2009
INTERNATIONAL ENERGY CONSERVATION CODE AMENDMENTS

FOR THE COMMERCIAL PORTIONS OF THE CODE

CITY OF HOUSTON

PUBLIC WORKS AND ENGINEERING DEPT.

Effective Date: September 2, 2011

CHAPTER 1

ADMINISTRATION

101.1 Title. This code shall be known as the ~~*International* City of Houston Commercial~~ *Energy Conservation Code* ~~of [NAME OF JURISDICTION], and shall~~, may be cited as such~~. It is~~, and will be referred to herein as "this code." *The City of Houston Construction Code* collectively includes this volume and certain other codes, pamphlets, specifications, and documents that are adopted in or by reference to the Adopting Ordinance, City of Houston Ordinance No. 2010-847.

101.2 Scope. This code applies to ~~*residential* and~~ *commercial buildings*.

Exception: Commercial buildings and structures shall be permitted to meet the provisions of the *City of Houston Commercial Energy Conservation Code - ASHRAE 90.1-2007* provisions in lieu of this code.

101.4.2 Historic buildings. Any building or structure that is listed in the State or National Register of Historic Places; designated as a historic property under local or state designation law or survey; certified as a contributing resource with a National Register listed or locally designated historic district; or with an opinion or certification that the property is eligible to be listed on the National or State Registers of Historic Places either individually or as a contributing building to a historic district by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places, ~~are exempt from~~ shall comply with all of the provisions of this code.

Exception: Whenever a provision or provisions would invalidate or jeopardize the historical designation or listing, the building or structure may be exempted from the provision or provisions.

101.4.3 Additions, alterations, renovations or repairs. Additions, alterations, renovations or repairs to an existing building, building system or portion thereof shall conform to the provisions of this code as they relate to new construction without requiring the unaltered portion(s) of the existing building or building system to comply with this code. Additions, alterations, renovations or repairs shall not create an unsafe or hazardous condition or overload existing building systems. An addition shall be deemed to comply with this code if the addition alone complies or if the existing building and addition comply with this code as a single building.

Exception: The following need not comply provided the energy use of the building is not increased:

1. Storm windows installed over existing fenestration.
2. Glass only replacements in an existing sash and frame.
3. Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are filled with insulation.
4. Construction where the existing roof, wall or floor cavity is not exposed.
5. Reroofing for roofs where neither the sheathing nor the insulation is exposed. Roofs without insulation in the cavity and where the sheathing or insulation is exposed during reroofing shall be insulated either above or below the sheathing.

6. Replacement of existing doors that separate *conditioned space* from the exterior shall not require the installation of a vestibule or revolving door, provided, however, that an existing vestibule that separates a *conditioned space* from the exterior shall not be removed,
7. Alterations that replace less than 50 percent of the luminaires in a space, provided that only those *luminaires* that are replaced need comply with this code ~~such alterations do not increase the installed interior lighting power~~.
8. Alterations that replace only the bulb and ballast within the existing luminaires in a space provided that the *alteration* does not increase the installed interior lighting power.

101.4.6 Mixed occupancy. Where a building includes both *residential* and *commercial* occupancies, each occupancy shall be separately considered and meet the applicable provisions of ~~Chapter 4~~ the City of Houston Residential Energy Conservation Code for *residential* and Chapter 5 of this code for *commercial*.

101.5 Compliance. *Residential buildings* shall meet the provisions of the ~~Chapter 4~~ City of Houston Residential Energy Conservation Code. *Commercial buildings* shall meet the provisions of Chapter 5 of this code.

SECTION 103
~~CONSTRUCTION DOCUMENTS~~ PERMITS

103.1 Administrative requirements. Administrative requirements relating to permit requirements, enforcement by the *authority having jurisdiction*, locally adopted energy standards, interpretations, claims of exemption, revocation and rights of appeal shall be as set forth in the applicable volume of the *City of Houston Construction Code*. ~~**General.** Construction documents and other supporting data shall be submitted in one or more sets with each application for a permit. The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the *code official* is authorized to require necessary construction documents to be prepared by a registered design professional.~~

~~**Exception:** The *code official* is authorized to waive the requirements for construction documents or other supporting data if the *code official* determines they are not necessary to confirm compliance with this code.~~

103.2 Construction documents. ~~**Information on construction documents.** Construction documents shall be drawn to scale upon suitable material. Electronic media documents are permitted to be submitted when *approved* by the *code official*.~~ Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and show in sufficient detail pertinent data and features of the building, systems and equipment as herein governed. ~~Details shall include, but are not limited to, applicable, insulation materials and their *R*-values; fenestration *U*-factors and SHGCs; area-weighted *U*-factor and SHGC calculations; mechanical system design criteria; mechanical and service water heating system and equipment types, sizes and efficiencies; economizer description; equipment and systems controls; fan motor horsepower (hp) and controls; duct sealing, duct and pipe insulation and location; lighting fixture schedule with wattage and control narrative; and air sealing details.~~

103.3 Supplemental information. Supplemental information necessary to verify compliance with this code, such as calculations, worksheets, compliance forms, vendor literature, or other data, shall be made available when required by the *building official*. ~~**Examination of documents.** The *code official* shall examine or cause to be examined the accompanying construction documents and shall ascertain whether the construction indicated and described is in accordance with the requirements of this code and other pertinent laws or ordinances.~~

~~**103.3.1 Approval of construction documents.** When the *code official* issues a permit where construction documents are required, the construction documents shall be endorsed in writing and stamped "Reviewed for Code Compliance." Such *approved* construction documents shall not be changed, modified or altered without authorization from the *code official*. Work shall be done in accordance with the *approved* construction documents.~~

~~One set of construction documents so reviewed shall be retained by the *code official*. The other set shall be returned to the applicant, kept at the site of work and shall be open to inspection by the *code official* or a duly authorized representative.~~

~~**103.3.2 Previous approvals.** This code shall not require changes in the construction documents, construction or designated occupancy of a structure for which a lawful permit has been heretofore issued or otherwise lawfully authorized, and the construction of which has been pursued in good faith within 180 days after the effective date of this code and has not been abandoned.~~

~~**103.3.3 Phased approval.** The *code official* shall have the authority to issue a permit for the construction of part of an energy conservation system before the construction documents for the entire system have been submitted or *approved*, provided adequate information and detailed statements have been filed complying with all pertinent requirements of this code. The holders of such permit shall proceed at their own risk without assurance that the permit for the entire energy conservation system will be granted.~~

~~**103.4 Amended construction documents.** Changes made during construction that are not in compliance with the *approved* construction documents shall be resubmitted for approval as an amended set of construction documents.~~

~~**103.5 Retention of construction documents.** One set of *approved* construction documents shall be retained by the *code official* for a period of not less than 180 days from date of completion of the permitted work, or as required by state or local laws.~~

104.3 Final inspection. The building shall have a final inspection ~~and not be occupied until *approved*~~**.**

~~**104.8.1 Revocation.** The *code official* is authorized to, in writing, suspend or revoke a notice of approval issued under the provisions of this code wherever the certificate is issued in error, or on the basis of incorrect information supplied, or where it is determined that the building or structure, premise, or portion thereof is in violation of any ordinance or regulation or any of the provisions of this code.~~

SECTION 105
~~VALIDITY~~ RESERVED

~~**105.1 General.** If a portion of this code is held to be illegal or void, such a decision shall not affect the validity of the remainder of this code.~~

~~**106.4 Other laws.** The provisions of this code shall not be deemed to nullify any provisions of local, state or federal law.~~

107.1 Fees. Fees shall be as set forth in the Houston Building Code. ~~A permit shall not be issued until the fees prescribed in Section 107.2 have been paid, nor shall an amendment to a permit be released until the additional fee, if any, has been paid.~~

~~**107.2 Schedule of permit fees.** A fee for each permit shall be paid as required, in accordance with the schedule as established by the applicable governing authority.~~

~~**107.3 Work commencing before permit issuance.** Any person who commences any work before obtaining the necessary permits shall be subject to an additional fee established by the *code official*, which shall be in addition to the required permit fees.~~

~~**107.4 Related fees.** The payment of the fee for the construction, *alteration*, removal or demolition of work done in connection to or concurrently with the work or activity authorized by a permit shall not relieve the applicant or holder of the permit from the payment of other fees that are prescribed by law.~~

~~**107.5 Refunds.** The *code official* is authorized to establish a refund policy.~~

108.1 Authority. Whenever the *code official* finds any work regulated by this code being performed in a manner either contrary to the provisions of this code or in a dangerous or unsafe manner, the *code official* is authorized to issue a stop work order.

108.2 Issuance. The stop work order shall be in writing and shall be given to the owner of the property involved, or to the owner's agent, or to the person doing the work. Upon issuance of a stop work order, the cited work shall immediately cease. The stop work order shall state the reason for the order, and the conditions under which the cited work will be permitted to resume.

At the time such a stop order is issued, the person doing the work and the permit holder shall be given notice of a right to a hearing on the matter pursuant to Section109. The notice shall be delivered to persons performing the work if present at the site or otherwise shall be conspicuously posted at the site. Upon request, such a hearing shall be held within three business days unless the permit holder or person who was doing the work requests an extension of time. Any stop order that has been issued shall remain in effect pending any hearing that has been requested unless the stop order is withdrawn by the code official.

108.4 Failure to comply. Any person who shall continue any work after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be ~~liable to a fine of not less than [AMOUNT] dollars or more than [AMOUNT] dollars~~ subject to penalties as prescribed by the building code.

SECTION 109
~~BOARD OF APPEALS~~ HEARING PROCEDURES

109.1 ~~General.~~ ~~In order to hear and decide appeals of orders, decisions or determinations made by the *code official* relative to the application and interpretation of this code, there shall be and is hereby created a board of appeals. The *code official* shall be an ex officio member of said board~~

~~but shall have no vote on any matter before the board. The board of appeals shall be appointed by the governing body and shall hold office at its pleasure. The board shall adopt rules of procedure for conducting its business, and shall render all decisions and findings in writing to the appellant with a duplicate copy to the *code official*.~~

~~**109.2 Limitations on authority.** An application for appeal shall be based on a claim that the true intent of this code or the rules legally adopted thereunder have been incorrectly interpreted, the provisions of this code do not fully apply or an equally good or better form of construction is proposed. The board shall have no authority to waive requirements of this code.~~

~~**109.3 Qualifications.** The board of appeals shall consist of members who are qualified by experience and training and are not employees of the jurisdiction.~~ **Hearing notice.** Whenever notice is to be given to any person concerning the right to a hearing, the notice may be given by personal delivery or by certified mail, return receipt requested.

If notice is being given to a building owner or to a tenant therein and the code official is unable to determine the name or address of such person after checking the building and the applicable records of the jurisdiction's Public Works and Engineering Department, the County Appraisal District, the electrical utility company, the gas utility company, and the water utility provider, notice shall be mailed to the billing addresses of the building as shown on the records of the electrical company and the gas company and shall be posted on or in view of each entrance to the building. Additionally, if any notice is mailed to a building owner or a building tenant and is returned without delivery, notice shall be effective if posted on or in view of each entrance to the building.

109.2 Hearings. Except where otherwise specifically provided, all hearings held pursuant to this code shall be conducted by the jurisdiction's Director of Public Works and Engineering or a representative, who shall hereinafter be referred to as the "hearing official." The director shall not designate any person to be a hearing official under this code who has taken any part in the investigation of the matter that is the subject of the hearing or any person who directly supervised the investigation. The hearing official shall consider only the evidence presented at the hearing in rendering a decision. The decision of the hearing official shall be set forth in writing and shall be served on each party in the same manner as a notice of a right to a hearing.

CHAPTER 2

DEFINITIONS

201.3 Terms defined in other codes. Terms that are not defined in this code but are defined in any volume of the ~~*International Building Code*, *International Fire Code*, *International Fuel Gas Code*, *International Mechanical Code*, *International Plumbing Code* or the *International Residential*~~ *City of Houston Construction Code* shall have the meanings ascribed to them in those codes.

201.5 International code reference. When one of the International Codes is referenced in this document, the reference shall be construed to mean the corresponding City of Houston adopted code.

SECTION 202*
GENERAL DEFINITIONS

ABOVE-GRADEWALL. A wall more than 50 percent above grade and enclosing *conditioned space* that has a slope of 60 degrees (1.05 rad) or greater with the horizontal plane. This includes between-floor spandrels, peripheral edges of floors, roof and basement knee walls, dormer walls, gable end walls, walls enclosing a mansard roof and skylight shafts.

ACCESSIBLE. ~~Admitting close approach as a result of not being guarded by locked doors, elevation or other effective means (see "Readily *accessible*").~~ Having access to but which first may require the removal of an access panel, door, or similar obstruction covering the item described.

BOILER. A closed vessel used for heating water or liquid, or for generating steam or vapor by direct application of heat from combustible fuels or electricity.

DUCT. ~~A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.~~ Any tube or conduit for transmission of air. This definition shall not include:

1. A vent, a vent connector or a chimney connector.
2. Any tube or conduit wherein the pressure of the air exceeds one (1) pound per square inch.
3. The air passages of listed self-contained systems.

GLAZING AREA. Total area of the glazed fenestration measured using the rough opening and including sash, curbing or other framing elements that enclose conditioned space. Glazing area includes the area of glazed fenestration assemblies in walls bounding conditioned basements. For

doors where the daylight opening area is less than 50 percent of the door area, the glazing area is the daylight opening area. For all other doors, the glazing area is the rough opening for the door including the door and frame.

INTERNATIONAL MECHANICAL CODE. The *City of Houston Mechanical Code*, as adopted by the *authority having jurisdiction*.

JURISDICTION. The City of Houston, Texas.

PROCESS ENERGY. Energy consumed in support of a manufacturing, industrial, or commercial process other than conditioning spaces and maintaining comfort for the human occupants of a building.

READILY ACCESSIBLE. Capable of being reached quickly for operation, ~~renewal~~ repair or inspection without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to the use of portable ladders or access equipment (see "*Accessible*").

***NOTE: ALL OTHER PORTIONS OF SECTION 202 REMAIN AS SET FORTH IN THE 2009 INTERNATIONAL ENERGY CONSERVATION CODE.**

CHAPTER 3

GENERAL REQUIREMENTS

301.1 General. ~~Climate *zones* from Figure 301.1 or Table 301.1 shall be used in determining the applicable requirements from Chapters 4 and 5. Locations not in Table 301.1 (outside the United States) shall be assigned a climate *zone* based on Section 301.3.~~ The climate zone designation for the jurisdiction is Zone 2.

301.2 Warm humid counties. Warm humid counties are identified in Table 301.1 by an asterisk. The jurisdiction shall be considered warm-humid for the purposes of this code.

302.2 Exterior design conditions. When using the total building performance compliance method, the criteria shall be as set forth in Table 302.2.

TABLE 302.2
EXTERIOR DESIGN CONDITIONS

CONDITION	VALUE
Winter, Design Dry-bulb (E_F)	28°F
Summer, Design Dry-bulb	96°F
Summer, Design Wet-bulb	80.5°F
Degree days heating (base 65)	1371
Degree days cooling (base 50)	7534
Climate Zone	2A

TABLE 303.1.3(3)
DEFAULT GLAZED FENESTRATION SHGC

SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
Clear	Tinted	Clear	Tinted	
~~0.8~~ 0.85	0.7	0.7	0.6	0.6

303.3 Maintenance information. Maintenance instructions shall be furnished for equipment and systems that require preventive maintenance. Required regular maintenance actions shall be clearly stated and incorporated on a ~~readily accessible~~ label. The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product.

CHAPTER 4

~~RESIDENTIAL ENERGY EFFICIENCY~~ RESERVED*

***NOTE: DELETE THIS CHAPTER IN ITS ENTIRETY AND RESERVE.**

CHAPTER 5

COMMERCIAL ENERGY EFFICIENCY

501.1 Scope. The requirements contained in this chapter are applicable to commercial buildings, or portions of commercial buildings. These commercial buildings shall meet either the requirements of the City of Houston Commercial Energy Conservation Code - ANSI/ASHRAE/IESNA Standard 90.1-2007, *Energy Standard for Buildings Except for Low-Rise Residential Buildings*, or the requirements contained in this chapter.

501.2 Application. The *commercial building* project shall comply with the requirements in Sections 502 (Building envelope requirements), 503 (Building mechanical systems), 504 (Service water heating) and 505 (Electrical power and lighting systems) in its entirety. ~~As an alternative the *commercial building* project shall comply with the requirements of ANSI/ASHRAE/IESNA 90.1 in its entirety.~~

Exception: Buildings conforming to Section 506, provided Sections 502.4, 502.5, 502.6, 503.2, 504, 505.2, 505.3, 505.4, 505.6 and 505.7 are each satisfied.

502.1.1 Insulation and fenestration criteria. The *building thermal envelope* shall meet the requirements of Tables 502.2(1) and 502.3 based on the climate *zone* specified in Chapter 3. Commercial buildings or portions of commercial buildings enclosing Group R occupancies shall use the *R*-values from the "Group R" column of Table 502.2(1). Commercial buildings or portions of commercial buildings enclosing occupancies other than Group R shall use the *R*-values from the "All other" column of Table 502.2(1). Buildings with a vertical fenestration area or skylight area that exceeds that allowed in Table 502.3 shall comply with the building envelope provisions of *City of Houston Commercial Energy Conservation Code – ASHRAE~~/IESNA~~ 90.1-2007*.

502.2.1 Roof assembly. The minimum thermal resistance (*R*-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table 502.2(1), based on construction materials used in the roof assembly.

Exception: Continuously insulated roof assemblies where the thickness of insulation varies 1 inch (25 mm) or less and where the area-weighted *U*-factor is equivalent to the same assembly with the *R*-value specified in Table 502.2(1).

Insulation installed on a suspended ceiling with removable ceiling tiles shall not be considered part of the minimum thermal resistance of the roof insulation.

Curbs shall be insulated to the level of roofs with insulation entirely above deck or R-8, whichever is less.

502.4.3 Sealing of the building envelope. Openings and penetrations in the building envelope shall be sealed with ~~caulking~~ sealant materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials spanning joints between construction materials shall allow for expansion and contraction of the construction materials.

502.4.5 Outdoor air intakes and exhaust openings. Stair and elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be equipped with not less than a Class I motorized, leakage-rated damper with a maximum leakage rate of 4 cfm per square foot (6.8 L/s · C m^2) of damper area at 1.0 inch water gauge (w.g.) (1250 Pa) when tested in accordance with AMCA 500D.

Exception: ~~Gravity (nonmotorized) dampers are permitted to be used in buildings less than three stories in height above grade.~~ In systems where dampers are prohibited by the Mechanical Code.

502.4.7 Vestibules. A door that separates *conditioned space* from the exterior shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time. Interior and exterior *doors* shall have a minimum distance between them of not less than 7 ft when in the closed position.

Exceptions:

1. ~~Buildings in climate Zones 1 and 2 as indicated in Figure 301.1 and Table 301.1.~~
2. ~~2.~~ Doors not intended to be used as a building *entrance door*, such as doors to mechanical or electrical equipment rooms.
3. ~~3~~ 2. Doors opening directly from a *sleeping unit* or dwelling unit.
4. ~~4~~ 3. Doors that open directly from a space less than 3,000 square feet (298 m^2) in area.
5. ~~5~~ 4. Revolving doors.
6. ~~6~~ 5. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

502.5 Cool roofs (Mandatory). Low slope *roofs* up to 2:12 shall be provided with a roof covering where the exterior surface has:

1. A minimum total solar reflectance of 0.70 when tested in accordance with one of the solar reflectance test methods listed below, and
2. A minimum thermal emittance of 0.75 when tested in accordance with one of the thermal emittance test methods listed below.

Solar Reflectance Test Methods: ASTM C1549, ASTM E903, ASTM E1175, or ASTM E1918.

Thermal Emittance Test Methods: ASTM C835, ASTM C1371, or ASTM E408.

The values for solar reflectance and thermal emittance shall be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the Cool Roof Rating Council CRRC-1 Product Rating Program, and shall be labeled and certified by the manufacturer.

See Appendix A for guideline.

Exceptions to 502.5:

1. The portion of the *roof* that is a rooftop garden, or green roof or covered by a rooftop deck covering 1/3 or less of the aggregate area of the roof, is exempted from the requirements of this section.
2. An area including and adjacent to rooftop photovoltaic and solar thermal equipment, totaling not more than three times the area that is covered with such equipment, is exempt from the requirements of this section.

502.6 Building Envelope Commissioning. For projects larger than 50,000 ft^2 conditioned area, except heated only warehouses and semiheated spaces, detailed instructions for commissioning *building envelope* systems (see Appendix B) shall be provided by the designer in plans and specifications.

503.2.1 Calculation of heating and cooling loads. Design loads shall be determined in accordance with generally accepted engineering standards and methods (for example, ASHRAE *Handbook—Fundamentals*) ~~the procedures described in the ASHRAE/ACCA Standard 183. Heating and cooling loads shall be adjusted to account for load reductions that are achieved when energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE *HVAC Systems and Equipment Handbook*~~. Alternatively, design loads shall be determined by an a*pproved* equivalent computation procedure, using the design parameters specified in Chapter 3.

503.2.2 Equipment and system sizing. Heating and cooling equipment and systems capacity shall not exceed the loads calculated in accordance with generally accepted engineering standards and methods. ~~Section 503.2.1. A single piece of equipment providing both heating and cooling must satisfy this provision for one function with the capacity for the other function as small as possible, within available equipment options.~~

~~**Exceptions:**~~

~~1. Required standby equipment and systems provided with controls and devices that allow such systems or equipment to operate automatically only when the primary equipment is not operating.~~

~~2. Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that have the capability to sequence the operation of each unit based on load.~~

503.2.3 HVAC equipment performance requirements. Equipment shall meet the minimum efficiency requirements of Tables 503.2.3(1), 503.2.3(2), 503.2.3(3), 503.2.3(4), 503.2.3(5), 503.2.3(6) and 503.2.3(7) when tested and rated in accordance with the applicable test procedure. The efficiency shall be verified through certification under an *approved* certification program or, if no certification program exists, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different manufacturers are used,

calculations and supporting data shall be furnished by the designer that demonstrates that the combined efficiency of the specified components meets the requirements herein.

Exception: Water-cooled centrifugal water-chilling packages listed in Table 503.2.3(7) not designed for operation at ARHI Standard 550/590 test conditions of 44°F (7°C) leaving chilled water temperature and 85°F (29°C) entering condenser water temperature with 3 gpm/ton (0.054 I/s.kW) condenser water flow shall have maximum full load and NPLV ratings adjusted using the following equations:

Adjusted maximum full load kW/ton rating = [full load kW/ton from Table 503.2.3(7)]/*K*adj

Adjusted maximum NPLV rating = [IPLV from Table 503.2.3(7)]/*K*adj

Where:

K_{adj} = $6.174722 - 0.303668(X) + 0.00629466(X)^2 - 0.000045780(X)^3$

X = DT_{std} + LIFT

DT_{std} = {24+[full load kW/ton from Table 503.2.3(7)] × 6.83}/Flow

Flow = Condenser water flow (GPM)/Cooling Full Load Capacity (tons)

LIFT = CEWT – CLWT (°F)

CEWT = Full Load Condenser Entering Water Temperature (°F)

CLWT = Full Load Leaving Chilled Water Temperature (°F)

The adjusted full load and NPLV values are only applicable over the following full-load design ranges:

Minimum Leaving Chilled Water Temperature: 38°F (3.3°C)

Maximum Condenser Entering Water Temperature: 102°F (38.9°C)

Condensing Water Flow: 1 to 6 gpm/ton 0.018 to 0.1076 1/s x kW) and X ≥39 and ≤60

Chillers designed to operate outside of these ranges or applications utilizing fluids or solutions with secondary coolants (e.g., glycol solutions or brines) with a freeze point of 27°F (-2.8°C) or lower for freeze protection are not covered by this code. All chillers shall meet the minimum ARI efficiency performance requirements of Table 503.2.3(7)

503.2.4.4 Shutoff damper controls. Both outdoor air supply and exhaust ducts shall be equipped with motorized dampers that will automatically shut when the systems or spaces served are not in use.

Exceptions:

1. ~~Gravity dampers shall be permitted in buildings less than three stories in height.~~
2. ~~Gravity dampers shall be permitted for buildings of any height located in Climate Zones 1, 2 and 3.~~
3. ~~Gravity dampers shall be permitted for outside air intake or exhaust airflows of 300 cfm (0.14 m^3/s) or less.~~
2. In systems where dampers are prohibited by the Mechanical Code.

~~**503.2.4.5 Snow melt system controls.** Snow- and ice-melting systems, supplied through energy service to the building, shall include automatic controls capable of shutting off the system when the pavement temperature is above 50°F (10°C) and no precipitation is falling and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F (4°C) so that the potential for snow or ice accumulation is negligible.~~

503.2.6 Energy recovery ventilation systems. Individual fan systems that have both a design supply air capacity of 5,000 cfm (2.36 m^3/s) or greater and a minimum outside air supply of 70 percent or greater of the design supply air quantity shall have an energy recovery system ~~that provides a change in the enthalpy of the outdoor air supply of 50 percent or more of the difference between the outdoor air and return air at design conditions. Provision shall be made to bypass or control the energy recovery system to permit cooling with outdoor air where cooling with outdoor air is required~~.

Exception: An energy recovery ventilation system shall not be required in any of the following conditions:

1. Where energy recovery systems are prohibited by the *International Mechanical Code*.
2. Laboratory fume hood systems and biological safety cabinets. ~~that include at least one of the following features:~~

   ~~2.1. Variable-air-volume hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to 50 percent or less of design values.~~

   ~~2.2. Direct makeup (auxiliary) air supply equal to at least 75 percent of the exhaust rate, heated no warmer than 2°F (1.1°C) below room setpoint, cooled to no cooler than 3°F (1.7°C) above room setpoint, no humidification added, and no simultaneous heating and cooling used for dehumidification control.~~
3. Systems serving spaces that are not cooled and are heated to less than 60°F (15.5°C).
4. Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site solar energy.
5. Heating systems in climates with less than 3,600 HDD.
6. ~~Cooling systems in climates with a 1-percent cooling design wet-bulb temperature less than 64°F (18°C).~~

~~7.~~ Systems requiring dehumidification that employ series-style energy recovery coils wrapped around the cooling coil.

503.2.7 Duct and plenum insulation and sealing. All supply and return air ducts and plenums shall be insulated with a minimum of R-5 insulation when located inside the building thermal envelope ~~unconditioned spaces~~ and a minimum of R-8 insulation when located outside the building thermal envelope in accordance with Table 503.2.7. When located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by a minimum of R-8 insulation.

Exceptions:

1. When located within equipment.
2. When the design temperature difference between the interior and exterior of the duct or plenum does not exceed 15°F (8°C).

All ducts, air handlers and filter boxes shall be sealed~~. Joints and seams shall comply with Section 603.9 of~~ in accordance with the ~~*International*~~ *Mechanical Code* and SMACNA Method A.

TABLE 503.2.7 Insulation Of Ducts

Duct Location	Insulation Types Mechanically Cooled and Outside Air	Insulation Types Heating Only
1. On roof or exterior of building	R-8, V, W	R-8,W
2. Located inside the building thermal envelope	R-5,V	R-5
3. Located outside the building thermal envelope	R-8,V	R-8 W

Note: Where ducts are used for both heating and cooling, the minimum insulation shall be as required for the most restrictive condition.

V. Vapor Retarders: Material with a perm rating not exceeding 0.5 perm (29 ng/Pa●s●m^2). All joints to be sealed.

W. Approved weatherproof barrier.

503.2.7.1.3 High-pressure duct systems. Ducts designed to operate at static pressures in excess of 3 inches w.g. (746 Pa) shall be insulated and sealed in accordance with Section 503.2.7. In addition, ducts and plenums shall be leak-tested in accordance with the SMACNA *HVAC Air Duct Leakage Test Manual* with the rate of air leakage. (*CL*) less than or equal to 6.0 as determined in accordance with Equation 5-2.

$$CL = F \text{ ~~*~~ } / P^{0.65} \qquad \textbf{(Equation 5-2)}$$

where:

F = The measured leakage rate in cfm per 100 square feet of duct surface.

P = The static pressure of the test.

Documentation shall be furnished by the ~~designer~~ installer demonstrating that representative sections totaling at least 25 percent of the duct area have been tested and that all tested sections meet the requirements of this section.

TABLE 503.2.8
MINIMUM PIPE INSULATION [a, b, c, d]
(thickness in inches)

FLUID	NOMINAL PIPE DIAMETER		
	<= 1.5	>1.5" – 4" [e]	> 4" [e]
Steam	1 ½	3	4
Hot water	1 ½	2	2
Service Hot Water	1 ½	2	2
Chilled water, brine or refrigerant	1 ½	1 ½	2

For SI: 1 inch = 25.4 mm.

a. Based on insulation having a conductivity (k) not exceeding 0.27 Btu per inch/h · ft^2 · °F.

b. For insulation with a thermal conductivity not equal to 0.27 Btu · inch/h · ft^2 · °F at a mean temperature of 75°F, the minimum required pipe thickness is adjusted using the following equation;
$T = r[(1+tlr)K/k-1]$
where:
T = Adjusted insulation thickness (in).
r = Actual pipe radius (in).
t = Insulation thickness from applicable cell in table (in).
K = New thermal conductivity at 75°F (Btu · in/hr · ft^2 · °F).
k = 0.27 Btu · in/hr · ft^2 · °F.

c. These thicknesses are based on energy efficiency considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.

d. These thicknesses are based on energy efficiency considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.

503.2.9 ~~HVAC system completion.~~ ~~Prior to the issuance of a certificate of occupancy, the design professional shall provide evidence of system completion in accordance with Sections 503.2.9.1 through 503.2.9.3.~~ **General.** Construction documents shall require that all HVAC systems be balanced in accordance with generally accepted engineering standards (see Appendix B). Construction documents shall require that a written balance report be provided to the owner or the designated representative of the building owner for HVAC systems serving *zones* with a total conditioned area exceeding 5000 ft^2.

503.2.9.1 Air system balancing. ~~Each supply air outlet and *zone* terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the *International Mechanical Code*. Discharge dampers are prohibited on constant volume fans and variable volume fans with motors 10 horsepower (hp) (7.5 kW) and larger~~. Air systems shall be balanced in a manner to first minimize throttling losses. Then, for fans with *fan system power* greater than 1 hp, fan speed shall be adjusted to meet design flow conditions. Each supply outlet and zone terminal device shall be equipped with means for air balancing.

503.2.9.2 Hydronic system balancing. ~~Individual hydronic heating and cooling coils shall be equipped with means for balancing and pressure test connections.~~ Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions. Individual hydronic heating and cooling coils shall be equipped with means for balancing and pressure test connections.

Exceptions: Impellers need not be trimmed nor pump speed adjusted:

a. For pumps with pump motors of 10 hp or less.

b. When throttling results in no greater than 5% of the nameplate horsepower draw, or 3 hp, whichever is greater, above that required if the impeller was trimmed.

503.2.9.4 Control Verification. HVAC control systems shall be tested to ensure that control elements are calibrated, adjusted, and in proper working condition, and in accordance with the designed sequence of operations.

503.2.9.5 System Commissioning. HVAC control systems shall be tested to ensure that control elements are calibrated, adjusted, and in proper working condition. For projects larger than 50,000 ft^2 conditioned area, except heated only warehouses and semiheated spaces,

detailed instructions for commissioning HVAC systems (see Informative Appendix B) shall be provided by the designer in plans and specifications.

~~**503.2.10 Air system design and control.** Each HVAC system having a total fan system motor nameplate horsepower (hp) exceeding 5 horsepower (hp) (3.7 kW) shall meet the provisions of Sections 503.2.10.1 through 503.2.10.2.~~

~~**503.2.10.1 Allowable fan floor horsepower.** Each HVAC system at fan system design conditions shall not exceed the allowable fan system motor nameplate hp (Option 1) or fan system bhp (Option 2) as shown in Table 503.2.10.1(1). This includes supply fans, return/relief fans, and fan-powered terminal units associated with systems providing heating or cooling capability.~~

~~**Exceptions:**~~

~~1. Hospital and laboratory systems that utilize flow control devices on exhaust and/or return to maintain space pressure relationships necessary for occupant health and safety or environmental control shall be permitted to use variable volume fan power limitation.~~

~~2. Individual exhaust fans with motor nameplate horsepower of 1 hp (0.7 kW) or less.~~

~~3. Fans exhausting air from fume hoods. (Note: If this exception is taken, no related exhaust side credits shall be taken from Table 503.2.10.1(2) and the Fume Exhaust Exception Deduction must be taken from Table 503.2.10.1(2).~~

[Delete TABLE 503.2.10.1(1) FAN POWER LIMITATION Without Substitution]

[Delete TABLE 503.2.10.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT Without Substitution]

~~**503.2.10.2 Motor nameplate horsepower.** For each fan, the selected fan motor shall be no larger than the first available motor size greater than the brake horsepower (bhp). The fan brake horsepower (bhp) shall be indicated on the design documents to allow for compliance verification by the *code official*.~~

~~**Exceptions:**~~

~~1. For fans less than 6 bhp, where the first available motor larger than the brake horsepower has a nameplate rating within 50 percent of the bhp, selection of the next larger nameplate motor size is allowed.~~

~~2. For fans 6 bhp and larger, where the first available motor larger than the bhp has a nameplate rating within 30 percent of the bhp, selection of the next larger nameplate motor size is allowed.~~

~~**503.3.1 Economizers.** Supply air economizers shall be provided on each cooling system as shown in Table 503.3.1(1).~~

~~Economizers shall be capable of providing 100 percent outdoor air, even if additional mechanical cooling is required to meet the cooling load of the building. Systems shall provide~~

~~a means to relieve excess outdoor air during economizer operation to prevent overpressurizing the building. The relief air outlet shall be located to avoid recirculation into the building. Where a single room or space is supplied by multiple air systems, the aggregate capacity of those systems shall be used in applying this requirement.~~

~~**Exceptions:**~~

1. ~~Where the cooling equipment is covered by the minimum efficiency requirements of Table 503.2.3(1) or 503.2.3(2) and meets or exceeds the minimum cooling efficiency requirement (EER) by the percentages shown in Table 503.3.1(2).~~
2. ~~Systems with air or evaporatively cooled condensors and which serve spaces with open case refrigeration or that require filtration equipment in order to meet the minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.~~

~~**TABLE 503.3.1(1)**~~
~~**ECONOMIZER REQUIREMENTS**~~

~~**Climate Zones**~~	~~**Economizer Requirement**~~
~~1A, 1B, 2A, 7, 8~~	~~No Requirement~~
~~2B, 3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 5C, 6A, 6B~~	~~Economizers on all cooling systems ≥54,000 Btu/h~~ [a]

~~For SI: 1 British thermal unit per hour = 0.293 W.~~

~~a. The total capacity of all systems without economizers shall not exceed 480,000 Btu/h per building, or 20 percent of its air economizer capacity, whichever is greater.~~

503.3.1 Economizers (When used.)

TABLE 503.3.1 High-Limit Shutoff Control Options for Air Economizers

Allowed Control Types	Prohibited Control Types
Fixed dry bulb Fixed enthalpy Electronic enthalpy[a] Differential enthalpy Dew-point and dry-bulb temperature	Differential dry bulb

[a] Electronic enthalpy controllers are devices that use a combination of humidity and dry-bulb temperature in their switching algorithm.

TABLE 503.3.2 High-Limit Shutoff Control Settings for Air Economizers

Device Type	Required High Limit (Economizer Off When):	
	Equation	**Description**
Fixed dry bulb	$T_{OA} > 65°$	*Outdoor air* temperature exceeds 65°F
Fixed enthalpy	$h_{OA} > 28$ Btu/lb[a]	*Outdoor air* enthalpy exceeds 28 Btu/lb of dry air[a]
Electronic enthalpy	$(T_{OA}, RH_{OA}) > A$	*Outdoor air* temperature/RH exceeds the "A" set point curve[a]

Differential enthalpy	$h_{OA} > h_{RA}$	*Outdoor air* enthalpy exceeds return air enthalpy
Dew point and Dry-bulb temperatures	DP_{oa}>55°F or T_{oa}>75°F	*Outdoor air* dry bulb exceeds 75°F or outside dew point exceeds 55°F (65 gr/lb)

[a] Set point "A" corresponds to a curve on the psychometric chart that goes through a point at approximately 75°F and 40% relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

[Delete TABLE 503.3.1(2) EQUIPMENT EFFICIENCY PERFORMANCE EXCEPTION OR ECONOMIZERS Without Substitution]

503.4.1 Reserved. ~~**Economizers.** Supply air economizers shall be provided on each cooling system according to Table 503.3.1(1). Economizers shall be capable of operating at 100 percent outside air, even if additional mechanical cooling is required to meet the cooling load of the building.~~

~~**Exceptions:**~~

1. ~~Systems utilizing water economizers that are capable of cooling supply air by direct or indirect evaporation or both and providing 100 percent of the expected system cooling load at outside air temperatures of 50°F (10°C) dry bulb/45°F (7°C) wet bulb and below.~~
2. ~~Where the cooling equipment is covered by the minimum efficiency requirements of Table 503.2.3(1), 503.2.3(2), or 503.2.3(6) and meets or exceeds the minimum EER by the percentages shown in Table 503.3.1(2)~~
3. ~~Where the cooling equipment is covered by the minimum efficiency requirements of Table 503.2.3(7) and meets or exceeds the minimum integrated part load value (IPLV) by the percentages shown in Table 503.3.1(2).~~

503.4.2 Variable air volume (VAV) fan control.

503.4.2.1 Individual VAV fans with motors of ~~10~~ 5 horsepower (~~7.5~~ 3.75 kW) or greater shall be:

1. Driven by a mechanical or electrical variable speed drive; or
2. The fan motor shall have controls or devices that will result in fan motor demand of no more than 30 percent of their design wattage at 50 percent of design airflow when static pressure set point equals one-third of the total design static pressure, based on manufacturer's certified fan data.

For systems with direct digital control of individual *zone* boxes ~~reporting to the central control panel, the~~ static pressure ~~set point shall be~~ reset shall be used ~~based on the *zone* requiring the most pressure, i.e., the set point is reset lower until one *zone* damper is nearly wide open~~.

503.4.2.1.1 VAV Fans with Motor Requirement of 1 hp and Less. Individual VAV fans with motor requirements of 1 hp and less fan powered terminal units shall be driven by electronically commutated motors (ECM).

Exception: Parallel flow boxes with intermittent heating only fan operation.

503.4.3.2 Two-pipe changeover system. Systems that use a common distribution system to supply both heated and chilled water shall not be used ~~be designed to allow a dead band between changeover from one mode to the other of at least 15°F (8.3°C) outside air temperatures; be designed to and provided with controls that will allow operation in one mode for at least 4 hours before changing over to the other mode; and be provided with controls that allow heating and cooling supply temperatures at the changeover point to be no more than 30°F (16.7°C) apart.~~

503.4.3.3.2 Heat rejection. Heat rejection equipment shall comply with Section~~s~~ 503.4.3.3.2.1 ~~and 503.4.3.3.2.2~~.

503.4.3.3.2.1 Climate Zones ~~3 and 4~~ 2. ~~For Climate Zones 3 and 4 as indicated in Figure 301.1 and Table 301.1:~~

1. If a closed-circuit cooling tower is used directly in the heat pump loop, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower, or lower leakage positive closure dampers shall be provided.
2. If an open-circuit tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the tower.
3. If an open- ~~or closed-~~circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the cooling tower from the heat pump loop, then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

~~**503.4.3.3.2.2 Climate Zones 5 through 8.** For climate Zones 5 through 8 as indicated in Figure 301.1 and Table 301.1, if an open- or closed-circuit cooling tower is used, then a separate heat exchanger shall be required to isolate the cooling tower from the heat pump loop, and heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop and providing an automatic valve to stop the flow of fluid.~~

503.4.3.3.3 Two position valve. Each hydronic heat pump ~~on the hydronic system having a total pump system power exceeding 10 horsepower (hp) (7.5 kW)~~ shall have a two-position automatic valve interlocked to shut off water flow when the compressor is off.

503.4.3.4 Part load controls. Hydronic systems greater than or equal to 300,000 Btu/h (87 930 W) in design output capacity supplying heated or chilled water to comfort conditioning systems shall include controls that have the capability to:

1. Automatically reset the supply-water temperatures using zone-return water temperature, building- return water temperature, or outside air ~~temperature~~ enthalpy as an indicator of building heating or cooling demand. The temperature shall be capable of being reset by at least 25 percent of the design supply-to-return water temperature difference; or
2. Reduce system pump flow by at least 50 percent of design flow rate utilizing adjustable speed drive(s) on pump(s), or multiple-staged pumps where at least one-half of the total pump horsepower is capable of being automatically turned off or

control valves designed to modulate or step down, and close, as a function of load, or other *approved* means.

503.4.4 ~~Heat rejection equipment fan speed control.~~ ~~Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at two-thirds of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.~~

~~**Exception:** Factory-installed heat rejection devices within HVAC equipment tested and rated in accordance with Tables 503.2.3(6) and 503.2.3(7).~~

Dehumidification. Where humidistatic controls are provided, such controls shall prevent reheating, mixing of hot and cold airstreams, or other means of simultaneous heating and cooling of the same airstream.

Exception: For the purposes of humidity control.

503.4.5 Requirements for complex mechanical systems serving multiple zones. Sections 503.4.5.1 through 503.4.5.3 shall apply to complex mechanical systems serving multiple zones. Supply air systems serving multiple zones shall be VAV systems which, during periods of occupancy, (except for dehumidification) shall be ~~are~~ designed and be capable of being controlled to reduce primary air supply to each *zone* to one of the following before reheating, recooling or mixing takes place:

1. ~~Thirty~~ Fifty percent of the maximum supply air to each *zone*.
2. Three hundred cfm (142 L/s) or less where the maximum flow rate is less than 10 percent of the total fan system supply airflow rate.
3. The minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.

Exception: The following define when individual zones or when entire air distribution systems are exempted from the requirement for VAV control:

1. Zones where special pressurization relationships or cross-contamination requirements are such that VAV systems are impractical.
2. Zones or supply air systems where at least 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered or site-solar energy source.
3. Zones where special humidity levels are required to satisfy process needs.
4. Zones with a peak supply air quantity of 300 cfm (142 L/s) or less and where the flow rate is less than 10 percent of the total fan system supply airflow rate.
5. Zones where the volume of air to be reheated, recooled or mixed is no greater than the volume of outside air required to meet the minimum ventilation requirements of Chapter 4 of the *International Mechanical Code*.
6. Zones or supply air systems with thermostatic and humidistatic controls capable of operating in sequence the supply of heating and cooling energy to the *zone*(s) and which are capable of preventing reheating, recooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has been previously mechanically heated.

503.4.5.1 Single duct variable air volume (VAV) systems, terminal devices. Single duct VAV systems shall use terminal devices capable of reducing the supply of primary supply air before reheating or recooling takes place. Individual VAV fans with motor requirements of 1 hp and less fan powered terminal units shall be driven by electronically commutated motors (ECM).

Exception: Parallel flow boxes with intermittent heating only fan operation.

503.4.5.4 Supply-air temperature reset controls. Multiple *zone* HVAC systems shall include controls that have the capability to automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls shall be capable of resetting the supply air temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

Exceptions:

1. Systems that prevent reheating, recooling or mixing of heated and cooled supply air.
2. Seventy five percent of the energy for reheating is from site-recovered or site solar energy sources.
3. Zones with peak supply air quantities of 300 cfm (142 L/s) or less.

503.4.6 Reserved. ~~**Heat recovery for service water heating.** Condenser heat recovery shall be installed for heating or reheating of service hot water provided the facility operates 24 hours a day, the total installed heat capacity of water-cooled systems exceeds 6,000,000 Btu/hr of heat rejection, and the design service water heating load exceeds 1,000,000 Btu/h.~~

~~The required heat recovery system shall have the capacity to provide the smaller of:~~

~~1. Sixty percent of the peak heat rejection load at design conditions; or~~

~~2. The preheating required to raise the peak service hot water draw to 85°F (29°C).~~

~~**Exceptions:**~~

~~1. Facilities that employ condenser heat recovery for space heating or reheat purposes with a heat recovery design exceeding 30 percent of the peak water-cooled condenser load at design conditions.~~

~~2. Facilities that provide 60 percent of their service water heating from site solar or site recovered energy or from other sources.~~

504.5 Pipe insulation. For automatic-circulating hot water systems, piping shall be insulated to the levels shown in Table 503.2.8 for the following: ~~with 1 inch (25 mm) of insulation having a conductivity not exceeding 0.27 Btu per inch/h × ft^2 × °F (1.53 W per 25 mm/m^2 × K). The first 8 feet (2438 mm) of p~~

1. Piping in noncirculating systems served by equipment without integral heat traps ~~shall be insulated with 0.5 inch (12.7 mm) of material having a conductivity not exceeding 0.27 Btu per inch/h × ft^2 × °F (1.53 W per 25 mm/m^2 × K)~~.
2. Recirculating system piping, including the supply and return piping of a circulating tank type water heater.
3. The inlet pipe between the storage tank and a heat trap in a nonrecirculating storage *system*.

4. Pipes that are externally heated (such as heat trace or impedance heating).

505.6.1 Exterior building grounds lighting. All exterior building grounds luminaires that operate at greater than 100 watts shall contain lamps having a minimum efficacy of ~~60~~ 45 lumens per watt unless the luminaire is controlled by a motion sensor or qualifies for one of the exceptions under Section 505.6.2.

506.2 Mandatory requirements. Compliance with this section requires that the criteria of Sections 502.4, 502.5, 502.6, 503.2, 504 and 505 be met.

INFORMATIVE APPENDIX A

COOL ROOF GUIDELINE

A1. BACKGROUND

Cool roofs are highly reflective and limit heat absorption in a roof to reduce temperatures as much as 60 degrees lower than a typical roof. According to the *Cool Roof Rating Council* http://www.coolroofs.org/, there are hundreds of products that have been tested to meet the Houston criteria and more continue to be tested. Qualified roof covering materials include a broad spectrum from coatings to modified bitumen, metal, single ply, and the exposed surface of a built-up roof.

A2. DEFINITIONS

Building Envelope. The exterior plus the semi-exterior portions of a building. For the purposes of determining building envelope requirements, the classifications are defined as follows:

Building Envelope, Exterior: the elements of a building that separate conditioned spaces from the exterior.

Building Envelope, Semi-exterior: the elements of a building that separate conditioned space from unconditioned space or that enclose semiheated spaces through which thermal energy may be transferred to or from the exterior, or to or from unconditioned spaces, or to or from conditioned spaces.

Positive Roof Drainage. The drainage condition in which consideration has been made for all loading deflections of the roof deck, and additional slope has been provided to ensure drainage of the roof within 48 hours of precipitation. ***(IBC)***

Roof. The upper portion of the building envelope, including opaque areas and fenestration, that is horizontal or tilted at an angle of less than 60° from horizontal. For the purposes of determining building envelope requirements, the classifications are defined as follows:

a. ***attic and other roofs:*** all other roofs, including roofs with insulation entirely below (inside of) the roof structure (i.e., attics, cathedral ceilings, and single rafter ceilings), roofs with insulation both above and below the roof structure, and roofs without insulation but excluding metal building roofs.

b. ***metal building roof:*** a roof that is constructed with:

1. a metal, structural, weathering surface,

2. has no ventilated cavity, and

3. has the insulation entirely below deck (i.e., does not include composite concrete and metal deck construction nor a roof framing system that is separated from the superstructure by a wood substrate) and whose structure consists of one or more of the following configurations:

(a) metal roofing in direct contact with the steel framing members or

(b) insulation between the metal roofing and the steel framing members or

(c) insulated metal roofing panels installed as described in 1 or 2.

c. ***roof with insulation entirely above deck:*** a roof with all insulation:

1. installed above (outside of) the roof structure and

2. continuous (i.e., uninterrupted by framing members).

d. ***single-rafter roof*****:** a subcategory of attic roofs where the roof above and the ceiling below are both attached to the same wood rafter and where insulation is located in the space between these wood rafters.

Roof Covering. The covering applied to the roof deck for weather resistance, fire classification or appearance. ***(IBC)***

Roof Recover. The process of installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering. ***(IBC)***

Roof Replacement. The process of removing the existing roof covering, repairing any damaged substrate & installing a new roof covering. ***(IBC)***

Reroofing. The process of recovering or replacing an existing roof covering. See "Roof recover" and "Roof replacement." ***(IBC)***

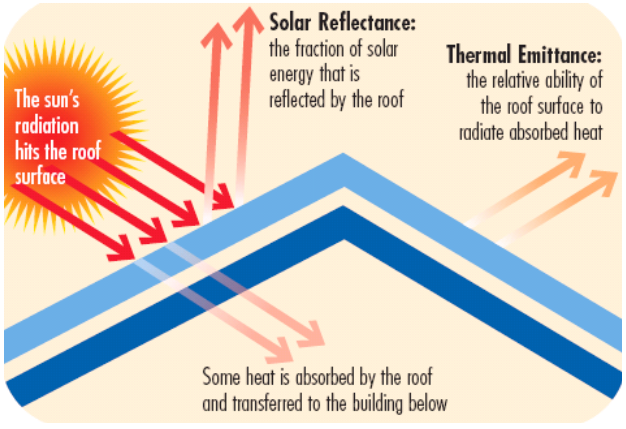
Roof Repair. Reconstruction or renewal of any part of an existing roof for the purposes of its maintenance. ***(IBC)***

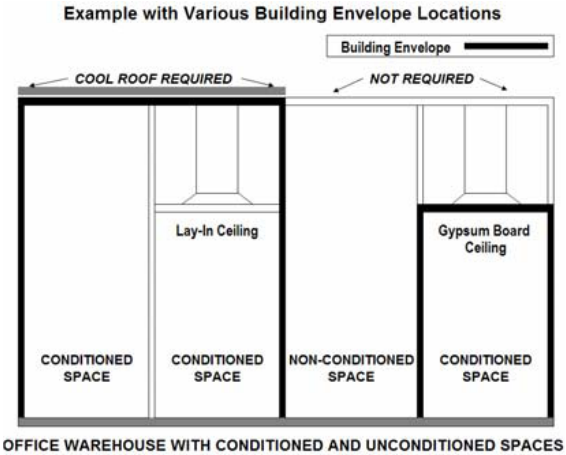
A3. REQUIREMENT

There are two (2) basic tests which classify the roof covering material. Results range from 0.0 to 1.0:

Solar Reflectance**:** the ratio of the light reflected by a surface to the light incident upon it. Minimum 0.70 required.

Thermal Emittance**:** the ratio of the radiant heat flux emitted by a specimen to that emitted by a blackbody at the same temperature and under the same conditions. Minimum 0.75 required.





A4. EXISTING BUILDING ENVELOPE

When there is no change to the status of an existing roof building envelope it does not need to meet the new guidelines. If the roof is already a building envelope and is not being reconstructed it may remain unchanged. For example, where a retail strip center has a change of occupancy to a restaurant and the roof is unaffected, it is not required to meet new provisions. If

the existing roof was not a building envelope, and will not become part of the building envelope due to changing the space below to conditioned space, the existing roof may remain.

A5. APPLICABILITY

Commercial Buildings or Multi-Family Residential Buildings over 3 stories, with a roof slope up to 2:12 pitch when any of the following occur:

1. **New building** (or addition) enclosing conditioned space where the roof serves as a portion of the building envelope.
2. **Conversion of a building** (or space) from unconditioned to conditioned space where the roof serves as a portion of the building envelope.
3. **Alteration or repair** (re-roof) to existing roofs where the roof serves as a portion of the building envelope. Alterations made to an existing roof that affect the existing building envelope must comply. Those that do not affect an existing building envelope may remain unchanged. These are the situations that affect whether the cool roof requirement applies:

SCOPE OF WORK	EXISTING ROOF COVERING	EXISTING INSULATION	REQUIREMENT
1. COMPLETE REMOVAL OF ROOF MATERIALS TO DECK	Removed	Above Deck Removed	Roof Insulation and Cool Roof
		Below Deck Remains	No Requirement
2. REPLACE PORTIONS OF ROOF FULL DEPTH (THICKNESS) [a]	Patches	Patches	Repair affected area to existing
	Edge-to-edge, and Corner-to-corner	Removed	Replace that portion of the roof insulation and cool roof
	NOT an Edge-to-edge, or Corner-to-corner but > 50% total area	Removed	Roof Insulation and Cool Roof
3. REPLACE ROOF COVERING ONLY (RECOVER)	Removed	Exposed	Roof Insulation and Cool Roof
		Not Exposed	No Requirement
4. APPLY COATINGS ONLY	Remains	Remains or None	No Requirement

a. The roof area will be between expansion joints or between area dividers such as parapets or edges.

A6. EXEMPTIONS

The provisions of this code do not apply to: (a) single-family houses, multi-family structures of three stories or fewer above grade, manufactured houses (mobile homes) and manufactured houses (modular), (b) buildings that do not use either electricity or fossil fuel, or (c) equipment and portions of building systems that use energy primarily to provide for industrial, manufacturing, or commercial processes. *When a space is conditioned solely for process energy needs, including product storage requirements such as humidity control or refrigeration, it is not required to meet the cool roof provisions.*

A7. ELEMENTS

A7.1 Gravel Roofs

Crushed stone and gravel roof coverings are prohibited in the City of Houston. This does not apply to ballast rock with minimum 1 ½ inch diameter.

A7.2 Lay-in Ceilings

Lay-in ceilings with insulation are not considered part of the building envelope because they allow air infiltration.

A7.3 Re-roofs

Roof covering replacements require positive roof drainage.

INFORMATIVE APPENDIX B

INFORMATIVE REFERENCES

This appendix contains informative references for the convenience of users of this code and to acknowledge source documents when appropriate. Some documents are also included in Section 12 "Normative References," because there are other citations of those documents within the code that are normative.

AABC
Associated Air Balance Council
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Washington, DC 20005
aabchg@aol.com

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http://www.nebb.org

SMACNA
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National Association
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