provide technical support to provide ongoing operator assistance.

C. Technical Assistance. Ensure that a manufacturer's technical representative is available on site to assist the Contractor's technical personnel at each installation site and with RVSD equipment installation and communication system configuration.

1. Do not execute the initial powering up of the RVSD without the permission of the manufacturer's representative.

D. Training. Provide training in accordance with TxDOT Special Specification 6005, "Testing, Training, Documentation, Final Acceptance and Warranty."

END OF SECTION

SECTION 16748

SYSTEM INTEGRATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This Item governs the integration of all furnished equipment as shown on the plans, as detailed in the Specifications, and as directed by the Engineer. This work consists of furnishing, installing, testing, terminating, interconnecting and integrating existing and proposed 2070 Traffic Signal Controllers to a Fiber Optic Ethernet Network.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement. This Item will be measured as a lump sum unit.

2. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "System Integration". This price shall be full compensation for the preparation, furnishing, and installing all materials, equipment and incidentals.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. National Transportation Communications for Intelligent Transportation Systems (ITS) Protocol (NTCIP)

B. NFPA 70 - National Electrical Code

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 INSTALLATION

A. Install, interconnect, configure and test the equipment as required to achieve a complete and fully operational Traffic Signal Ethernet Interconnect system as shown on the plans, as detailed in the Specifications, as directed by the Engineer, and in accordance with the National Electrical Code (NEC) and NTCIP.

3.02 INTEGRATION

A. Provide an integrated system that encompasses: 1) installation and integration of new and existing Traffic Signal Controllers to the proposed Fiber Optic Ethernet network; installation, configuration and integration of all communications equipment such asbut not limited to: Ethernet switches, servers, and Fiber Optic Cable necessary for communicating with the new and existing Traffic Signal Controllers.

B. Install, test and make operational the proposed route (fiber) prior to switching operations from the existing interconnect system to the proposed Ethernet network.

C. Perform all necessary work to achieve a fully functional and operational system including all fiber optic routing, terminations, connections, splicing and assignments. Install and integrate all field and communications components. Provide items not specifically mentioned or addressed in this specification necessary for a complete and operational system as described herein. These will not be paid for directly but will be considered incidental to this Item.

END OF SECTION

SECTION 16750

ACCESSIBLE PEDESTRIAN PUSH BUTTON STATION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Accessible Pedestrian Push Button Station Assembly with control unit and mounting hardware. The assembly shall be the 2-Wire Navigator Push Button Station and 2-Wire Navigator Central Control Unit (CCU) as manufactured by Polara Engineering, Inc.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

B. Section 02582 - Traffic Pole Assemblies (Steel)

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. Payment for pedestrian push button station assemblies is on a unit price basis for each pedestrian push button assembly.

2. Payment for pedestrian push button station central control units is on a unit price basis for each central control unit.

3. The price shall be full compensation for furnishing, assembling, installing, made fully operational and testing the unit, as well as all mounting attachments, labor, tools, equipment, and incidentals necessary to complete the work.

4. Pedestrian push button station poles including foundation are paid separately according to Section 02582 - Traffic Pole Assemblies (Steel).

5. Refer to Section 01270 – Measurement and Payment for unit price procedure.

1.04 REFERENCES

A. ANSI/ASQ Z1.4 - Sampling Procedures and Tables for Inspection by Attributes

B. TxDOT - Texas Manual on Uniform Traffic Control Devices (TMUTCD)

1.05 WARRANTY

A. A minimum guarantee for both materials and workmanship shall be provided for the products bid as specified. The guarantee (warranty) period shall begin the day the City officially accepts the item. Any guarantee work is to be completed within 15 days after receipt of notice of material deficiencies.

B. All material, workmanship and labor furnished shall be covered by Supplier(s)/Manufacturer(s) guarantee and/or warranty for a minimum period of thirty-six (36) months. Warranty period shall begin the day the item is received by the City of Houston, either as new order or warranty repair. Bidder shall also be required to have resources to complete any required warranty work within fifteen (15) days after receipt of found defective item. The City of Houston's preference is for all non-warranty service to be charged a singular flat-rate. Successful bidder will include flat rate repair cost, if available in bid document for all non-warranty covered repairs. If flat rate repair charge is not available, then Supplier(s)/Manufacturer(s) will provide current hourly labor rate, along with any associated minimum charges that may apply.

C. Successful bidder shall bear all expenses connected with return of any material which the City deems necessary to return for adjustments during guarantee period. Said work shall be done by manufacturer's representative at no cost to the City.

D. The City of Houston may perform random sample testing on all shipments. Random sample testing will be completed within 45 days after delivery. The number of modules tested shall be determined by the quantity of each shipment. The Traffic Operations Division shall determine the sampling parameters to be used for the random testing. Acceptance or rejection of the shipment shall conform to ANSI/ASQ Z1.4 for random sampled shipments.

E. The City of Houston reserves the right to withhold payments which may be due, should it be discovered that material does not meet specifications and/or claims of bidder.

F. Supplier(s)/Manufacturer(s) shall make all engineering data, diagrams, software changes or improvements, which increases performance of equipment purchased under this bid, available to the City of Houston at no additional cost during guarantee period.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide new materials that comply with the details shown on the plans and the requirements of this specification.

2.02 ACCESSIBLE PEDESTRIAN PUSH BUTTON STATION

A. The assembly and manufacturing process for all internal electronic components shall be adequately supported to withstand mechanical shock and vibration from high winds and other sources.

B. Weather-proof speaker protected by vandal proof screen.

C. Central Control Unit (CCU) for the pushbutton detector unit that resides in the Traffic Signal Controller Cabinet capable of controlling a minimum of 12 units using no more than one pair of wires for each phase. The CCU must be capable of controlling up to 4 phases and all inputs and outputs shall have Transient Voltage Protection.

1. Pedestrian Walk / Don't Walk inputs: optically isolated 80-150 Volts AC/DC 5 mA maximum.

2. General purpose outputs and pedestrian outputs: optically isolated 36 Volts AC/DC peak 0.3A solid state fused contact closure.

3. Fault Output: normally open and closed relay contacts 125 Volts AC/DC 1A maximum.

4. A, B, C, D PBS power outputs: nominal 22 Volts DC, short circuit protected – auto recovering.

5. General Purpose Inputs: 10-36 Volts AC/DC peak 10 mA maximum, optically isolated.

6. Environmental: operating and storage -30˚F (-34˚C) to 165˚F (74˚C) 0-100% humidity non-condensing.

D. Each unit will contain a vibrating tactile arrow to provide a tactile representation of the status of the WALK indication. The arrow shall contrast with the background.

E. Confirmation of button push via latching LED, sound, and vibrotactile bounce.

F. Vibrating tactile arrow shall be able to be adjusted for directional indication.

G. Pedestrian push buttons shall be at least 2 inches in diameter or width, contrast visually with the housing, and require 5 lbf (pound force) maximum force.

H. The pushbutton assembly shall be die-cast aluminum, powder coated from aluminum alloy 319 or equivalent.

I. The unit shall be fabricated free of voids, pits, dents, molding sand and excessive foundry grinding marks. All design radii shall be smooth and intact. Exterior surface finish shall be smooth and cosmetically acceptable by being free of molding fins, cracks and other exterior blemishes.

J. Assembly color shall be yellow.

K. Mounting bolts shall be brass or stainless steel.

L. Push button unit shall have an actuation indication which will activate upon depression of the push button. If actuation indication is a light then it shall remain on until the next walk cycle.

M. All push button assemblies shall be mounted to the poles by drilling and tapping. Stainless Steel ¼ - 20 bolts shall be used to mount the push button assemblies to poles. Self-tapping screws shall not be used. Stainless steel strapping shall not be allowed.

N. Attached crossing signs shall be 9" x 15" R10-3e, as per the Texas Manual on Uniform Traffic Control Devices (TMUTCD).

O. The back panel portion of the push button assembly shall be designed to accommodate pole diameters from 4" to 14".

2.03 AUDIBLE INDICATIONS

A. A push button locator tone shall sound at each push button.

B. Locator tones should be audible 6 to 12 feet from the push button or to the building line, whichever is less.

C. Locator tones shall have a duration of 0.15 seconds or less, and shall repeat at 1-second intervals.

D. Automatic volume adjustments in response to ambient traffic sound level shall be provided up to a maximum of 89 dB. Locator tone and verbal messages shall be no more than 5 dB louder than ambient sound.

E. All sounds must automatically adjust to ambient noise levels over a 60 dB range.

F. Standard locating tone during Don’t Walk (and clearance if desired) and cuckoo, chirp, or standard voice message during walk.

G. Standard locating tone, custom sound, or verbal countdown during PED clearance.

H. Most sounds can have minimum and maximum volume independently set.

I. Extended button push can turn on, boost, volumes, and/or mute all sounds except those on activated crosswalk.

J. The tone or voice volume, measured at 36 inches from the APS, should be 2dB minimum and 5 dB maximum above the ambient noise.

K. Cuckoo - 1250 Hz and 1000 Hz.

L. Chirp - 2700 Hz and 1700 Hz.

M. Substituting Cuckoo and Chirp sounds with "walk" and "don't walk" audible sounds is optional.

N. Push button locator tone different from cuckoo or chirp.

O. Extended button press which can be used to request a louder WALK signal and locator tone for subsequent clearance interval.

P. System shall allow for independent volume control for locate tones, clearance, and walk tones.

Q. All sounds shall be synchronized to reduce sound clutter.

R. Custom message and sound options definable by customer include:

1. Custom locating tone

2. Informational Message

3. Custom walk sounds/message

4. Custom clearance sound

5. Multiple languages (up to three, selectable by user)

6. Street name in Braille on the sign

2.04 ENVIRONMENTAL REQUIREMENTS

A. The Accessible Pedestrian Push Button Station Assembly (pole unit and central control unit) shall be rated for use in the ambient operating temperature range of -40°C to +65°C (-40°F to +150°F).

B. Push button shall be rated for minimum of 20 million operations with >2 lb. actuation force.

2.05 ELECTRICAL REQUIREMENTS

A. The Accessible Pedestrian Push Button Station Assembly shall operate over a voltage range of 95 to 130 VAC, 60 Hz. E. TRANSIENT

2.06 VOLTAGE PROTECTION

A. The on-board circuitry of a module shall include voltage surge protection, to withstand high-repetition noise transients and low-repetition high-energy transients.

2.07 INPUT PROTECTION

A. At the point of entry to the module for each input, provide two 0.5-Ohm, 10-watt wire-wound power resistors with 0.2 micro Henries inductance (one on the AC+ Line & one on the AC- Line). Provide one 20 Joule surge arrestor between AC+ to AC-. A 0.68 microfarad capacitor must be placed between AC+ & AC- (between the resistor & arrestor).

2.08 POWER FAILURES

A. Whenever there is a loss of power to the "Walk" or "Don't Walk" for a period greater than 2.0 seconds, the sound shall be deactivated.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Supplier(s)/Manufacturer(s) shall have field engineers or technicians available on request to assure satisfactory initial operation, and to consult with City Traffic Engineer, or City Traffic Engineer's representative, on any special circuitry that may be required in certain applications.

END OF SECTION

SECTION 16780

CCTV FIELD EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnish and install closed circuit television (CCTV) field equipment.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement: This Item will be measured as each unit furnished, installed, and tested.

2. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "CCTV Field Equipment". This price is for equipment, cables and connectors; documentation and testing; and labor, materials, warranty, training and incidentals.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERENCES

A. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code)

B. NEMA TS2 - Traffic Controller Assemblies with NTCIP Requirements

C. TxDOT Special Specification 6005 - Testing, Training, Documentation, Final Acceptance, and Warranty

D. TxDOT Special Specification 6006 - Electronic Components.

1.05 QUALITY ASSURANCE

A. Perform documentation, testing and training in accordance with TxDOT Special Specification 6005, "Testing, Training, Documentation, Final Acceptance, and Warranty".

1.06 DELIVERY, STORAGE, AND HANDLING

A. Prior to delivery and installation of "CCTV Field Equipment", sample units will be delivered to TranStar for evaluation by TranStar IS personnel to confirm compatibility with TranStar systems.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide new, corrosion resistant materials in accordance with the details shown on the plans and this item.

1. Provide CCTV field equipment including, but not limited to, the following:

2. Color video camera units.

3. Camera lenses, filters, control circuits and accessories.

4. Camera housings.

5. Medium duty pan and tilt units.

6. Camera control receivers.

7. Video and camera control and power cable harnesses, connectors and coaxial cable.

8. Source ID Generator.

9. Surge protection equipment.

B. Functional Requirements. Provide color, PTZ CCTV Cameras in accordance with the plans and specifications.

1. Provide field equipment that operates in all weather conditions and able to withstand a wind load of 120 mph without permanent damage to mechanical and electrical equipment, unless otherwise shown on the plans.

2. Provide equipment from the same manufacturer at each field location. All equipment shall be compatible with existing City of Houston and Houston TranStar infrastructure.

C. Electrical and Mechanical Requirements.

1. Video Camera Unit. Provide color video cameras of solid state design, and that meet the following requirements:

a. Top of pole mount or outdoor mini-dome type, as indicated on the plans for each location

b. Color Image: solid state 1/4" Exview HAD or interline transfer CCD sensor

c. Resolution: 520 horizontal TV lines minimum

d. Sensitivity: 0.1 fc or less at 1/60 second shutter (color mode).

e. Signal to Noise Ratio: 50 dB minimum (AGC off)

f. White Balance: Continuous automatic

g. Physical mounting: Either “Top of Pole” or “Environmental Dome” as indicated for each location on the plans.

h. Video Interface: EIA-170A, 75 Ohm, BNC connector.

i. PTZ control Interface: Ethernet, RS-232 or RS-422 using one of the TranStar supported protocols (see section below).

j. Title: On Screen display with a minimum of 16 characters.

k. Weatherproof enclosure conforming to IP66 (IEC 60529 standard) or better.

l. Sun shield to reduce heating from direct sunlight.

m. Pan: 360 degrees continuous rotation. Variable speed with at least 80 deg/sec maximum. No dead zone.

n. Tilt Range: -90 degrees to +90 degrees from level.

o. Ambient Operating Conditions: -29.2F to 165F (-34C to 74C) Per NEMA TS2, para. 2.1.5.1, using fig. 2.1 test profile.

2. Camera Lens. Provide an integral lens assembly for each camera with the following features:

a. When coupled with the imaging sensor in the camera, the wide angle position shall have a horizontal view of fifty-five (55) degrees or more, and the telephoto position shall have a horizontal view of two (2) degrees or less.

b. There shall be no change in focus when zooming from full wide angle to full telephoto. For the purposes of this requirement, the viewing angle shall be determined by the lens only, and shall not include the use of any available digital zoom capability.

c. An auto iris shall be provided to maintain white levels at 100% over the normal range of lighting changes, from full sunlight down to the maximum nighttime sensitivity of the camera.

d. Minimum F-stop no greater than: F1.4 (wide), F4.2 (telephoto)

e. The lens shall not introduce any measurable chromatic aberation or distortion at the maximum camera resolution.

f. Provide a lens with capabilities for remote control of zoom, focus and iris operations. Provide mechanical or electrical means to protect the motors from overrunning in extreme positions. The lens and control system must be capable of both auto iris, and remote manual iris operation.

3. Camera Housing. Furnish and install an environmental resistant and tamperproof housing pressurized to 5 psi dry Nitrogen with Schrader purge fitting and 20 psi relief valve for each camera.

a. The internal humidity of the housing must be less than 10%, when sealed and pressurized. Securely place desiccant packs inside the housing to absorb any residual moisture and maintain internal humidity at 10% or less.

b. Construct the viewing window in such a way that unrestricted camera views can be obtained at all camera and lens positions.

c. Provide a sun shield to shield the entire housing from direct sunlight and vertical rainfall. Construct it in such a way as to allow the free passage of air between the housing and the shield, but it must not form a “sail” to place an excessive load on the pan/tilt unit in high winds.

d. Provide with an internal 18 Watt low temperature heater with its own thermostat control in each housing.

e. Provide lightning protection as shown on the plans in each housing.

4. Pan-Tilt Zoom.

a. The PTZ control protocol shall be one of the following protocols supported by the TxDOT LoneStar software used at Houston TranStar:

(1) American Dynamics

(2) Cohu

(3) Cohu 382x, and 383x

(4) Cohu 3855

(5) CohuiDome2lcu

(6) CohuiDomeLCU

(7) CohuMPC111

(8) PelcoD

(9) QC

(10) VC-C50i

(11) Vicon

b. The contractor shall submit a sample unit to the City project manager so that compliance with this requirement can be verified by Houston TranStar IS.

5. Camera Control. Provide camera and pan/tilt/zoom functions that are operable via RS- 232 serial communications. Provide remote control functions that meet the following specific requirements:

a. Camera remote control functions: Provide units with, as a minimum, control and drive circuits for the following functions:

(1) DSP Functions: Zoom, Long-Term Exposure, Auto-Focus, Auto/Manual focus Control, and I.D. Generator Operation.

(2) Pan/Tilt Position preset.

(3) Pan Left.

(4) Pan Right.

(5) Tilt Up.

(6) Tilt Down.

(7) Zoom and focus position preset.

(8) Zoom In.

(9) Zoom Out.

(10) Focus

(11) Manual and Auto Iris control.

(12) Iris Open.

(13) Iris Close.

b. Power Supplies: Provide power supplies required to operate the camera, pan/tilt, and lens movements and include them with the housing, camera control receiver, and pan/tilt unit.

c. Communications Interface: Provide an RS-232 interface for control of camera Pan / Tilt / Zoom. Use a minimum 9600 Baud data rate. Data must be sent asynchronously as either 8 bit with no parity, or 7 bit with parity. Supply complete hardware interface and protocol description to the City of Houston as part of the required documentation.

d. Power Input: 115 VAC plus or minus 10%, 60 Hz ± 3 Hz, 50 W. Maximum.

e. Connectors: Provide and install connectors which are compatible with the communications equipment interface. Use Connectors for connections at the pan/tilt mechanism. Make connections through a pigtail with a connector on it coming out of the bottom center of the pan/tilt unit. Provide the connector on the pigtail that is an AMP type connector. Provide connections down to the pole to the transmission cables to this connector. Supply mating connectors. Provide connector pins and mating connectors that are plated to ensure good electrical connection and resist corrosion. Use pressure tight multi-conductor MS-type cable connectors for camera connections.

6. Source ID Generator: Provide the built-in ID Generator that inserts camera ID over each of the camera generated videos.

a. Submit a list of proposed camera identification text to the Engineer for approval before the ID is programmed.

b. Once programmed, the programmed ID must automatically be displayed with its associated video signal.

c. The source ID generator shall automatically “pass through” video in case of equipment failure.

7. Surge Protection.

a. All conductors (except for grounding) to the camera, pan/tilt/zoom, communications equipment, and ground or pole mounted cabinet, shall have surge protection at both ends of the conductor.

b. The surge protection device shall be located as close as practical to the point where the wiring enters the enclosure, or for devices with no enclosure, where the wiring terminates at the device.

c. For devices where there is no room in the enclosure (such as a camera), a separate external weather proof enclosure may be added for the surge protection devices.

d. Any external surge protection enclosure shall be located in such a manner as to minimize the length of the wiring between the surge protectors and the protected device.

e. Each device shall utilize a primary stage Gas Discharge Tube (GDT), and a secondary stage Silicon Avalanche Diode (SAD) as the active protection medium, and a series solid- state resettable fuse (PTC). Clamp voltages for each device shall be appropriate for the voltages on the conductor that they protect.

f. The surge protection devices shall be grounded to a #6 solid copper wire that connects each device to a common ground rod point.

g. Protection devices within a common enclosure may be grounded by a short wire to a common point in the enclosure, which in turn is connected to a wire that connects to the ground rod.

h. Devices not in the same enclosure shall each have a separate ground wire that connects to the ground rod.

i. Devices outside an enclosure shall not share the same ground wire with devices in an enclosure. In general, ground wires should be kept as short as possible.

j. Ground wires inside metal conduits (or metal poles) shall be bonded to the conduit (or pole) at each end.

k. The ground rod shall be driven into the ground a minimum of ten (10) feet.

8. Power Requirements. Provide CCTV field equipment that meets its specified requirements when the input power is 115 VAC ± 10%, 60 Hz ± 3 Hz. The maximum power required must not exceed 350 W.

a. Provide equipment operations that are not affected by the transient voltages, surges and sags normally experienced on commercial power lines. Check the local power service to determine if any special design is needed for the equipment. The extra cost, if required, must be included in the bid of this item.

9. Primary Input Power Interruption. Provide CCTV field equipment that meets the requirements in Section 2.1.4. “Power Interruption” of the NEMA Standard TS2 for Traffic Control System.

10. Power Service Transients. Provide CCTV field equipment that meets the requirements of Section 2.1.6., “Transients, Power Service” of the NEMA Standard TS2.

11. Wiring. Provide wiring that meets the requirements of the National Electric Code. Provide wires that are cut to proper length before assembly. Do not doubled-back wire to take up slack. Lace wires neatly into cable with nylon lacing or plastic straps. Secure cables with clamps. Provide service loops at connections.

    a. Provide coaxial cable between the camera and the communications equipment interface that is of the RG-59 type with a stranded center conductor and 100% shield coverage

    b. Provide coaxial cable that has a cellular polyethylene dielectric.

12. Transient Suppression. Provide DC relays, solenoids and holding coils that have diodes or other protective devices across the coils for transient suppression.

13. Power Service Protection. Provide equipment that contains readily accessible, manually resettable or replaceable circuit protection devices (such as circuit breakers or fuses) for equipment and power source protection.

    a. Provide and size circuit breakers or fuses such that no wire, component, connector, PC board or assembly must be subjected to sustained current in excess of their respective design limits upon the failure of any single circuit element or wiring.

14. Fail Safe Provision. Provide equipment that is designed such that the failures of the equipment must not cause the failure of any other unit of equipment.

15. Modular Design. Provide CCTV field equipment that is modular in design to allow major portions to be readily replaced in the field. Identify modules and assemblies clearly with name, model number, serial number and any other pertinent information required to facilitate equipment maintenance.

16. Connectors and Harnesses. Provide external connections made by means of connectors. Provide connectors that are keyed to preclude improper hookups. Color code and/or appropriately mark wires to and from the connectors.

    a. Provide connecting harnesses of appropriate length and terminated with matching connectors for interconnection with the communications system equipment.

    b. Provide pins and mating connectors that are plated to improve conductivity and resist corrosion. Cover connectors utilizing solder type connections by a piece of heat shrink tubing securely shrunk to ensure that it protects the connection.

D. Environmental Design Requirements. Provide equipment that meets its specified requirements during and after subjecting to any combination of the following conditions.

1. Ambient temperature range of -29.2F to 165F (-34C to 74C)

2. Temperature shock not to exceed 30°F per hour during which the relative humidity must not exceed 95%.

3. Relative humidity range not to exceed 95% over the temperature range of 40°F to 110°F.

4. Moisture condensation on exterior surfaces caused by temperature changes.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. General. Provide equipment that utilizes the latest available techniques for design and construction with a minimum number of parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality.

1. Design the equipment for ease of maintenance. Provide component parts that are readily accessible for inspection and maintenance. Provide test points that are for checking essential voltages and waveforms.

B. Electronic Components. Provide electronic components in accordance with TxDOT Special Specification 6006, “Electronic Components”.

C. Mechanical Components. Provide external screws, nuts and locking washers that are stainless steel; no self-tapping screws will be used. Provide parts made of corrosion resistant material, such as plastic, stainless steel, anodized aluminum or brass. Protect materials from fungus growth and moisture deterioration. Separate dissimilar metals by an inert dielectric material.

END OF SECTION

SECTION 16785

GPS SERIAL COMMUNICATIONS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnish, install, and make fully operational a GPS Serial Communications Module at designated locations as shown on the plans and as detailed in accordance with these specifications. Use the same manufacturer and model for each GPS Serial Communications Module. The GPS Serial Communications Module provides a reliable and independent GPS time reference for 2070 controller applications.

1.02 RELATED SECTIONS

A. Section 01270 – Measurement and Payment

1.03 MEASUREMENT AND PAYMENT

A. Unit Prices

1. Measurement: This item will be measured as each unit furnished, installed, made fully functional and tested in accordance with these special specifications or as directed by the Engineer. A unit will include one (1) GPS Serial Communications Module meeting all specifications, standards and requirements contained herein, antenna and antenna cabling back to module, all mounting hardware, manufacturer's operation manual, required testing results, manufacturers technical specification, and the cost of all materials, training, warranty, equipment, and all accessories necessary to the complete installation of the unit.

2. Payment: Payment for the work performed and materials furnished in accordance with this item will be paid for at the unit price bid for "GPS Communications Module." This price will include all equipment described under this Item with all antenna, cables and connectors; all documentation and testing and will also include the cost of furnishing all labor, materials, software, warranty, training, equipment, and incidentals.

3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

1.04 REFERNCES

A. TxDOT Special Specification 6006, "Electronic Components"

1.05 SUBMITTALS

A. Manufacturers' cut sheets / specifications and software for all equipment proposed under these specifications shall be submitted to the City of Houston's Traffic Signal and Operations branch at Houston TranStar (713-881-3172) prior to construction.

1.06 WARRANTY

A. All equipment, materials and other appurtenances will be warranted by the manufacturer for five years following the acceptance of the system by City of Houston. The warranty will include the specific installation characteristics for the geographic region and project limits.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide a GPS Serial Communications Module unit that meets the following requirements.

B. General Requirements.

1. Provide only equipment that is new, corrosion resistant and in strict accordance with the details shown on the plans and in the specifications. Provide a GPS Serial Communications Module that is fully compatible with the 2070 controller.

C. GPS Serial Communications Module.

1. Provide a GPS Serial Communications Module unit that has the following 2070 controller interface features:

a. GPS receiver operates in SP3 or SP1 slots in the back of the 2070 controller.

b. Microwave OS-9 clock update application included (operates with any 2070-1A or - 1B CPU Module)

c. Communicates to 2070 via Din 95P connector

d. Tracking LED that indicates GPS satellite acquisition status

D. GPS Antenna

1. Provide a GPS Serial Communications Module unit with a GPS Antenna that has the following features:

a. 28dB gain

b. 3m Cable

c. SMA Male

E. C22S Serial Port

1. Provide a GPS Serial Communications Module unit with a C22S Serial Port that has the following features:

a. DB9 Female

b. up to 38,400 bps

c. Electrically-isolated

d. 2070 SP2/SP4

e. Full modem control when used as SP2 (RTS/CTS/DCD)

F. Additional Features.

1. Provide an Ethernet Media Converter unit that has the following additional features:

a. Visual Indicators to display status of the following:

(1) GPS satellite acquisition

(2) Transmitting (TX)/Receiving (RX) for GPS connections

(3) Transmitting (TX)/Receiving (RX) for C22S serial connections

G. Dimensions.

1. Provide an Ethernet Media Converter with dimensions that do not exceed the following maximums:

a. Height: 5 in.

b. Width: 1 6/8 in.

c. Depth: 8 3/4 in.

d. Weight: 2 lb.

H. Power.

1. Provide a GPS Serial Communications Module that meets the following power specifications:

a. 125mA @ 12V

b. LED power status indicator

I. Environmental.

1. Provide a GPS Serial Communications Module that is designed to operate in the following environmental conditions:

J. -40ºC to 85ºC operating temperature range
Operation.

1. Once the GPS Communication Serial Module acquires satellite communication (as shown by LED indicator), the GPS unit shall then operate as follows:

a. It shall have the operating software of the 2070 controller interface with the GPS Communication Module to sync the date of the 2070 controller once per minute.

b. It shall have the operating software of the 2070 controller interface with the GPS Communication Module to sync the time of the 2070 controller once per minute.

PART 3 EXECUTION

3.01 CONSTRUCTION

A. General.

1. Provide equipment that utilizes the latest available techniques for design and construction with a minimum number of parts, subassemblies, circuits, cards, and modules to maximize standardization and commonality.

2. Design the equipment for ease of maintenance. Provide component parts that are readily accessible for inspection and maintenance. Provide test points that are for checking essential voltages and waveforms.

B. Electronic Components.

1. Provide this item in accordance with TxDOT Special Specification 6006 - "Electronic Components".

C. Mechanical Components.

1. Provide external screws, nuts and locking washers that are stainless steel; no self-tapping screws will be used. Provide parts made of corrosion resistant material, such as plastic, stainless steel, anodized aluminum or brass. Protect materials from fungus growth and moisture deterioration. Separate dissimilar metals by an inert dielectric material.

D. Documentation Requirements.

1. Provide one (1) copy of the manufacturer's operation manual at each installation location. Deliver 10 additional paper copies of the manufacturer's operation manual, plus an electronic copy (in either .doc or .pdf format) to the Engineer prior to the first GPS Serial Communications Module installation.

E. Testing.

1. City of Houston reserves the right to do testing on GPS Serial Communications Modules to ensure quality assurance before installations and random sampling of units being provided to the City. GPS Communication Modules that fail will be removed from the Prequalified Products List (QPL). City of Houston's QPL testing procedures will include the following:

   a. GPS Serial Communication Module will meet all criteria of the specification.

   b. GPS unit shall demonstrate all of the operations described in 2.01.J section this specification.

   c. GPS Communication Serial Module and all of its component will be tested in an environmental chamber (temperature ranges from -40 ºC to 85 ºC).

F. Experience Requirements.

1. Meet the following requirements, as a minimum, for Contractor or designated subcontractors involved in the installation and testing of the GPS Serial Communication equipment:

2. Three years experience in the installation of GPS equipment.

3. Two installed systems where GPS Communications Modules are installed and the systems have been in continuously satisfactory operation for at least two (2) year. Submit as proof, photographs or other supporting documents, and the names, addresses and telephone numbers of the operating personnel who can be contacted regarding the system.

4. Provide necessary documentation of subcontractor qualifications pursuant to contract award.

G. Technical Assistance.

1. Ensure that a manufacturer's technical representative is available on site to assist the technical personnel at each installation site and with GPS equipment installation and communication system configuration.

2. Do not execute the initial powering up of the GPS equipment without the permission of the manufacturer's representative.

END OF SECTION