HOUSTON
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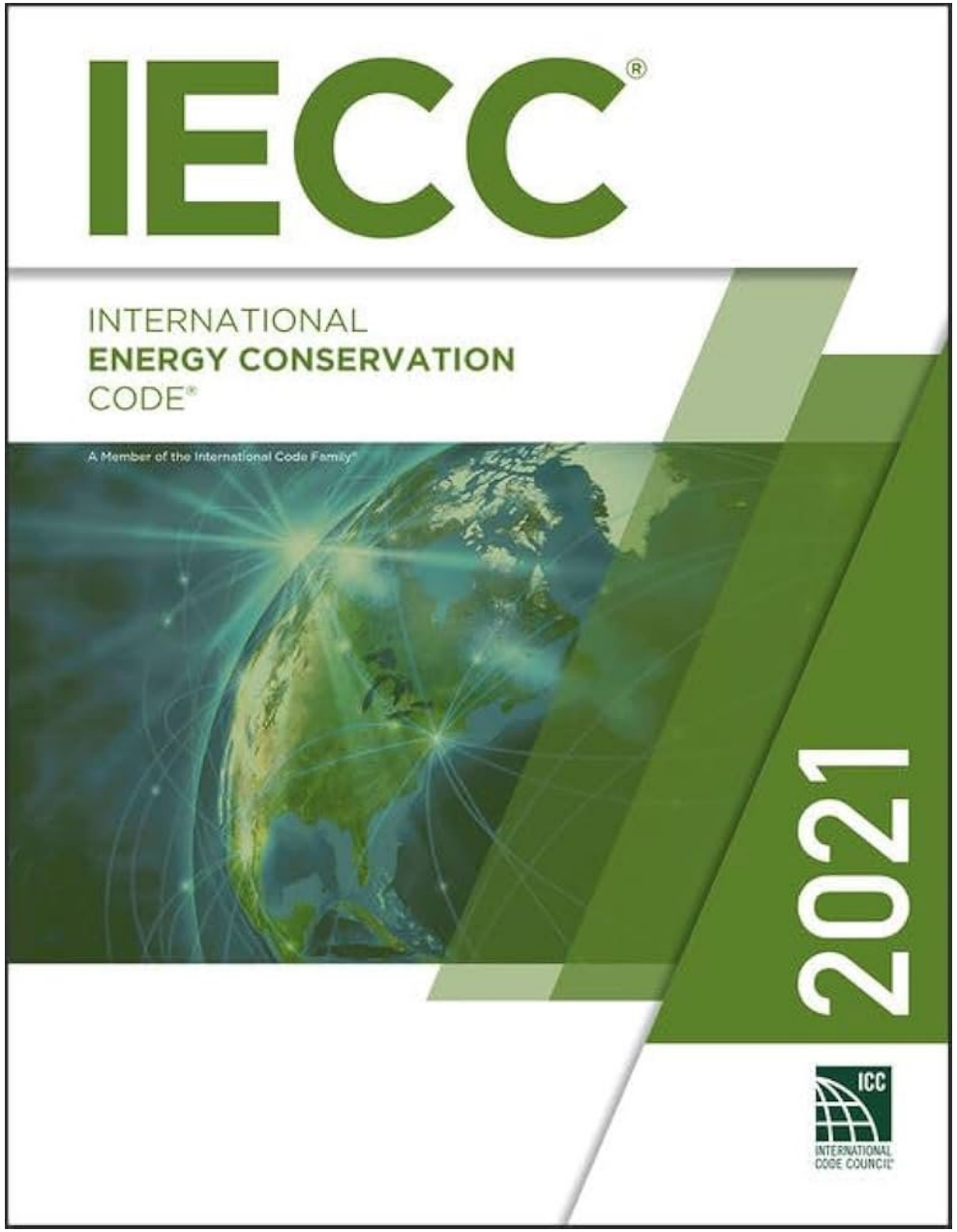
# HOUSTON CONSTRUCTION CODE MODERNIZATION

## SIGNIFICANT CODE CHANGES & HIGHLIGHTS OF THE 2018 AND 2021 INTERNATIONAL ENERGY CONSERVATION CODE (IECC)




# 2021 ENERGY CONSERVATION CODE

Significant changes to base code requirements from 2015 to 2018 and 2018 to 2021

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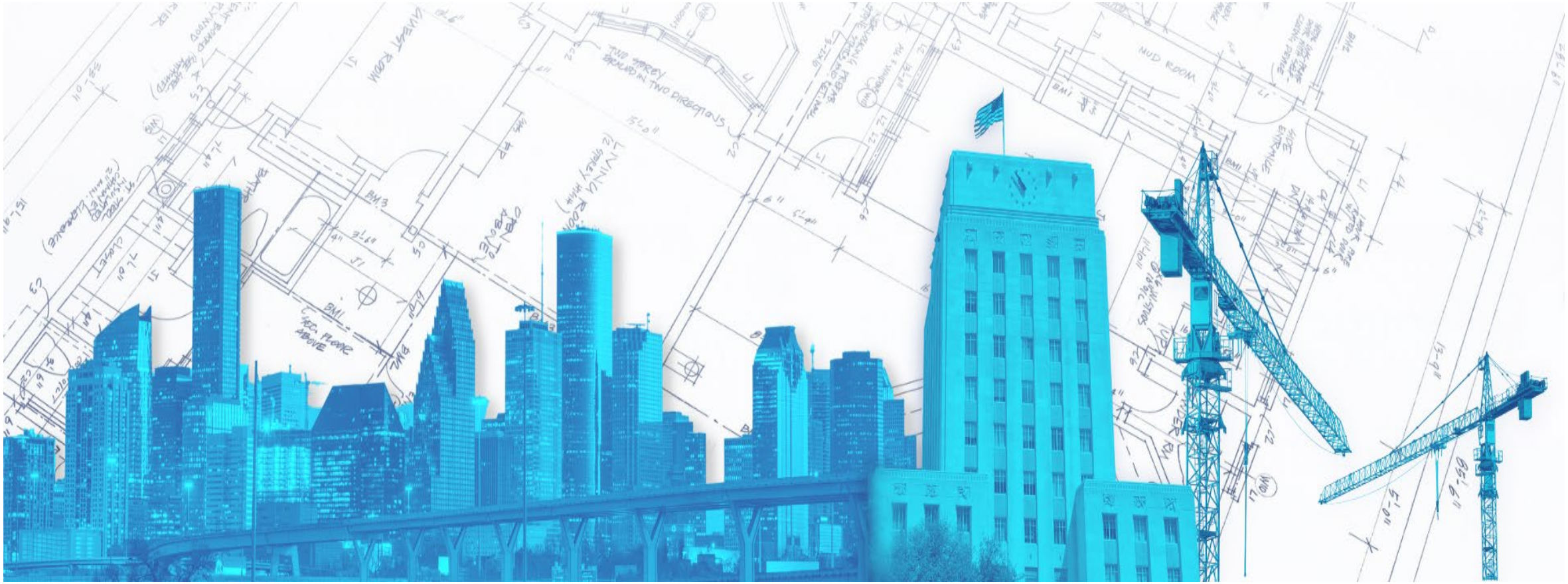
# IECC CHAPTER 2 DEFINITIONS - COMMERCIAL



# GENERAL DEFINITIONS: C202 (2021 EDITION)

- Additions and revisions in C202:

**VEGETATIVE ROOF.** An assembly of interacting components designed to waterproof a building's top surface that includes, by design, vegetation and related landscape elements.

**VISIBLE TRANSMITTANCE, ANNUAL ($VT_{annual}$).** The ratio of visible light entering the space through the fenestration product assembly to the incident visible light during the course of a year, which includes the effects of glazing material, frame, and light well or tubular conduit, and is expressed as a number between 0 and 1.

**COMPUTER ROOM.** A room whose primary function is to house equipment for the processing and storage of electronic data ~~and that~~ which has a design ~~electronic data~~ total information technology equipment (ITE) equipment power density ~~of~~ less than or equal to 20 watts per square foot (20 watts per 0.092 $m^2$) of conditioned ~~floor~~ area or a ~~connected~~ design ~~electronic data~~ total ITE equipment load ~~of~~ less than or equal to 10 kW.

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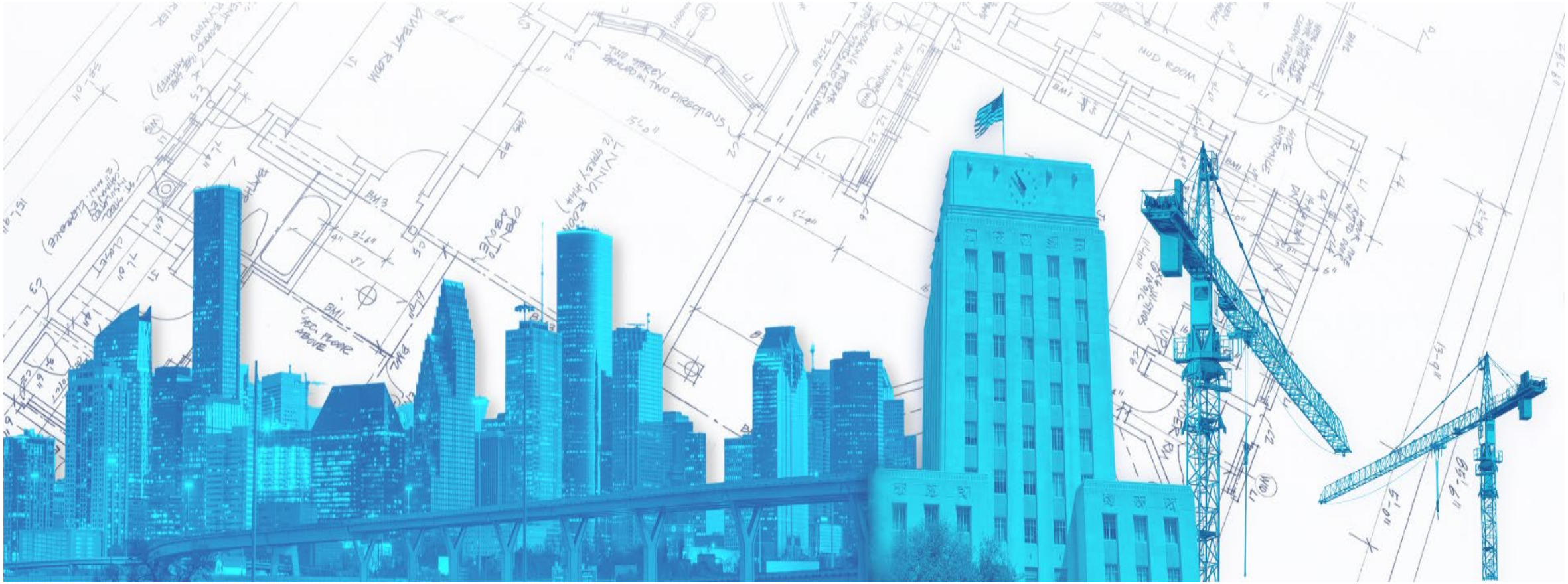
# IECC CHAPTER 4 COMMERCIAL ENERGY EFFICIENCY



# GENERAL: C401 (2021 EDITION)

- Addition in C401.3:

**C401.3 Thermal envelope certificate.** A permanent thermal envelope certificate shall be completed by an *approved* party. Such certificate shall be posted on a wall in the space where the space conditioning equipment is located, a utility room or other *approved* location. If located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. A copy of the certificate shall also be included in the construction files for the project. The certificate shall include the following:

1. *R*-values of insulation installed in or on ceilings, roofs, walls, foundations and slabs, *basement walls*, crawl space walls and floors and ducts outside *conditioned spaces*.
2. *U*-factors and *solar heat gain coefficients* (SHGC) of fenestrations.
3. Results from any *building* envelope air leakage testing performed on the *building*.

Where there is more than one value for any component of the building envelope, the certificate shall indicate the area-weighted average value where available. If the area-weighted average is not available, the certificate shall list each value that applies to 10 percent or more of the total component area.

# BUILDING ENVELOPE REQUIREMENTS: C402 (2018 EDITION)

- Addition in C402.1.3:

**C402.1.3 Insulation component R-value-based method.**
*Building thermal envelope* opaque assemblies shall ~~meet~~comply with the requirements of Sections C402.2 and C402.4 based on the *climate zone* specified in Chapter 3. For opaque portions of the *building thermal envelope* intended to comply on an insulation component *R-value* basis, the *R*-values for insulation ~~in framing cavities, where required, and for continuous insulation, where required,~~ shall be not less than that specified in Table C402.1.3~~, 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 C402.1.3. 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 C402.1.3.~~The thermal resistance or R-value of the insulating material installed continuously within or on the below-grade exterior walls of the building envelope required in accordance with Table C402.1.3 shall extend to a depth of not less than 10 feet (3048 mm) below the outside finished ground level, or to the level of the lowest floor of the conditioned space enclosed by the below-grade wall, whichever is less. Opaque swinging doors shall comply with Table C402.1.4 and opaque nonswinging doors shall comply with Table C402.1.3.~~

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Addition in C402.1.3:

**C402.1.3 Insulation component *R*-value-based method.** *Building thermal envelope* opaque assemblies shall comply with the requirements of **Sections C402.2** and **C402.4** based on the *climate zone* specified in **Chapter 3**. For opaque portions of the *building thermal envelope* intended to comply on an insulation component *R*-value basis, the *R*-values for cavity insulation and continuous insulation shall be not less than that specified in **Table C402.1.3**. Where cavity insulation is installed in multiple layers, the cavity insulation *R*-values shall be summed to determine compliance with the cavity insulation *R*-value requirements. Where continuous insulation is installed in multiple layers, the continuous insulation *R*-values shall be summed to determine compliance with the continuous insulation *R*-value requirements. Cavity insulation *R*-values shall not be used to determine compliance with the continuous insulation *R*-value requirements in **Table C402.1.3**. Commercial buildings or portions of commercial buildings enclosing *Group R* occupancies shall use the *R*-values from the "*Group R*" column of **Table C402.1.3**. 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 C402.1.3**.

# BUILDING ENVELOPE REQUIREMENTS: C402 (2018 EDITION)

- Revisions in Table C402.1.3 for Heated Slab Insulation:

**TABLE C402.1.3**
**OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD[a, i]**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heated slabs[h] | R-7.5 for 12" below + R-5 full slab | R-7.5 for 12" below + R-5 full slab | R-7.5 for 12" below + R-5 full slab | R-7.5 for 12" below + R-5 full slab | R-10 for 24" below + R-5 full slab | R-10 for 24" below + R-5 full slab | R-15 for 24" below + R-5 full slab | R-15 for 24" below + R-5 full slab | R-15 for 36" below + R-5 full slab | R-15 for 36" below + R-5 full slab | R-15 for 36" below + R-5 full slab | R-20 for 48" below + R-5 full slab | R-20 for ~~24~~ 48" below + R-5 full slab | R-20 for 48" below + R-5 full slab | R-20 for 48" below + R-5 full slab | R-20 for 48" below + R-5 full slab |

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in Table C402.1.3 for Roofs:

**TABLE C402.1.3**
**OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, *R*-VALUE METHOD**

| CLIMATE ZONE | 0 AND 1 | | 2 | | 3 | | 4 EXCEPT MARINE | | 5 AND MARINE 4 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R |
| **Roofs** | | | | | | | | | | | | | | | | |
| Insulation entirely above roof deck | R-20ci | R-25ci | R-25ci | R-25ci | R-25ci | R-25ci | R-30ci | R-30ci | R-30ci | R-30ci | R-30ci | R-30ci | R-35ci | R-35ci | R-35ci | R-35ci |
| Metal buildings[b] | R-19 + R-11 LS | R-19 + R-11 LS | R-19 +R11 LS | R-19 + R-11 LS | R-19 + R-11 LS | R-19 + R-11 LS | R-19 + R-11 LS | R-19 + R-11 LS | R-19 + R-11 LS | R-19 + R-11 LS | R-25 + R-11 LS | ~~R-25 + R-11 LS~~R-30 + R-11 LS | R-30 + R-11 LS | R-30 + R-11 LS | ~~R-30 +R-11 LS~~R-25 + R-11 + R-11 LS | ~~R-30 +R-11 LS~~R-25 + R-11 + R-11 LS |
| Attic and other | R-38 | R-38 | R-38 | R-38 | R-38 | R-38 | ~~R-38~~R-49 | ~~R-38~~R-49 | ~~R-38~~R-49 | R-49 | R-49 | R-49 | ~~R-49~~R-60 | ~~R-49~~R-60 | ~~R-49~~R-60 | ~~R-49~~R-60 |

HOUSTON PUBLIC WORKS

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in Table C402.1.3 for Above Grade Walls:

**TABLE C402.1.3**
**OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, *R*-VALUE METHOD**[a][i]

| CLIMATE ZONE | 0 AND 1 | | 2 | | 3 | | 4 EXCEPT MARINE | | 5 AND MARINE 4 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R |
| Mass[g] | R-5.7ci[c] | R-5.7ci[c] | R-5.7ci[c] | R-7.6ci | R-7.6ci | R-9.5ci | R-9.5ci | R-11.4ci | R-11.4ci | R-13.3ci | R-13.3ci | R-15.2ci | R-15.2ci | R-15.2ci | R-25ci | R-25ci |
| Metal building | R-13 +R-6.5ci | R-13 +R-6.5ci | R13 + R-6.5ci | R-13 + R-13ci | R-13 + R-6.5ci | R-13 + R-13ci | R-13 + R-13ci | ~~R-13 + R-13ci~~R-13 + R-14ci | ~~R-13 + R-13ci~~R-13 + R-14ci | ~~R-13 + R-13ci~~R-13 + R-14ci | ~~R-13 + R-13e~~R-13 + R-14ci | ~~R-13 + R-13e~~R-13 + R-14ci | ~~R-13 + R-13e~~R-13 + R-17ci | R-13 + R-19.5ci | ~~R-13 + R-13e~~R-13 + R-19.5ci | R-13 + R-19.5ci |
| Metal framed | R-13 + R-5ci | R-13 + R-5ci | R-13 + R-5ci | R-13 +R-7.5ci | R-13 +R-7.5ci | R-13 +R-7.5ci | R-13 +R-7.5ci | R-13 +R-7.5ci | ~~R-13 +R-7.5ci~~R-13 + R-10ci | ~~R-13 +R-7.5ci~~R-13 + R-10ci | ~~R-13 +R-7.5ci~~R-13 + R-12.5ci | ~~R-13 +R-7.5ci~~R-13 + R-12.5ci | ~~R-13 +R-7.5ci~~R-13 + R-12.5ci | R-13 + R-15.6ci | ~~R-13 +R-7.5ci~~R-13 + R-18.8ci | ~~R-13 +R-17.5ci~~R-13 + R-18.8ci |
| Wood framed and other | R-13 +R-3.8ci or R-20 | R-13 +R-3.8ci or R-20 | R-13 +R-3.8ci or R-20 | R-13 +R-3.8ci or R-20 | R-13 +R-3.8ci or R-20 | R-13 +R-3.8ci or R-20 | R-13 +R-3.8ci or R-20 | R-13 +R-3.8ci or R-20 | ~~R-13 + R-3.8ci or R-29~~R-13 + R-7.5ci or R20 + R3.8ci | R-13 + R-7.5ci or R-20 +R-3.8ci | R-13 + R-7.5ci or R-20 +R-3.8ci | R-13 + R-7.5ci or R-20 +R-3.8ci | R-13 + R-7.5ci or R-20 +R-3.8ci | R-13 + R-7.5ci or R-20 +R-3.8ci | ~~R13 +R-15.6ci orR-20 +R-10ci~~R-13 + R-18.8ci | ~~R13 +R-15.6ci orR-20 +R-10ci~~R-13 + R-18.8ci |

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in Table C402.1.3 for Below Grade Walls:

**TABLE C402.1.3**
**OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, *R*-VALUE METHOD**[a,b]

| CLIMATE ZONE | 0 AND 1 | | 2 | | 3 | | 4 EXCEPT MARINE | | 5 AND MARINE 4 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R |
| **Walls, below grade** | | | | | | | | | | | | | | | | |
| Below-grade wall[d] | NR | NR | NR | NR | NR | NR | R-7.5ci | ~~R-7.5ci~~R-10ci | R-7.5ci | ~~R-7.5ci~~R-10ci | ~~R-7.5ci~~R-10ci | ~~R-7.5ci~~R-15ci | ~~R-10ci~~R-15ci | ~~R-10ci~~R-15ci | ~~R-10ci~~R-15ci | ~~R-12.5ci~~R-15ci |

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in Table C402.1.3 for Exterior Floors:

**TABLE C402.1.3**
**OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, *R*-VALUE METHOD**[a][j]

| CLIMATE ZONE | 0 AND 1 | | 2 | | 3 | | 4 EXCEPT MARINE | | 5 AND MARINE 4 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R |
| **Floors** | | | | | | | | | | | | | | | | |
| Mass[e] | NR | NR | R-6.3ci | R-8.3ci | R-10ci | R-10ci | ~~R-10ci~~R-14.6ci | ~~R-10ci~~R-16.7ci | ~~R-10ci~~R-14.6ci | ~~R-~~ ~~12.5ci~~R-16.7ci | ~~R-~~ ~~12.5ci~~R-16.7ci | ~~R-~~ ~~12.5ci~~R-16.7ci | ~~R-15ci~~R-20.9ci | ~~R-~~ ~~16.7ci~~R-20.9ci | ~~R-15ci~~R-23ci | ~~R-~~ ~~16.7ci~~R-23ci |
| Joist/framing | ~~NR~~R-13 | ~~NR~~R-13 | R-30 | R-30 | R-30 | R-30 | R-30 | R-30 | R-30 | R-30 | ~~R-~~ ~~30~~R-38 | ~~R-30[f]~~R-38 | ~~R-30[f]~~R-38 | ~~R-30[f]~~R-38 | ~~R-30[f]~~R-38 | ~~R-30[f]~~R-38 |

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in Table C402.1.3 for Slabs and Floors:

**TABLE C402.1.3**
**OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, *R*-VALUE METHOD**[a]

| CLIMATE ZONE | 0 AND 1 | | 2 | | 3 | | 4 EXCEPT MARINE | | 5 AND MARINE 4 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R |
| Unheated slabs | NR | NR | NR | NR | NR | ~~NR~~R-10 for 24" below | ~~R-10 for24" below~~R-15 for 24" below | ~~R-10 for24" below~~R-15 for 24" below | ~~R-10 for24" below~~R-15 for 24" below | ~~R-10 for24" below~~R-20 for 24" below | ~~R-10 for24" below~~R-20 for 24" below | ~~R-15 for24" below~~R-20 for 24" below | ~~R-15 for24" below~~R-20 for 48" below | ~~R-15 for24" below~~R-20 for 48" below | ~~R-15 for24" below~~R-20 for 48" below | ~~R-20 for24" below~~R-25 for 48" below |

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in Table C402.1.3 for Doors:

TABLE C402.1.4
OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, *U*-FACTOR METHOD[a, b]

| CLIMATE ZONE | 0 AND 1 | | 2 | | 3 | | 4 EXCEPT MARINE | | 5 AND MARINE 4 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R |
| Opaque doors | | | | | | | | | | | | | | | | |
| Nonswinging door | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 |
| Swinging door[h] | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | U-0.37 | U-0.37 | U-0.37 | U-0.37 | U-0.37 | U-0.37 | U-0.37 | U-0.37 |
| Garage door < 14% glazing[i] | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 |

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in Table C402.1.3 for Doors:

TABLE C402.1.4
OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, *U*-FACTOR METHOD[a, b]

| CLIMATE ZONE | 0 AND 1 | | 2 | | 3 | | 4 EXCEPT MARINE | | 5 AND MARINE 4 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R | All other | Group R |
| Opaque doors | | | | | | | | | | | | | | | | |
| Nonswinging door | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 |
| Swinging door[h] | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | ~~U-0.61~~U-0.37 | U-0.37 | U-0.37 | U-0.37 | U-0.37 | U-0.37 | U-0.37 | U-0.37 | U-0.37 |
| Garage door < 14% glazing[i] | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 |

# BUILDING ENVELOPE REQUIREMENTS: C402 (2018 EDITION)

- Revisions in Table C402.1.4 for Garage Door Glazing:

**TABLE C402.1.4**
**OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, U-FACTOR METHOD[a, b]**

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Garage door ≤14% glazing | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 | U-0.31 |

# BUILDING ENVELOPE REQUIREMENTS: C402 (2018 EDITION)

- Addition of C402.2.7:

C402.2.7 Airspaces.
Where the thermal properties of airspaces are used to comply with this code in accordance with Section C401.2, such airspaces shall be enclosed in an unventilated cavity constructed to minimize airflow into and out of the enclosed airspace. Airflow shall be deemed minimized where the enclosed airspace is located on the interior side of the continuous air barrier and is bounded on all sides by building components.

Exception: The thermal resistance of airspaces located on the exterior side of the continuous air barrier and adjacent to and behind the exterior wall-covering material shall be determined in accordance with ASTM C1363 modified with an airflow entering the bottom and exiting the top of the airspace at an air movement rate of not less than 70 mm/second.

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in C402.2.7:

**C402.2.7 Airspaces.** Where the ~~thermal properties of airspaces are used to comply with this code~~ *R*-value of an airspace is used for compliance in accordance with ~~Section C401.2, such airspaces~~ **Section C402.1**, the airspace shall be enclosed in an unventilated cavity constructed to minimize airflow into and out of the enclosed airspace. Airflow shall be deemed minimized where the enclosed airspace is located on the interior side of the continuous air barrier and is bounded on all sides by building components.

**Exception:** The thermal resistance of airspaces located on the exterior side of the continuous air barrier and adjacent to and behind the exterior wall-covering material shall be determined in accordance with **ASTM C1363** modified with an airflow entering the bottom and exiting the top of the airspace at an air movement rate of not less than 70 mm/second.

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in C402.3:

**C402.3 Roof solar reflectance and thermal emittance.** Low-sloped roofs directly above cooled conditioned spaces in *Climate Zones* ~~1, 2 and~~ 0 through 3 shall comply with one or more of the options in **Table C402.3**.

**Exceptions:** The following roofs and portions of roofs are exempt from the requirements of **Table C402.3**:

1. Portions of the roof that include or are covered by the following:
   - 1.1. Photovoltaic systems or components.
   - 1.2. Solar air or water-heating systems or components.
   - 1.3. ~~Roof gardens~~Vegetative roofs or landscaped roofs.
   - 1.4. Above-roof decks or walkways.
   - 1.5. Skylights.
   - 1.6. HVAC systems and components, and other opaque objects mounted above the roof.
2. Portions of the roof shaded during the peak sun angle on the summer solstice by permanent features of the building or by permanent features of adjacent buildings.
3. Portions of roofs that are ballasted with a minimum stone ballast of 17 pounds per square foot (74 kg/m$^2$) or 23 psf (117 kg/m$^2$) pavers.
4. Roofs where not less than 75 percent of the roof area complies with one or more of the exceptions to this section.

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in Table C402.4 for Vertical Fenestration:

**TABLE C402.4**
**BUILDING ENVELOPE FENESTRATION MAXIMUM *U*-FACTOR AND SHGC REQUIREMENTS**

| CLIMATE ZONE | 0 AND 1 | 2 | 3 | 4 EXCEPT MARINE | 5 AND MARINE 4 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Vertical fenestration | | | | | | | | |
| *U*-factor | | | | | | | | |
| Fixed fenestration | 0.50 | ~~0.50~~0.45 | ~~0.46~~0.42 | ~~0.38~~0.36 | ~~0.38~~0.36 | ~~0.36~~0.34 | 0.29 | ~~0.29~~0.26 |
| Operable fenestration | ~~0.65~~0.62 | ~~0.65~~0.60 | ~~0.60~~0.54 | 0.45 | 0.45 | ~~0.43~~0.42 | ~~0.37~~0.36 | ~~0.37~~0.32 |
| Entrance doors | ~~1.10~~0.83 | ~~0.83~~0.77 | ~~0.77~~0.68 | ~~0.77~~0.63 | ~~0.77~~0.63 | ~~0.77~~0.63 | ~~0.77~~0.63 | ~~0.77~~0.63 |

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in Table C402.4 for SHGC:

**TABLE C402.4**
**BUILDING ENVELOPE FENESTRATION MAXIMUM *U*-FACTOR AND SHGC REQUIREMENTS**

| CLIMATE ZONE | 0 AND 1 | | 2 | | 3 | | 4 EXCEPT MARINE | | 5 AND MARINE 4 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SHGC | | | | | | | | | | | | | | | |
| | ~~SEW~~Fixed | ~~N~~Operable | ~~SEW~~Fixed | ~~N~~Operable | ~~SEW~~Fixed | ~~N~~Operable | ~~SEW~~Fixed | ~~N~~Operable | ~~SEW~~Fixed | ~~N~~Operable | ~~SEW~~Fixed | ~~N~~Operable | ~~SEW~~Fixed | ~~N~~Operable | ~~SEW~~Fixed | ~~N~~Operable |
| PF < 0.2 | ~~0.25~~0.23 | ~~0.33~~0.21 | 0.25 | ~~0.33~~0.23 | 0.25 | ~~0.33~~0.23 | 0.36 | ~~0.48~~0.33 | 0.38 | ~~0.51~~0.33 | ~~0.40~~0.38 | ~~0.53~~0.34 | ~~0.45~~0.40 | ~~NR~~0.36 | ~~0.45~~0.40 | ~~NR~~0.36 |
| 0.2 ≤ PF < 0.5 | ~~0.30~~0.28 | ~~0.37~~0.25 | 0.30 | ~~0.37~~0.28 | 0.30 | ~~0.37~~0.28 | 0.43 | ~~0.53~~0.40 | 0.46 | ~~0.56~~0.40 | ~~0.48~~0.46 | ~~0.58~~0.41 | ~~NR~~0.48 | ~~NR~~0.43 | ~~NR~~0.48 | ~~NR~~0.43 |
| PF ≥ 0.5 | ~~0.40~~0.37 | ~~0.40~~0.34 | 0.40 | ~~0.40~~0.37 | 0.40 | ~~0.40~~0.37 | 0.58 | ~~0.58~~0.53 | 0.61 | ~~0.61~~0.53 | ~~0.64~~0.61 | ~~0.64~~0.54 | ~~NR~~0.64 | ~~NR~~0.58 | ~~NR~~0.64 | ~~NR~~0.58 |

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in Table C402.4 for Skylights:

**TABLE C402.4**
**BUILDING ENVELOPE FENESTRATION MAXIMUM *U*-FACTOR AND SHGC REQUIREMENTS**

| CLIMATE ZONE | 0 AND 1 | 2 | 3 | 4 EXCEPT MARINE | 5 AND MARINE 4 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Skylights | | | | | | | | |
| *U*-factor | ~~0.75~~0.70 | 0.65 | 0.55 | 0.50 | 0.50 | 0.50 | ~~0.50~~0.44 | ~~0.50~~0.41 |
| SHGC | ~~0.35~~0.30 | ~~0.35~~0.30 | ~~0.35~~0.30 | 0.40 | 0.40 | 0.40 | NR | NR |

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in C402.4.2:

**C402.4.2 Minimum skylight fenestration area.** ~~In an enclosed space~~ Skylights shall be provided in enclosed spaces greater than 2,500 square feet (232 $m^2$) in floor area, directly under a roof with not less than 75 percent of the ceiling area with a ceiling height greater than 15 feet (4572 mm), and used as an office, lobby, atrium, concourse, corridor, storage space, gymnasium/exercise center, convention center, automotive service area, space where manufacturing occurs, nonrefrigerated warehouse, retail store, distribution/sorting area, transportation depot or workshop.~~, the~~ The total *toplit daylight zone* shall be not less than half the floor area and shall ~~provide~~ comply with one of the following:

1. A minimum skylight area to *toplit daylight zone* of not less than 3 percent where all skylights have a VT of not less than 0.40, or $VT_{annual}$ of not less than 0.26, as determined in accordance with **Section C303.1.3**.
2. A minimum skylight effective aperture ~~of not less than 1 percent~~, determined in accordance with Equation 4-4, of:
   - 2.1. Not less than 1 percent, using a skylight's VT rating; or
   - 2.2. Not less than 0.66 percent using a Tubular Daylighting Device's $VT_{annual}$ rating.

$$\text{Skylight Effective Aperture} = \frac{0.85 \times \text{Skylight Area} \times \text{Skylight VT} \times \text{WF}}{\text{Toplit Zone}} \qquad \text{(Equation 4-4)}$$

where:
Skylight area = Total fenestration area of skylights.
Skylight VT = Area-weighted average visible transmittance of skylights.
WF = Area-weighted average well factor, where well factor is 0.9 if light well depth is less than 2 feet (610 mm), or 0.7 if light well depth is 2 feet (610 mm) or greater, or 1.0 for Tubular Daylighting Devices with $VT_{annual}$ ratings.
Light well depth = Measure vertically from the underside of the lowest point of the skylight glazing to the ceiling plane under the skylight.

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in C402.4.2 continued:

**Exception:** Skylights above *daylight zones* of enclosed spaces are not required in:

1. Buildings in *Climate Zones* 6 through 8.
2. Spaces where the designed *general lighting* power densities are less than 0.5 W/ft$^2$ (5.4 W/m$^2$).
3. Areas where it is documented that existing structures or natural objects block direct beam sunlight on not less than half of the roof over the enclosed area for more than 1,500 daytime hours per year between 8 a.m. and 4 p.m.
4. Spaces where the *daylight zone* under rooftop monitors is greater than 50 percent of the enclosed space floor area.
5. Spaces where the total area minus the area of ~~sidelight~~ *sidelit daylight zones* is less than 2,500 square feet (232 m$^2$), and where the lighting is controlled in accordance with **Section C405.2.3**.
6. Spaces designed as storm shelters complying with **ICC 500**.

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Revisions in C402.5 and C402.5.1:

**C402.5 Air leakage—thermal envelope ~~(Mandatory)~~.** The *building thermal envelope* ~~of buildings~~ shall comply with **Sections C402.5.1** through **Section C402.5.11.1**, or the building *thermal envelope* shall be tested in accordance with ~~ASTM E 779 at a pressure differential of 0.3 inch water gauge (75 Pa) or an equivalent method approved by the code official and deemed to comply with the provisions of this section when the tested air leakage rate of the building thermal envelope is not greater than 0.40 cfm/ft$^2$ (2.0 L/s • m$^2$).~~ **Section C402.5.2** or **C402.5.3**. Where compliance is based on such testing, the building shall also comply with **Sections C402.5.7**, **C402.5.8** and **C402.5.9**.

**C402.5.1 Air barriers.** A continuous air barrier shall be provided throughout the *building thermal envelope*. The continuous air barriers shall be ~~permitted to be~~ located on the inside or outside of the building thermal envelope, located within the assemblies composing the building thermal envelope, or any combination thereof. The air barrier shall comply with **Sections C402.5.1.1**, and **C402.5.1.2**.

**Exception:** Air barriers are not required in buildings located in *Climate Zone* 2B.

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Addition in C402.5.2:

**C402.5.2 Dwelling and sleeping unit enclosure testing.** The *building thermal envelope* shall be tested in accordance with **ASTM E779**, **ANSI/RESNET/ICC 380**, **ASTM E1827** or an equivalent method approved by the *code official*. The measured air leakage shall not exceed 0.30 cfm/ft$^2$ (1.5 L/s m$^2$) of the testing unit enclosure area at a pressure differential of 0.2 inch water gauge (50 Pa). Where multiple dwelling units or sleeping units or other occupiable conditioned spaces are contained within one *building thermal envelope*, each unit shall be considered an individual testing unit, and the building air leakage shall be the weighted average of all testing unit results, weighted by each testing unit's enclosure area. Units shall be tested separately with an unguarded blower door test as follows:

1. Where buildings have fewer than eight testing units, each testing unit shall be tested.
2. For buildings with eight or more testing units, the greater of seven units or 20 percent of the testing units in the building shall be tested, including a top floor unit, a ground floor unit and a unit with the largest testing unit enclosure area. For each tested unit that exceeds the maximum air leakage rate, an additional two units shall be tested, including a mixture of testing unit types and locations.

# BUILDING ENVELOPE REQUIREMENTS: C402 (2021 EDITION)

- Addition in C402.5.3:

**C402.5.3 Building thermal envelope testing.** The *building thermal envelope* shall be tested in accordance with **ASTM E779**, **ANSI/RESNET/ICC 380**, **ASTM E3158** or **ASTM E1827** or an equivalent method approved by the code official. The measured air leakage shall not exceed 0.40 cfm/ft$^2$ (2.0 L/s × m$^2$) of the *building thermal envelope* area at a pressure differential of 0.3 inch water gauge (75 Pa). Alternatively, portions of the building shall be tested and the measured air leakages shall be area weighted by the surface areas of the building envelope in each portion. The weighted average test results shall not exceed the whole building leakage limit. In the alternative approach, the following portions of the building shall be tested:

1. The entire envelope area of all stories that have any spaces directly under a roof.
2. The entire envelope area of all stories that have a building entrance, exposed floor, or loading dock, or are below grade.
3. Representative above-grade sections of the building totaling at least 25 percent of the wall area enclosing the remaining conditioned space.

**Exception:** Where the measured air leakage rate exceeds 0.40 cfm/ft$^2$ (2.0 L/s × m$^2$) but does not exceed 0.60 cfm/ft$^2$ (3.0 L/s × m$^2$), a diagnostic evaluation using smoke tracer or infrared imaging shall be conducted while the building is pressurized along with a visual inspection of the air barrier. Any leaks noted shall be sealed where such sealing can be made without destruction of existing building components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the code official and the building owner, and shall be deemed to comply with the requirements of this section.

# BUILDING MECHANICAL SYSTEMS: C403 (2021 EDITION)

- Addition in C403.2.3:

**C403.2.3 Fault detection and diagnostics.** New buildings with an HVAC system serving a gross conditioned floor area of 100,000 square feet (9290 $m^2$) or larger shall include a fault detection and diagnostics (FDD) system to monitor the HVAC system's performance and automatically identify faults. The FDD system shall:

1. Include permanently installed sensors and devices to monitor the HVAC system's performance.
2. Sample the HVAC system's performance at least once every 15 minutes.
3. Automatically identify and report HVAC system faults.
4. Automatically notify authorized personnel of identified HVAC system faults.
5. Automatically provide prioritized recommendations for repair of identified faults based on analysis of data collected from the sampling of HVAC system performance.
6. Be capable of transmitting the prioritized fault repair recommendations to remotely located authorized personnel.

**Exception:** R-1 and R-2 occupancies.

# BUILDING MECHANICAL SYSTEMS: C403 (2021 EDITION)

- Revisions in C403.3.2:

**C403.3.2 HVAC equipment performance requirements ~~(Mandatory)~~.** Equipment shall meet the minimum efficiency requirements of **Tables C403.3.2(1)** through ~~C403.3.2(9)~~ **C403.3.2(16)** when tested and rated in accordance with the applicable test procedure. Plate-type liquid-to-liquid heat exchangers shall meet the minimum requirements of ~~Table C403.3.2(10).~~ **AHRI 400**. The efficiency shall be verified through certification under an approved certification program or, where a certification program does not exist, 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.

# BUILDING MECHANICAL SYSTEMS: C403 (2021 EDITION)

- Revisions in C403.4.2.3:

**C403.4.2.3 Automatic start ~~(Mandatory)~~ and stop.** Automatic start controls shall be provided for each HVAC system. The automatic start controls shall be configured to automatically adjust the daily start time of the HVAC system in order to bring each space to the desired occupied temperature immediately prior to scheduled occupancy. Automatic stop controls shall be provided for each HVAC system with direct digital control of individual *zones*. The automatic stop controls shall be configured to reduce the HVAC system's heating temperature setpoint and increase the cooling temperature setpoint by not less than 2°F (-16.6°C) before scheduled unoccupied periods based on the thermal lag and acceptable drift in space temperature that is within comfort limits.

# BUILDING MECHANICAL SYSTEMS: C403 (2021 EDITION)

- Revisions in C403.4.3.3.2:

**C403.4.3.3.2 Heat rejection.** The following shall apply to hydronic water loop heat pump systems in Climate Zones 3 through 8:

1. Where a closed-circuit cooling tower is used directly in the heat pump loop, either an automatic valve shall be installed to bypass the flow of water around the closed-circuit cooling tower, except for any flow necessary for freeze protection, or low-leakage positive-closure dampers shall be provided.
2. Where an open-circuit cooling tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the open-circuit cooling tower.
3. Where an open-circuit or closed-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the open-circuit cooling tower from the heat pump loop, heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

**Exception:** Where it can be demonstrated that a heat pump system will be required to reject heat throughout the year.

# BUILDING MECHANICAL SYSTEMS: C403 (2021 EDITION)

- Revisions in C403.5:

**C403.5 Economizers ~~(Prescriptive)~~.** Economizers shall comply with **Sections C403.5.1** through **C403.5.5**.

An air or water economizer shall be provided for the following cooling systems:

1. Chilled water systems with a total cooling capacity, less cooling capacity provided with air economizers, as specified in **Table C403.5(1)**.
2. Individual fan systems with cooling capacity greater than or equal to 54,000 Btu/h (15.8 kW) in buildings having other than a *Group R* occupancy,

   The total supply capacity of all fan cooling units not provided with economizers shall not exceed 20 percent of the total supply capacity of all fan cooling units in the building or 300,000 Btu/h (88 kW), whichever is greater.
3. Individual fan systems with cooling capacity greater than or equal to 270,000 Btu/h (79.1 kW) in buildings having a *Group R* occupancy.

   The total supply capacity of all fan cooling units not provided with economizers shall not exceed 20 percent of the total supply capacity of all fan cooling units in the building or 1,500,000 Btu/h (440 kW), whichever is greater.

**Exceptions:** Economizers are not required for the following systems.

1. Individual fan systems not served by chilled water for buildings located in *Climate Zones* 0A, 0B, 1A and 1B.
2. Where more than 25 percent of the air designed to be supplied by the system is to spaces that are designed to be humidified above 35°F (1.7°C) dew-point temperature to satisfy process needs.
3. Systems expected to operate less than 20 hours per week.
4. Systems serving supermarket areas with open refrigerated casework.
5. Where the cooling efficiency is greater than or equal to the efficiency requirements in **Table C403.5(2)**.
6. Systems that include a heat recovery system in accordance with **Section C403.10.5**.
7. VRF systems installed with a dedicated outdoor air system.

# BUILDING MECHANICAL SYSTEMS: C403 (2021 EDITION)

- Revisions in C403.6.5:

**C403.6.5 Supply-air temperature reset controls.** Multiple-zone HVAC systems shall include controls that are capable of and configured to automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls shall be configured to reset the supply air temperature not less than 25 percent of the difference between the design supply-air temperature and the design room air temperature. Controls that adjust the reset based on zone humidity are allowed in Climate Zones 0B, 1B, 2B, 3B, 3C and 4 through 8. HVAC zones that are expected to experience relatively constant loads~~,~~ shall have maximum airflow designed to accommodate the fully reset supply-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. Systems in Climate Zones ~~with peak supply air quantities of 300 cfm (142 L/s) or less.~~ 0A, 1A and 3A with less than 3,000 cfm (1500 L/s) of design outside air.
4. Systems in Climate Zone 2A with less than 10,000 cfm (5000 L/s) of design outside air.
5. Systems in Climate Zones 0A, 1A, 2A and 3A with not less than 80 percent outside air and employing exhaust air energy recovery complying with **Section C403.7.4**.

**C403.6.5.1 Dehumidification control interaction.** In Climate Zones 0A, 1A, 2A and 3A, the system design shall allow supply-air temperature reset while dehumidification is provided. When dehumidification control is active, air economizers shall be locked out.

# BUILDING MECHANICAL SYSTEMS: C403 (2021 EDITION)

- Revisions in C403.7.1:

**C403.7.1 Demand control ventilation.** Demand control ventilation (DCV) shall be provided for all single-zone systems required to comply with **Sections C403.5** through **C403.5.3** and spaces larger than 500 square feet (46.5 m$^2$) and with an average occupant load of ~~25~~ 15 people or greater per 1,000 square feet (93 m$^2$) of floor area, as established in Table 403.3.1.1 of the *International Mechanical Code*, and served by systems with one or more of the following:

1. An air-side economizer.
2. Automatic modulating control of the outdoor air damper.
3. A design outdoor airflow greater than 3,000 cfm (1416 L/s).

# BUILDING MECHANICAL SYSTEMS: C403 (2021 EDITION)

- Revisions in C403.7.2:

**C403.7.2 Enclosed parking garage ventilation controls ~~(Mandatory)~~.** Enclosed parking garages used for storing or handling automobiles operating under their own power shall employ ~~contamination-sensing devices~~ carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors and automatic controls configured to stage fans or modulate fan average airflow rates to 50 percent or less of design capacity, or intermittently operate fans less than 20 percent of the occupied time or as required to maintain acceptable contaminant levels in accordance with International Mechanical Code provisions. Failure of contamination-sensing devices shall cause the exhaust fans to operate continuously at design airflow.

**Exceptions:**

1. Garages with a total exhaust capacity less than ~~22,500~~ 8,000 cfm (~~10 620~~ 3,755 L/s) with ventilation systems that do not utilize heating or mechanical cooling.
2. Garages that have a garage area to ventilation system motor nameplate power ratio that exceeds 1,125 cfm/hp (710 L/s/kW) and do not utilize heating or mechanical cooling.

# BUILDING MECHANICAL SYSTEMS: C403 (2021 EDITION)

- Revisions in C403.7.4:

**C403.7.4 Energy recovery systems.** Energy recovery ventilation systems shall be provided as specified in either **Section C403.7.4.1** or **C403.7.4.2**, as applicable.

**C403.7.4.1 Nontransient dwelling units.** Nontransient dwelling units shall be provided with outdoor air energy recovery ventilation systems with an enthalpy recovery ratio of not less than 50 percent at cooling design condition and not less than 60 percent at heating design condition.

**Exceptions:**

1. Nontransient dwelling units in Climate Zone 3C.
2. Nontransient dwelling units with not more than 500 square feet (46 $m^2$) of *conditioned floor area* in Climate Zones 0, 1, 2, 3, 4C~~,~~ and 5C.
3. Enthalpy recovery ratio requirements at heating design condition in Climate Zones 0, 1~~,~~ and 2.
4. Enthalpy recovery ratio requirements at cooling design condition in Climate Zones 4, 5, 6, 7~~,~~ and 8.

# BUILDING MECHANICAL SYSTEMS: C403 (2021 EDITION)

- Revisions in C403.7.6:

**C403.7.6 Automatic control of HVAC systems serving guestrooms ~~(Mandatory)~~.** In Group R-1 buildings containing more than 50 guestrooms, each guestroom shall be provided with controls complying with the provisions of **Sections C403.7.6.1** and **C403.7.6.2**. Card key controls comply with these requirements.

**C403.7.6.1 Temperature setpoint controls.** Controls shall be provided on each HVAC system that are capable of and configured ~~to automatically raise the cooling setpoint and lower the heating setpoint by not less than 4°F (2°C) from the occupant setpoint within 30 minutes after the occupants have left the guestroom. The controls shall be capable of and configured to automatically raise the cooling setpoint to not lower than 80°F (27°C) and lower the heating setpoint to not higher than 60°F (16°C) when the guestroom is unrented or has not been continuously occupied for more than 16 hours or a *networked guestroom control system* indicates that the guestroom is unrented and the guestroom is unoccupied for more than 30 minutes. A *networked guestroom control system* that is capable of returning the thermostat setpoints to default occupied setpoints 60 minutes prior to the time a guestroom is scheduled to be occupied is not precluded by this section. Cooling that is capable of limiting relative humidity with a setpoint not lower than 65-percent relative humidity during unoccupied periods is not precluded by this section.~~ with three modes of temperature control.

1. When the guestroom is rented but unoccupied, the controls shall automatically raise the cooling setpoint and lower the heating setpoint by not less than 4°F (2°C) from the occupant setpoint within 30 minutes after the occupants have left the guestroom.
2. When the guestroom is unrented and unoccupied, the controls shall automatically raise the cooling setpoint to not lower than 80°F (27°C) and lower the heating setpoint to not higher than 60°F (16°C). Unrented and unoccupied guestroom mode shall be initiated within 16 hours of the guestroom being continuously occupied or where a *networked guestroom control system* indicates that the guestroom is unrented and the guestroom is unoccupied for more than 20 minutes. A *networked guestroom control system* that is capable of returning the thermostat setpoints to default occupied setpoints 60 minutes prior to the time a guestroom is scheduled to be occupied is not precluded by this section. Cooling that is capable of limiting relative humidity with a setpoint not lower than 65-percent relative humidity during unoccupied periods is not precluded by this section.
3. When the guestroom is occupied, HVAC setpoints shall return to their occupied setpoints once occupancy is sensed.

# BUILDING MECHANICAL SYSTEMS: C403 (2021 EDITION)

- Addition in C403.8.5:

**C403.8.5 Low-capacity ventilation fans.** Mechanical ventilation system fans with motors less than $^{1}/_{12}$ hp (0.062 kW) in capacity shall meet the efficacy requirements of **Table C403.8.5** at one or more rating points.

**Exceptions:**

1. Where ventilation fans are a component of a listed heating or cooling appliance.
2. Dryer exhaust duct power ventilators, domestic range hoods, and domestic range booster fans that operate intermittently.

**TABLE C403.8.5**
**LOW-CAPACITY VENTILATION FAN EFFICACY[a]**

| FAN LOCATION | AIRFLOW RATE MINIMUM (CFM) | MINIMUM EFFICACY (CFM/WATT) | AIRFLOW RATE MAXIMUM (CFM) |
|---|---|---|---|
| HRV or ERV | Any | 1.2 cfm/watt | Any |
| In-line fan | Any | 3.8 cfm/watt | Any |
| Bathroom, utility room | 10 | 2.8 cfm/watt | < 90 |
| Bathroom, utility room | 90 | 3.5 cfm/watt | Any |

For SI: 1 cfm/ft = 47.82 W.

a. Airflow shall be tested in accordance with **HVI 916** and listed. Efficacy shall be listed or shall be derived from listed power and airflow. Fan efficacy for fully ducted HRV, ERV, balanced and in-line fans shall be determined at a static pressure not less than 0.2 inch w.c. Fan efficacy for ducted range hoods, bathroom and utility room fans shall be determined at a static pressure not less than 0.1 inch w.c.

# SERVICE WATER HEATING: C404 (2018 EDITION)

- Revision in C404.2:

**C404.2 Service water-heating equipment performance efficiency.**
Water-heating equipment and hot water storage tanks shall meet the requirements of Table C404.2. The efficiency shall be verified through data furnished by the manufacturer of the equipment or through certification under an *approved* certification program. Water-heating equipment ~~also~~ intended to be used to provide space heating shall meet the applicable provisions of Table C404.2.

# SERVICE WATER HEATING: C404 (2021 EDITION)

- Addition in C404.2.1:

**C404.2.1 High input service water-heating systems.** Gas-fired water-heating equipment installed in new buildings shall be in compliance with this section. Where a singular piece of water-heating equipment serves the entire building and the input rating of the equipment is 1,000,000 Btu/h (293 kW) or greater, such equipment shall have a thermal efficiency, $E_t$, of not less than ~~90~~ 92 percent. Where multiple pieces of water-heating equipment serve the building and the combined input rating of the water-heating equipment is 1,000,000 Btu/h (293 kW) or greater, the combined input-capacity-weighted-average thermal efficiency, $E_t$, shall be not less than 90 percent.

**Exceptions:**

1. Where not less than 25 percent of the annual service water-heating requirement is provided by *on-site renewable energy* or site-recovered energy, the minimum thermal efficiency requirements of this section shall not apply.
2. The input rating of water heaters installed in individual dwelling units shall not be required to be included in the total input rating of service water-heating equipment for a building.
3. The input rating of water heaters with an input rating of not greater than 100,000 Btu/h (29.3 kW) shall not be required to be included in the total input rating of service water-heating equipment for a building.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Revisions in C405.1:

**C405.1 General ~~(Mandatory)~~.** ~~This section covers lighting~~ Lighting system controls, the maximum lighting power for interior and exterior applications, and electrical energy consumption shall comply with this section. *Sleeping units* shall comply with **Section C405.2.4** and with either **Section C405.1.1** or **C405.3**. *General lighting* shall consist of all lighting included when calculating the total connected interior lighting power in accordance with **Section C405.3.1** and which does not require specific application controls in accordance with **Section C405.2.4**.

~~*Dwelling units* within multifamily buildings shall comply with Section R404.1. All other *dwelling units* shall comply with Section R404.1, or with Sections C405.2.4 and C405.3. *Sleeping units* shall comply with Section C405.2.4, and with Section R404.1 or C405.3. Lighting installed in walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with the lighting requirements of Section C403.11.1 or C403.11.2.~~ Transformers, uninterruptable power supplies, motors and electrical power processing equipment in data center systems shall comply with Section 8 of **ASHRAE 90.4** in addition to this code.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2018 EDITION)

- Revisions in C405.2:

**C405.2 Lighting controls (Mandatory).**
Lighting systems shall be provided with controls ~~as specified in Sections C405.2.1, C405.2.2, C405.2.3, C405.2.4 and C405.2.5~~ that comply with one of the following.

1. Lighting controls as specified in Sections C405.2.1 through C405.2.6.

2. Luminaire level lighting controls (LLLC) and lighting controls as specified in Sections C405.2.1, C405.2.4 and C405.2.5. The LLLC luminaire shall be independently capable of:

   2.1. Monitoring occupant activity to brighten or dim lighting when occupied or unoccupied, respectively.

   2.2. Monitoring ambient light, both electric light and daylight, and brighten or dim artificial light to maintain desired light level.

   2.3. For each control strategy, configuration and reconfiguration of performance parameters including: bright and dim setpoints, timeouts, dimming fade rates, sensor sensitivity adjustments, and wireless zoning configurations.

**Exceptions:** Lighting controls are not required for the following:

1. Areas designated as security or emergency areas that are required to be continuously lighted.
2. Interior exit stairways, interior exit ramps and exit passageways.
3. Emergency egress lighting that is normally off.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2018 EDITION)

- Revision of C405.2.1:

**C405.2.1 Occupant sensor controls.**
Occupant *sensor controls* shall be installed to control lights in the following space types:

1. Classrooms/lecture/training rooms.
2. Conference/meeting/multipurpose rooms.
3. Copy/print rooms.
4. Lounges/breakrooms.
5. ~~Employee lunch and break rooms~~Enclosed offices.
6. ~~Private~~Open plan office areas.
7. Restrooms.
8. Storage rooms.
9. ~~Janitorial closets.~~
10. ~~10.~~ Locker rooms.
11. ~~10~~. Other spaces 300 square feet (28 $m^2$) or less that are enclosed by floor-to-ceiling height partitions.
12. ~~11~~. Warehouse storage areas.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2018 EDITION)

- Revision of C405.2.1.1:

**C405.2.1.1 Occupant sensor control function.**
Occupant sensor controls in ~~spaces other than~~ warehouses shall comply with Section C405.2.1.2. Occupant sensor controls in open plan office areas shall comply with Section C405.2.1.3. Occupant sensor controls for all other spaces specified in Section C405.2.1 shall comply with the following:

1. ~~A~~They shall automatically turn off lights within ~~3~~20 minutes ~~of~~after all occupants ~~leaving~~have left the space.

2. ~~B~~They shall be manual on or controlled to automatically turn on the lighting ~~on~~ to not more than 50 ~~-~~percent power.

   **Exception:** Full automatic-on controls shall be permitted to control lighting in public corridors, stairways, restrooms, primary building entrance areas and lobbies, and areas where manual-on operation would endanger the safety or security of the room or building occupants.

3. ~~S~~They shall incorporate a *manual control* to allow occupants to turn off lights ~~off~~.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Revisions in C405.2.1.1:

**C405.2.1.1 Occupant sensor control function.** Occupant sensor controls in warehouses shall comply with **Section C405.2.1.2**. Occupant sensor controls in open plan office areas shall comply with **Section C405.2.1.3**. Occupant sensor controls in corridors shall comply with **Section C405.2.1.4**. Occupant sensor controls for all other spaces specified in **Section C405.2.1** shall comply with the following:

1. They shall automatically turn off lights within 20 minutes after all occupants have left the space.
2. They shall be manual on or controlled to automatically turn on the lighting to not more than 50-percent power.
3. They shall incorporate a manual control to allow occupants to turn off lights.

**Exception:** Full automatic-on controls with no manual control shall be permitted ~~to control lighting~~ in ~~public~~ corridors, interior parking areas, stairways, restrooms, ~~primary building entrance areas and lobbies,~~ locker rooms, lobbies, library stacks and areas where ~~manual-on~~ manual operation would endanger ~~the safety or security of the room or building occupants.~~ occupant safety or security.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Revisions in C405.2.1.2:

**C405.2.1.2 Occupant sensor control function in ~~warehouses.~~warehouse storage areas.** Lighting in warehouse storage areas shall be controlled as follows: ~~In warehouses, the lighting in aisleways and open areas shall be controlled with occupant sensors that automatically reduce lighting power by not less than 50 percent when the areas are unoccupied. The occupant sensors shall control lighting in each aisleway independently and shall not control lighting beyond the aisleway being controlled by the sensor.~~

1. Lighting in each aisleway shall be controlled independently of lighting in all other aisleways and open areas.
2. Occupant sensors shall automatically reduce lighting power within each controlled area to an occupied setpoint of not more than 50 percent within 20 minutes after all occupants have left the controlled area.
3. Lights that are not turned off by occupant sensors shall be turned off by time-switch control complying with **Section C405.2.2.1**.
4. A manual control shall be provided to allow occupants to turn off lights in the space.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2018 EDITION)

- Addition of C405.2.1.3:

C405.2.1.3 Occupant sensor control function in open plan office areas. Occupant sensor controls in open plan office spaces less than 300 square feet (28 $m^2$) in area shall comply with Section C405.2.1.1. Occupant sensor controls in all other open plan office spaces shall comply with all of the following:

1. The controls shall be configured so that general lighting can be controlled separately in control zones with floor areas not greater than 600 square feet (55 $m^2$) within the open plan office space.

2. The controls shall automatically turn off general lighting in all control zones within 20 minutes after all occupants have left the open plan office space.

3. The controls shall be configured so that general lighting power in each control zone is reduced by not less than 80 percent of the full zone general lighting power in a reasonably uniform illumination pattern within 20 minutes of all occupants leaving that control zone. Control functions that switch control zone lights completely off when the zone is vacant meet this requirement.

4. The controls shall be configured such that any daylight responsive control will activate open plan office space general lighting or control zone general lighting only when occupancy for the same area is detected.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Revisions in C405.2.1.3:

**C405.2.1.3 Occupant sensor control function in open plan office areas.** Occupant sensor controls in open plan office spaces less than 300 square feet (28 $m^2$) in area shall comply with **Section C405.2.1.1**. Occupant sensor controls in all other open plan office spaces shall comply with all of the following:

1. The controls shall be configured so that general lighting can be controlled separately in control zones with floor areas not greater than 600 square feet (55 $m^2$) within the open plan office space.
2. General lighting in each control zone shall be permitted to automatically turn on upon occupancy within the control zone. General lighting in other unoccupied zones within the open plan office space shall be permitted to turn on to not more than 20 percent of full power or remain unaffected.

~~2.~~ 3. The controls shall automatically turn off general lighting in all control zones within 20 minutes after all occupants have left the open plan office space.

**Exception:** Where general lighting is turned off by time-switch control complying with **Section C405.2.2.1**.

~~3.~~ 4. ~~The controls shall be configured so that general lighting power~~ General lighting in each control zone ~~is reduced by not less than 80 percent of the full zone general lighting power in a reasonably uniform illumination pattern within 20 minutes of all occupants leaving that control zone. Control functions that switch control zone lights completely off when the zone is vacant meet this requirement.~~ shall turn off or uniformly reduce lighting power to an unoccupied setpoint of not more than 20 percent of full power within 20 minutes after all occupants have left the control zone.

~~4. The controls shall be configured such that any daylight responsive control will activate open plan office space general lighting or control zone general lighting only when occupancy for the same area is detected.~~

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Additions in C405.2.3:

**C405.2.3 Light-reduction controls.** Where not provided with occupant sensor controls complying with **Section C405.2.1.1**, general lighting shall be provided with light-reduction controls complying with **Section C405.2.3.1**.

**Exceptions:**

1. Luminaires controlled by daylight responsive controls complying with **Section C405.2.4**.
2. Luminaires controlled by special application controls complying with **Section C405.2.5**.
3. Where provided with manual control, the following areas are not required to have light-reduction control:
   - 3.1. Spaces that have only one luminaire with a rated power of less than 60 watts.
   - 3.2. Spaces that use less than 0.45 watts per square foot (4.9 W/m²).
   - 3.3. Corridors, lobbies, electrical rooms and/or mechanical rooms.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Additions in C405.2.3.1:

~~C405.2.2.2~~**C405.2.3.1 Light-reduction ~~controls~~ control function.** Spaces required to have light-reduction controls shall have a *manual control* that allows the occupant to reduce the connected lighting load by not less than 50 percent in a reasonably uniform illumination pattern with an intermediate step in addition to full on or off, or with continuous dimming control, ~~by not less than 50 percent. Lighting reduction shall be achieved by~~ using one of the following or another *approved* method:

1. ~~Controlling all lamps or luminaires.~~Continuous dimming of all luminaires from full output to less than 20 percent of full power.
2. ~~Dual switching of alternate rows of luminaires, alternate luminaires or alternate lamps.~~ Switching all luminaires to a reduced output of not less than 30 percent and not more than 70 percent of full power.
3. Switching alternate luminaires or alternate rows of luminaires to achieve a reduced output of not less than 30 percent and not more than 70 percent of full power ~~the middle lamp luminaires independently of the outer lamps~~
4. ~~Switching each luminaire or each lamp.~~

~~**Exception:** Light reduction controls are not required in *daylight zones* with *daylight responsive controls* complying with **Section C405.2.4**.~~

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Revisions in C405.2.7.3:

~~C405.2.6.3~~C405.2.7.3 **Lighting setback.** Lighting that is not controlled in accordance with **Section C405.2.7.2** shall ~~be controlled so that the total wattage of such lighting is automatically reduced by not less than 30 percent by selectively switching off or dimming luminaires at one of the following times~~ comply with the following:

1. ~~From not later than midnight to not earlier than 6 a.m.~~ Be controlled so that the total wattage of such lighting is automatically reduced by not less than 50 percent by selectively switching off or dimming luminaires at one of the following times:
    1.1. From not later than midnight to not earlier than 6 a.m.
    1.2. From not later than one hour after business closing to not earlier than one hour before business opening.
    1.3. During any time where activity has not been detected for 15 minutes or more.
2. ~~From not later than one hour after business closing to not earlier than one hour before business opening.~~ Luminaires serving outdoor parking areas and having a rated input wattage of greater than 78 watts and a mounting height of 24 feet (7315 mm) or less above the ground shall be controlled so that the total wattage of such lighting is automatically reduced by not less than 50 percent during any time where activity has not been detected for 15 minutes or more. Not more than 1,500 watts of lighting power shall be controlled together.
3. ~~During any time where activity has not been detected for 15 minutes or more.~~

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Additions in C405.2.8:

**C405.2.8 Parking garage lighting control.** Parking garage lighting shall be controlled by an *occupant sensor* complying with **Section C405.2.1.1** or a *time-switch control* complying with **Section C405.2.2.1**. Additional lighting controls shall be provided as follows:

1. Lighting power of each luminaire shall be automatically reduced by not less than 30 percent when there is no activity detected within a lighting zone for 20 minutes. Lighting zones for this requirement shall be not larger than 3,600 square feet (334.5 $m^2$).

   **Exception:** Lighting zones provided with less than 1.5 footcandles of illumination on the floor at the darkest point with all lights on are not required to have automatic light-reduction controls.

2. Where lighting for eye adaptation is provided at covered vehicle entrances and exits from buildings and parking structures, such lighting shall be separately controlled by a device that automatically reduces lighting power by at least 50 percent from sunset to sunrise.
3. The power to luminaires within 20 feet (6096 mm) of perimeter wall openings shall automatically reduce in response to daylight by at least 50 percent.

   **Exceptions:**

   1. Where the opening-to-wall ratio is less than 40 percent as viewed from the interior and encompassing the vertical distance from the driving surface to the lowest structural element.
   2. Where the distance from the opening to any exterior daylight blocking obstruction is less than one-half the height from the bottom of the opening or fenestration to the top of the obstruction.
   3. Where openings are obstructed by permanent screens or architectural elements restricting daylight entering the interior space.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Addition in C405.3.1:

**C405.3.1 Total connected interior lighting power.** The total connected interior lighting power shall be determined in accordance with **Equation 4-10**.

$$TCLP = [LVL + BLL + LED + TRK + \text{Other}] \qquad \textbf{(Equation 4-10)}$$

where:

*TCLP* = Total connected lighting power (watts).
*LVL* = For luminaires with lamps connected directly to building power, such as line voltage lamps, the rated wattage of the lamp.
*BLL* = For luminaires incorporating a ballast or transformer, the rated input wattage of the ballast or transformer when operating that lamp.
*LED* = For light-emitting diode luminaires with either integral or remote drivers, the rated wattage of the luminaire.
*TRK* = For lighting track, cable conductor, rail conductor, and plug-in busway systems that allow the addition and relocation of luminaires without rewiring, the wattage shall be one of the following:

1. The specified wattage of the luminaires, but not less than 8 W per linear foot (25 W/lin m).
2. The wattage limit of the permanent current-limiting devices protecting the system.
3. The wattage limit of the transformer supplying the system.

Other = The wattage of all other luminaires and lighting sources not covered previously and associated with interior lighting verified by data supplied by the manufacturer or other *approved* sources.

The connected power associated with the following lighting equipment and applications is not included in calculating total connected lighting power.

20. Antimicrobial lighting used for the sole purpose of disinfecting a space.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Revisions in C405.3.2 (See 2021 IECC for full section and referenced tables):

**C405.3.2 Interior lighting power allowance.** The total interior lighting power allowance (watts) ~~is~~ for an entire building shall be determined according to ~~Table C405.3.2(1)~~ **Table C405.3.2(1)** using the Building Area Method or ~~Table C405.3.2(2) using the Space-by-Space Method, for all areas of the building covered in this permit.~~ **Table C405.3.2(2)** using the Space-by-Space Method. The interior lighting power allowance for projects that involve only portions of a building shall be determined according to **Table C405.3.2(2)** using the Space-by-Space Method. Buildings with unfinished spaces shall use the Space-by-Space Method.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Revisions in C405.3.2.2:

**C405.3.2.2 Space-by-Space Method.** ~~For the Space-by-Space Method, the interior lighting power allowance is determined by multiplying the floor area of each space times the value for the space type in Table C405.3.2(2) that most closely represents the proposed use of the space, and then summing the lighting power allowances for all spaces. Tradeoffs among spaces are permitted.~~ Where a building has unfinished spaces, the lighting power allowance for the unfinished spaces shall be the total connected lighting power for those spaces, or 0.2 watts per square foot (10.76 w/m$^2$), whichever is less. For the Space-by-Space Method, the interior lighting power allowance is calculated as follows:

1. For each space enclosed by partitions that are not less than 80 percent of the ceiling height, determine the applicable space type from **Table C405.3.2(2)**. For space types not listed, select the space type that most closely represents the proposed use of the space. Where a space has multiple functions, that space may be divided into separate spaces.
2. Determine the total floor area of all the spaces of each space type and multiply by the value for the space type in **Table C405.3.2(2)** to determine the lighting power (watts) for each space type.
3. The total interior lighting power allowance (watts) shall be the sum of the lighting power allowances for all space types.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Addition in C405.4:

**C405.4 Lighting for plant growth and maintenance.** Not less than 95 percent of the permanently installed luminaires used for plant growth and maintenance shall have a photon efficiency of not less than 1.6 µmol/J as defined in accordance with **ANSI/ASABE S640**.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Revisions in C405.9.2:

~~C405.8.2~~C405.9.2 **Escalators and moving walks.** Escalators and moving walks shall comply with **ASME A17.1/CSA B44** and shall have automatic controls ~~configured to~~ that reduce speed ~~to the minimum~~ as permitted ~~speed~~ in accordance with **ASME A17.1/CSA B44** ~~or~~ and applicable local code ~~when not conveying passengers~~.

**Exception:** A variable voltage drive system that reduces operating voltage in response to light loading conditions is an alternative to the reduced speed function.

~~C405.8.2.1~~C405.9.2.1 **Regenerative drive ~~(Mandatory).~~ Energy recovery.** ~~An escalator~~ Escalators shall be designed to recover electrical energy when resisting overspeed in the down direction ~~either for one-way down operation only or for reversible operation shall have a variable frequency regenerative drive that supplies electrical energy to the building electrical system when the escalator is loaded with passengers whose combined weight exceeds 750 pounds (340 kg)~~. The escalator shall be designed to recover, on average, more power than is consumed by the power recovery feature of its motor controller system.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Revisions in C405.10:

~~**C405.9**~~**C405.10 Voltage drop ~~in feeders and branch circuits~~.** The total *voltage drop* across the combination of ~~feeders~~ customer-owned service conductors, feeder conductors and branch ~~circuits~~ circuit conductors shall not exceed 5 percent.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Additions in C405.11:

**C405.11 Automatic receptacle control.** The following shall have automatic receptacle control complying with **Section C405.11.1**:

1. At least 50 percent of all 125V, 15- and 20-amp receptacles installed in enclosed offices, conference rooms, rooms used primarily for copy or print functions, breakrooms, classrooms, and individual workstations, including those installed in modular partitions and module office workstation systems.
2. At least 25 percent of branch circuit feeders installed for modular furniture not shown on the construction documents.

**C405.11.1 Automatic receptacle control function.** Automatic receptacle controls shall comply with the following:

1. Either split controlled receptacles shall be provided with the top receptacle controlled, or a controlled receptacle shall be located within 12 inches (304.8 mm) of each uncontrolled receptacle.
2. One of the following methods shall be used to provide control:
   - 2.1. A scheduled basis using a time-of-day operated control device that turns receptacle power off at specific programmed times and can be programmed separately for each day of the week. The control device shall be configured to provide an independent schedule for each portion of the building of not more than 5,000 square feet (464.5 $m^2$) and not more than one floor. The occupant shall be able to manually override an area for not more than 2 hours. Any individual override switch shall control the receptacles of not more than 5,000 feet (1524 m).
   - 2.2. An occupant sensor control that shall turn off receptacles within 20 minutes of all occupants leaving a space.
   - 2.3. An automated signal from another control or alarm system that shall turn off receptacles within 20 minutes after determining that the area is unoccupied.
3. All controlled receptacles shall be permanently marked in accordance with **NFPA 70** and be uniformly distributed throughout the space.
4. Plug-in devices shall not comply.

**Exceptions:** Automatic receptacle controls are not required for the following:

1. Receptacles specifically designated for equipment requiring continuous operation (24 hours per day, 365 days per year).
2. Spaces where an automatic control would endanger the safety or security of the room or building occupants.
3. Within a single modular office workstation, noncontrolled receptacles are permitted to be located more than 12 inches (304.8 mm), but not more than 72 inches (1828 mm) from the controlled receptacles serving that workstation.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Additions in C405.12:

**C405.12 Energy monitoring.** New buildings with a gross *conditioned floor area* of 25,000 square feet (2322 $m^2$) or larger shall be equipped to measure, monitor, record and report energy consumption data in compliance with **Sections C405.12.1** through **C405.12.5**.

**Exception:** R-2 occupancies and individual tenant spaces are not required to comply with this section provided that the space has its own utility services and meters and has less than 5,000 square feet (464.5 $m^2$) of *conditioned floor area*.

**C405.12.1 Electrical energy metering.** For all electrical energy supplied to the building and its associated site, including but not limited to site lighting, parking, recreational facilities and other areas that serve the building and its occupants, meters or other measurement devices shall be provided to collect energy consumption data for each end-use category required by **Section C405.12.2**.

**C405.12.2 End-use metering categories.** Meters or other approved measurement devices shall be provided to collect energy use data for each end-use category indicated in **Table C405.12.2**. Where multiple meters are used to measure any end-use category, the data acquisition system shall total all of the energy used by that category. Not more than 5 percent of the measured load for each of the end-use categories indicated in **Table C405.12.2** shall be permitted to be from a load that is not within that category.

**Exceptions:**

1. HVAC and water heating equipment serving only an individual dwelling unit shall not require end-use metering.
2. End-use metering shall not be required for fire pumps, stairwell pressurization fans or any system that operates only during testing or emergency.
3. End-use metering shall not be required for an individual tenant space having a floor area not greater than 2,500 square feet (232 $m^2$) where a dedicated source meter complying with **Section C405.12.3** is provided.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Additions in C405.12 continued:

**TABLE C405.12.2**
**ENERGY USE CATEGORIES**

| LOAD CATEGORY | DESCRIPTION OF ENERGY USE |
|---|---|
| Total HVAC system | Heating, cooling and ventilation, including but not limited to fans, pumps, boilers, chillers and water heating. Energy used by 120-volt equipment, or by 208/120-volt equipment that is located in a building where the main service is 480/277-volt power, is permitted to be excluded from total HVAC system energy use. |
| Interior lighting | Lighting systems located within the building. |
| Exterior lighting | Lighting systems located on the building site but not within the building. |
| Plug loads | Devices, appliances and equipment connected to convenience receptacle outlets. |
| Process load | Any single load that is not included in an HVAC, lighting or plug load category and that exceeds 5 percent of the peak connected load of the whole building, including, but not limited to data centers, manufacturing equipment and commercial kitchens. |
| Building operations and other miscellaneous loads | The remaining loads not included elsewhere in this table, including but not limited to vertical transportation systems, automatic doors, motorized shading systems, ornamental fountains, ornamental fireplaces, swimming pools, in-ground spas and snow-melt systems. |

**C405.12.3 Meters.** Meters or other measurement devices required by this section shall be configured to automatically communicate energy consumption data to the data acquisition system required by **Section C405.12.4**. Source meters shall be allowed to be any digital-type meter. Lighting, HVAC or other building systems that can monitor their energy consumption shall be permitted instead of meters. Current sensors shall be permitted, provided that they have a tested accuracy of ±2 percent. Required metering systems and equipment shall have the capability to provide at least hourly data that is fully integrated into the data acquisition system and graphical energy report in accordance with **Sections C405.12.4** and **C405.12.5**.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: C405 (2021 EDITION)

- Additions in C405.12 continued:

**C405.12.4 Data acquisition system.** A data acquisition system shall have the capability to store the data from the required meters and other sensing devices for a minimum of 36 months. The data acquisition system shall have the capability to store real-time energy consumption data and provide hourly, daily, monthly and yearly logged data for each end-use category required by Section **C405.12.2**.

**C405.12.5 Graphical energy report.** A permanent and readily accessible reporting mechanism shall be provided in the building that is accessible by building operation and management personnel. The reporting mechanism shall have the capability to graphically provide the energy consumption for each end-use category required by **Section C405.12.2** at least every hour, day, month and year for the previous 36 months.

# ADDITIONAL EFFICIENCY REQUIREMENTS: C406 (2018 EDITION)

- Revisions and additions in C406 (See 2018 IECC for full section and details):

**SECTION C406**
**ADDITIONAL EFFICIENCY PACKAGE OPTIONS**

**C406.1 Requirements.**
Buildings shall comply with ~~at least~~ one or more of the following:

1. More efficient HVAC performance in accordance with Section C406.2.
2. Reduced lighting power ~~density system~~ in accordance with Section C406.3.
3. Enhanced lighting controls in accordance with Section C406.4.
4. On-site supply of renewable energy in accordance with Section C406.5.
5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with Section C406.6.
6. High-efficiency service water heating in accordance with Section C406.7
7. Enhanced envelope performance in accordance with Section C406.8.
8. Reduced air infiltration in accordance with Section C406.9

# ADDITIONAL EFFICIENCY REQUIREMENTS: C406 (2021 EDITION)

- Revisions and additions in C406 (See 2021 IECC for full section and details):

**SECTION C406**
**ADDITIONAL EFFICIENCY ~~PACKAGES~~ REQUIREMENTS**

**C406.1 Additional energy efficiency credit requirements.** ~~Buildings shall comply with one or more of the following:~~ New buildings shall achieve a total of 10 credits from **Tables C406.1(1)** through **C406.1(5)** where the table is selected based on the use group of the building and from credit calculations as specified in relevant subsections of **Section C406**. Where a building contains multiple-use groups, credits from each use group shall be weighted by floor area of each group to determine the weighted average building credit. Credits from the tables or calculation shall be achieved where a building complies with one or more of the following:

1. More efficient HVAC performance in accordance with **Section C406.2**.
2. Reduced lighting power in accordance with **Section C406.3**.
3. Enhanced lighting controls in accordance with **Section C406.4**.
4. On-site supply of renewable energy in accordance with **Section C406.5**.
5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with **Section C406.6**.
6. High-efficiency service water heating in accordance with **Section C406.7**.
7. Enhanced envelope performance in accordance with **Section C406.8**.
8. Reduced air infiltration in accordance with **Section C406.9**
9. Where not required by **Section C405.12**, include an energy monitoring system in accordance with **Section C406.10**.
10. Where not required by **Section C403.2.3**, include a fault detection and diagnostics (FDD) system in accordance with **Section C406.11**.
11. Efficient kitchen equipment in accordance with **Section C406.12**.

# ADDITIONAL EFFICIENCY REQUIREMENTS: C406 (2021 EDITION)

- Revisions in C406.4:

**C406.4 Enhanced digital lighting controls.** Interior general lighting in the building shall have the following enhanced lighting controls that shall be located, scheduled and operated in accordance with **Sections C405.2.1** through **C405.2.3**.

1. Luminaires shall be configured for continuous dimming.
2. Luminaires shall be addressed individually. Where individual addressability is not available for the luminaire class type, a controlled group of not more than four luminaries shall be allowed.
3. Not more than eight luminaires shall be controlled together in a *daylight zone*.
4. Fixtures shall be controlled through a digital control system that includes the following function:
    - 4.1. Control reconfiguration based on digital addressability.
    - 4.2. Load shedding.
    - ~~4.3. Individual user control of overhead general illumination in open offices.~~
    - ~~4.4.~~
    - 4.3. Occupancy sensors shall be capable of being reconfigured through the digital control system.
5. Construction documents shall include submittal of a Sequence of Operations, including a specification outlining each of the functions in Item 4.
6. Functional testing of lighting controls shall comply with **Section C408**.

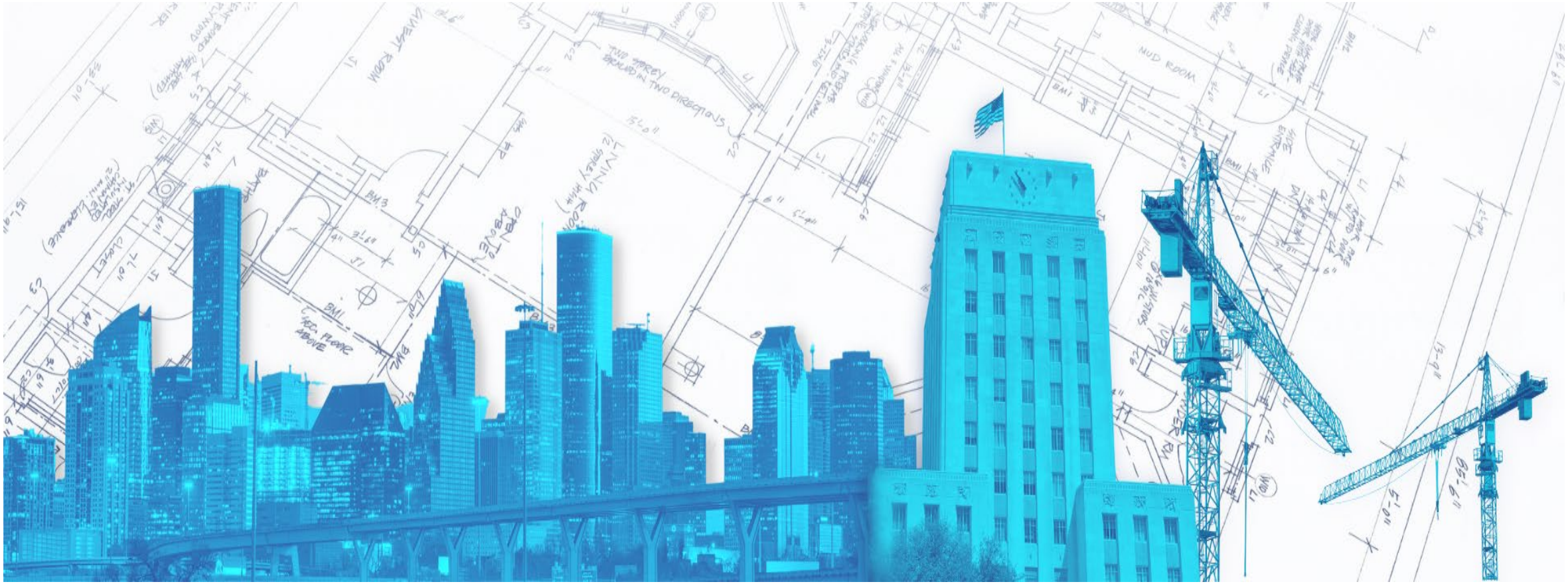
# TOTAL BUILDING PERFORMANCE: C407 (2018 EDITION)

- Revisions in C407.3:

**C407.3 Performance-based compliance.**
Compliance based on total building performance requires that a proposed building (*proposed design)* be shown to have an annual energy cost that is less than or equal to the annual energy cost of the *standard reference design*. Energy prices shall be taken from a source *approved* by the *code official*, such as the Department of Energy, Energy Information Administration's *State Energy Price and Expenditure Report*. *Code officials* shall be permitted to require time-of-use pricing in energy cost calculations. ~~Nondepletable energy collected off site shall be treated and priced the same as purchased energy. Energy from nondepletable energy sources collected on site shall be omitted from the annual energy cost of the *proposed design*~~**The reduction in energy cost of the proposed design associated with *on-site renewable energy* shall be not more than 5 percent of the total energy cost. The amount of renewable energy purchased from off-site sources shall be the same in the *standard reference design* and** the *proposed design*.

HOUSTON PUBLIC WORKS

# IECC APPENDIX CC ZERO ENERGY COMMERCIAL BUILDING PROVISIONS



# ZERO ENERGY COMMERCIAL BUILDING PROVISIONS: APPENDIX CC (2021 EDITION)

- Addition of Appendix CC (See 2021 IECC for full section):

## APPENDIX CC ZERO ENERGY COMMERCIAL BUILDING PROVISIONS

*The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.*

**User note:**

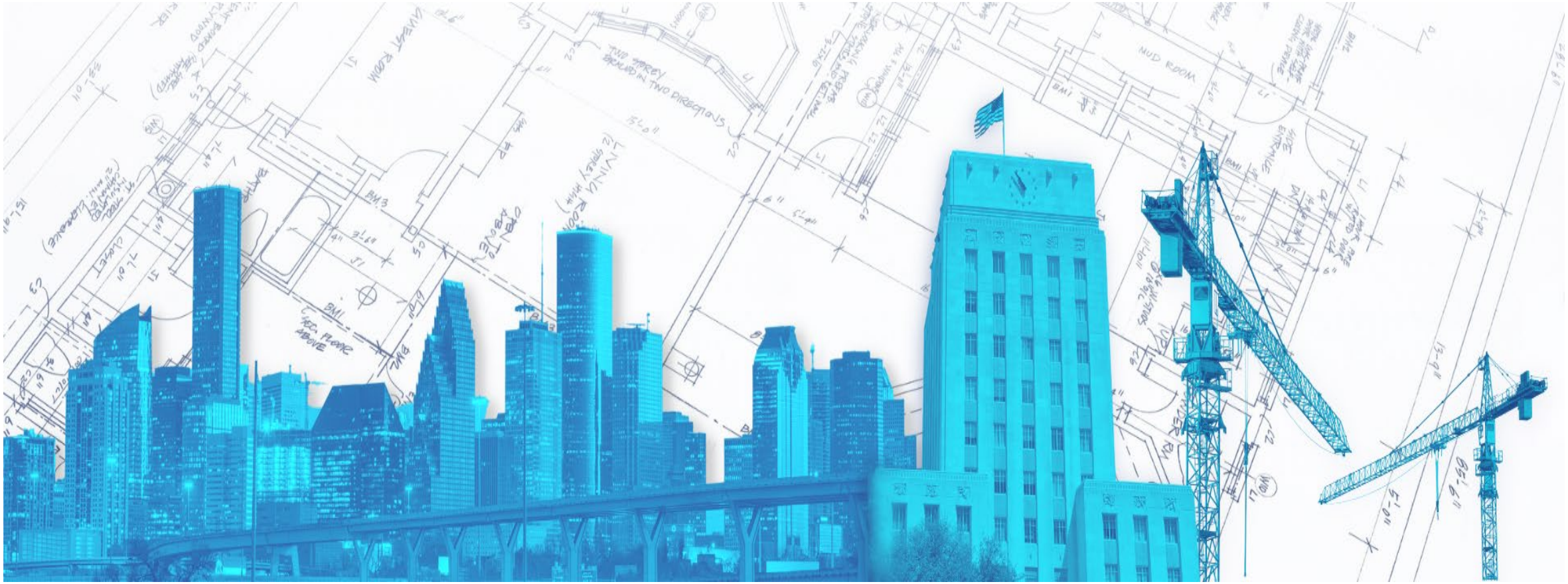
***About this chapter:*** *Appendix CC provides a model for applying new renewable energy generation when new buildings add electric load to the grid. This renewable energy will avoid the additional emissions that would otherwise occur from conventional power generation.*

### SECTION CC101
### GENERAL

**CC101.1 Purpose.** The purpose of this appendix is to supplement the *International Energy Conservation Code* and require renewable energy systems of adequate capacity to achieve net zero carbon.

HOUSTON PUBLIC WORKS

# IECC CHAPTER 4 RESIDENTIAL ENERGY EFFICIENCY



# BUILDING THERMAL ENVELOPE: R402 (2018 EDITION)

- Revisions in R402.1:

**R402.1 General (Prescriptive).**
The *building thermal envelope* shall ~~meet~~comply with the requirements of Sections R402.1.1 through R402.1.5.

**Exceptions:**

1. The following low-energy *buildings*, or portions thereof, separated from the remainder of the building by *building thermal envelope* assemblies complying with this section shall be exempt from the *building thermal envelope* provisions of Section R402.

   1.1. Those with a peak design rate of energy usage less than 3.4 Btu/h · $ft^2$ (10.7 $W/m^2$) or 1.0 watt/$ft^2$ of floor area for space-conditioning purposes.:

   1.2. Those that do not contain *conditioned space*.

2. Log homes designed in accordance with ICC 400.

# BUILDING THERMAL ENVELOPE: R402 (2018 EDITION)

- Revisions in Tables R402.1.2 and R402.1.4:

**TABLE R402.1.2**
**INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]**

| CLIMATE ZONE | FENESTRATION *U*-FACTOR[b] |
|---|---|
| 1 | NR |
| 2 | 0.40 |
| 3 | 0.35~~5~~2 |
| 4 except Marine | 0.35~~5~~2 |
| 5 and Marine 4 | 0.32~~5~~0 |
| 6 | 0.32~~5~~0 |
| 7 and 8 | 0.32~~5~~0 |

**TABLE R402.1.4**
**EQUIVALENT U-FACTORS[a]**

| CLIMATE ZONE | FENESTRATION *U*-FACTOR |
|---|---|
| 1 | 0.50 |
| 2 | 0.40 |
| 3 | 0.35~~5~~2 |
| 4 except Marine | 0.35~~5~~2 |
| 5 and Marine 4 | 0.32~~5~~0 |
| 6 | 0.32~~5~~0 |
| 7 and 8 | 0.32~~5~~0 |

# BUILDING THERMAL ENVELOPE: R402 (2018 EDITION)

- Revisions in Table R402.1.2 Footnote d:

~~d. R-5 shall be added to the required slab edge R-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Climate Zones 1 through 3 for heated slabs~~ R-5 insulation shall be provided under the full slab area of a heated slab in addition to the required slab edge insulation *R*-value for slabs, as indicated in the table. The slab edge insulation for heated slabs shall not be required to extend below the slab.

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revisions in Table R402.1.2 Footnote f:

- Allows fenestration U-Factor of 0.32 for residences located above 4,000 ft in elevation in Climate Zones 5 - 8

f. A maximum *U*-factor of 0.32 shall apply in Marine Climate Zone 4 and Climate Zones 5 through 8 to vertical fenestration products installed in buildings located either:

1. Above 4,000 feet in elevation above sea level, or
2. In windborne debris regions where protection of openings is required by Section R301.2.1.2 of the *International Residential Code*.

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revisions in Table R402.1.3:
- Increase wood frame wall R-values by R-5 in Climate Zones 4 & 5

~~TABLE R402.1.2~~TABLE R402.1.3
INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

| CLIMATE ZONE | FENESTRATION *U*-FACTOR[b, i] | SKYLIGHT[b] *U*-FACTOR | GLAZED FENESTRATION SHGC[b, e] | CEILING *R*-VALUE | WOOD FRAME WALL *R*-VALUE[g] | MASS WALL *R*-VALUE[g,h] | FLOOR *R*-VALUE | BASEMENT[c,g] WALL *R*-VALUE | SLAB[d] *R*-VALUE & DEPTH | CRAWL SPACE[c,g] WALL *R*-VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 1 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 2 | 0.40 | 0.65 | 0.25 | ~~38~~ 49 | 13 or 0 + 10 | 4/6 | 13 | 0 | 0 | 0 |
| 3 | ~~0.32~~.30 | 0.55 | 0.25 | ~~38~~ 49 | 20 or ~~13+5[h]~~13 + 5ci or 0 + 15 | 8/13 | 19 | ~~5/13[f]~~5ci or 13[f] | ~~0~~10ci, 2 ft | ~~5/13~~5ci or 13[f] |
| 4 except Marine | ~~0.32~~.30 | 0.55 | 0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5[h]~~ 13 + 10ci or0 + 15 | 8/13 | 19 | ~~10/13~~10ci or 13 | 10ci, ~~2~~4 ft | ~~10/13~~10ci or 13 |
| 5 and Marine 4 | 0.30[j] | 0.55 | ~~NR~~0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5[h]~~ 13 + 10ci or0 + 15 | 13/17 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, ~~2~~4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 6 | 0.30[j] | 0.55 | NR | ~~49~~ 60 | ~~20+5[h] or 13+10[h]~~ 20 + 5ci or13 + 10ci or0 + 20 | 15/20 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 7 and 8 | 0.30[j] | 0.55 | NR | ~~49~~ 60 | ~~20 + 5 or 13 + 10~~ 20 + 5ci or13 + 10ci or0 + 20 | 19/21 | 38 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revisions in Table R402.1.3:
- New R-10 slab insulation at 2 ft depth for Climate Zone 3
- Increase slab depth to 4 ft for Climate Zone 4 & 5

~~TABLE R402.1.2~~TABLE R402.1.3
INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

| CLIMATE ZONE | FENESTRATION *U*-FACTOR[b, i] | SKYLIGHT[b] *U*-FACTOR | GLAZED FENESTRATION SHGC[b, e] | CEILING *R*-VALUE | WOOD FRAME WALL *R*-VALUE[g] | MASS WALL *R*-VALUE[h] | FLOOR *R*-VALUE | BASEMENT[c, g] WALL *R*-VALUE | SLAB[d] *R*-VALUE & DEPTH | CRAWL SPACE[c, g] WALL *R*-VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 1 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 2 | 0.40 | 0.65 | 0.25 | ~~38~~ 49 | 13 or 0 + 10 | 4/6 | 13 | 0 | 0 | 0 |
| 3 | ~~0.32~~.30 | 0.55 | 0.25 | ~~38~~ 49 | 20 or ~~13+5[h]~~13 + 5ci or 0 + 15 | 8/13 | 19 | ~~5/13[f]~~5ci or 13[f] | ~~0~~10ci, 2 ft | ~~5/13~~5ci or 13[f] |
| 4 except Marine | ~~0.32~~.30 | 0.55 | 0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5[h]~~ 13 + 10ci or0 + 15 | 8/13 | 19 | ~~10/13~~10ci or 13 | 10ci, ~~2~~4 ft | ~~10/13~~10ci or 13 |
| 5 and Marine 4 | 0.30[j] | 0.55 | ~~NR~~0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5[h]~~ 13 + 10ci or0 + 15 | 13/17 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, ~~2~~4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 6 | 0.30[j] | 0.55 | NR | ~~49~~ 60 | ~~20+5[h] or 13+10[h]~~ 20 + 5ci or13 + 10ci or0 + 20 | 15/20 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 7 and 8 | 0.30[j] | 0.55 | NR | ~~49~~ 60 | ~~20 + 5 or 13 + 10~~ 20 + 5ci or13 + 10ci or0 + 20 | 19/21 | 38 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revisions in Table R402.1.3:
- Increase ceiling insulation from R-38 to R-49 in Climate Zones 2 & 3

~~TABLE R402.1.2~~TABLE R402.1.3
INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

| CLIMATE ZONE | FENESTRATION *U*-FACTOR[b, i] | SKYLIGHT[b] *U*-FACTOR | GLAZED FENESTRATION SHGC[b, e] | CEILING *R*-VALUE | WOOD FRAME WALL *R*-VALUE[g] | MASS WALL *R*-VALUE[i, h] | FLOOR *R*-VALUE | BASEMENT[c, g] WALL *R*-VALUE | SLAB[d] *R*-VALUE & DEPTH | CRAWL SPACE[c, g] WALL *R*-VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 1 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 2 | 0.40 | 0.65 | 0.25 | ~~38~~ 49 | 13 or 0 + 10 | 4/6 | 13 | 0 | 0 | 0 |
| 3 | ~~0.32~~.30 | 0.55 | 0.25 | ~~38~~ 49 | 20 or ~~13+5~~[h]13 + 5ci or 0 + 15 | 8/13 | 19 | ~~5/13~~[f]5ci or 13[f] | ~~0~~10ci, 2 ft | ~~5/13~~5ci or 13[f] |
| 4 except Marine | ~~0.32~~.30 | 0.55 | 0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5~~[h] 13 + 10ci or0 + 15 | 8/13 | 19 | ~~10/13~~10ci or 13 | 10ci, ~~2~~4 ft | ~~10/13~~10ci or 13 |
| 5 and Marine 4 | 0.30[i] | 0.55 | ~~NR~~0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5~~[h] 13 + 10ci or0 + 15 | 13/17 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, ~~2~~4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 6 | 0.30[i] | 0.55 | NR | ~~49~~ 60 | ~~20+5~~[h] ~~or 13+10~~[h] 20 + 5ci or13 + 10ci or0 + 20 | 15/20 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 7 and 8 | 0.30[i] | 0.55 | NR | ~~49~~ 60 | ~~20 + 5 or 13 + 10~~ 20 + 5ci or13 + 10ci or0 + 20 | 19/21 | 38 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revisions in Table R402.1.3:
- Increase ceiling insulation from R-49 to R-60 in Climate Zones 4 - 8

~~TABLE R402.1.2~~TABLE R402.1.3
INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

| CLIMATE ZONE | FENESTRATION *U*-FACTOR[b, i] | SKYLIGHT[b] *U*-FACTOR | GLAZED FENESTRATION SHGC[b, e] | CEILING *R*-VALUE | WOOD FRAME WALL *R*-VALUE[g] | MASS WALL *R*-VALUE[i, h] | FLOOR *R*-VALUE | BASEMENT[c, g] WALL *R*-VALUE | SLAB[d] *R*-VALUE & DEPTH | CRAWL SPACE[c, g] WALL *R*-VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 1 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 2 | 0.40 | 0.65 | 0.25 | ~~38~~ 49 | 13 or 0 + 10 | 4/6 | 13 | 0 | 0 | 0 |
| 3 | ~~0.32~~.30 | 0.55 | 0.25 | ~~38~~ 49 | 20 or ~~13+5[h]~~13 + 5ci or 0 + 15 | 8/13 | 19 | ~~5/13[f]~~5ci or 13[f] | ~~0~~10ci, 2 ft | ~~5/13~~5ci or 13[f] |
| 4 except Marine | ~~0.32~~.30 | 0.55 | 0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5[h]~~ 13 + 10ci or0 + 15 | 8/13 | 19 | ~~10/13~~10ci or 13 | 10ci, ~~2~~4 ft | ~~10/13~~10ci or 13 |
| 5 and Marine 4 | 0.30[j] | 0.55 | ~~NR~~0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5[h]~~ 13 + 10ci or0 + 15 | 13/17 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, ~~2~~4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 6 | 0.30[j] | 0.55 | NR | ~~49~~ 60 | ~~20+5[h] or 13+10[h]~~ 20 + 5ci or13 + 10ci or0 + 20 | 15/20 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 7 and 8 | 0.30[j] | 0.55 | NR | ~~49~~ 60 | ~~20 + 5 or 13 + 10~~ 20 + 5ci or13 + 10ci or0 + 20 | 19/21 | 38 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revisions in Table R402.1.3:
- Reduce fenestration U-Factors to 0.30 in Climate Zones 3 & 4

~~TABLE R402.1.2~~TABLE R402.1.3
INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

| CLIMATE ZONE | FENESTRATION *U*-FACTOR[b, i] | SKYLIGHT[b] *U*-FACTOR | GLAZED FENESTRATION SHGC[b, e] | CEILING *R*-VALUE | WOOD FRAME WALL *R*-VALUE[g] | MASS WALL *R*-VALUE[h] | FLOOR *R*-VALUE | BASEMENT[c, g] WALL *R*-VALUE | SLAB[d] *R*-VALUE & DEPTH | CRAWL SPACE[c, g] WALL *R*-VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 1 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 2 | 0.40 | 0.65 | 0.25 | ~~38~~ 49 | 13 or 0 + 10 | 4/6 | 13 | 0 | 0 | 0 |
| 3 | ~~0.32~~.30 | 0.55 | 0.25 | ~~38~~ 49 | 20 or ~~13+5~~[h]13 + 5ci or 0 + 15 | 8/13 | 19 | ~~5/13~~[f]5ci or 13[f] | ~~0~~10ci, 2 ft | ~~5/13~~5ci or 13[f] |
| 4 except Marine | ~~0.32~~.30 | 0.55 | 0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5~~[h] 13 + 10ci or0 + 15 | 8/13 | 19 | ~~10/13~~10ci or 13 | 10ci, ~~2~~4 ft | ~~10/13~~10ci or 13 |
| 5 and Marine 4 | 0.30[i] | 0.55 | ~~NR~~0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5~~[h] 13 + 10ci or0 + 15 | 13/17 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, ~~2~~4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 6 | 0.30[i] | 0.55 | NR | ~~49~~ 60 | ~~20+5[h] or 13+10[h]~~ 20 + 5ci or13 + 10ci or0 + 20 | 15/20 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 7 and 8 | 0.30[i] | 0.55 | NR | ~~49~~ 60 | ~~20 + 5 or 13 + 10~~ 20 + 5ci or13 + 10ci or0 + 20 | 19/21 | 38 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revisions in Table R402.1.3:
- Sets required SHGC for Climate Zones 4C & 5 to 0.40

~~TABLE R402.1.2~~TABLE R402.1.3
INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

| CLIMATE ZONE | FENESTRATION *U*-FACTOR[b, i] | SKYLIGHT[b] *U*-FACTOR | GLAZED FENESTRATION SHGC[b, e] | CEILING *R*-VALUE | WOOD FRAME WALL *R*-VALUE[g] | MASS WALL *R*-VALUE[h] | FLOOR *R*-VALUE | BASEMENT[c, g] WALL *R*-VALUE | SLAB[d] *R*-VALUE & DEPTH | CRAWL SPACE[c, g] WALL *R*-VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 1 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 2 | 0.40 | 0.65 | 0.25 | ~~38~~ 49 | 13 or 0 + 10 | 4/6 | 13 | 0 | 0 | 0 |
| 3 | ~~0.32~~.30 | 0.55 | 0.25 | ~~38~~ 49 | 20 or ~~13+5[h]~~13 + 5ci or 0 + 15 | 8/13 | 19 | ~~5/13[f]~~5ci or 13[f] | ~~0~~10ci, 2 ft | ~~5/13~~5ci or 13[f] |
| 4 except Marine | ~~0.32~~.30 | 0.55 | 0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5[h]~~ 13 + 10ci or0 + 15 | 8/13 | 19 | ~~10/13~~10ci or 13 | 10ci, ~~24~~ ft | ~~10/13~~10ci or 13 |
| 5 and Marine 4 | 0.30[i] | 0.55 | ~~NR~~0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5[h]~~ 13 + 10ci or0 + 15 | 13/17 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, ~~24~~ ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 6 | 0.30[i] | 0.55 | NR | ~~49~~ 60 | ~~20+5[h] or 13+10[h]~~ 20 + 5ci or13 + 10ci or0 + 20 | 15/20 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 7 and 8 | 0.30[i] | 0.55 | NR | ~~49~~ 60 | ~~20 + 5 or 13 + 10~~ 20 + 5ci or13 + 10ci or0 + 20 | 19/21 | 38 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |

HOUSTON PUBLIC WORKS

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revisions in Table R402.1.3:
- Basement wall alternative prescription options

~~TABLE R402.1.2~~TABLE R402.1.3
INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

| CLIMATE ZONE | FENESTRATION *U*-FACTOR[b, i] | SKYLIGHT[b] *U*-FACTOR | GLAZED FENESTRATION SHGC[b, e] | CEILING *R*-VALUE | WOOD FRAME WALL *R*-VALUE[g] | MASS WALL *R*-VALUE[h] | FLOOR *R*-VALUE | BASEMENT[c, g] WALL *R*-VALUE | SLAB[d] *R*-VALUE & DEPTH | CRAWL SPACE[c, g] WALL *R*-VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 1 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 2 | 0.40 | 0.65 | 0.25 | ~~38~~ 49 | 13 or 0 + 10 | 4/6 | 13 | 0 | 0 | 0 |
| 3 | ~~0.32~~.30 | 0.55 | 0.25 | ~~38~~ 49 | 20 or ~~13+5~~[h]13 + 5ci or 0 + 15 | 8/13 | 19 | ~~5/13~~[f]5ci or 13[f] | ~~0~~10ci, 2 ft | ~~5/13~~5ci or 13[f] |
| 4 except Marine | ~~0.32~~.30 | 0.55 | 0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5~~[h] 13 + 10ci or0 + 15 | 8/13 | 19 | ~~10/13~~10ci or 13 | 10ci, ~~2~~4 ft | ~~10/13~~10ci or 13 |
| 5 and Marine 4 | 0.30[i] | 0.55 | ~~NR~~0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5~~[h] 13 + 10ci or0 + 15 | 13/17 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, ~~2~~4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 6 | 0.30[i] | 0.55 | NR | ~~49~~ 60 | ~~20+5[h] or 13+10[h]~~ 20 + 5ci or13 + 10ci or0 + 20 | 15/20 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 7 and 8 | 0.30[i] | 0.55 | NR | ~~49~~ 60 | ~~20 + 5 or 13 + 10~~ 20 + 5ci or13 + 10ci or0 + 20 | 19/21 | 38 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |

HOUSTON PUBLIC WORKS

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revisions in Table R402.1.3:
- Above grade wall alternative prescriptive options

~~TABLE R402.1.2~~TABLE R402.1.3
INSULATION MINIMUM *R*-VALUES AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

| CLIMATE ZONE | FENESTRATION *U*-FACTOR[b, i] | SKYLIGHT[b] *U*-FACTOR | GLAZED FENESTRATION SHGC[b, e] | CEILING *R*-VALUE | WOOD FRAME WALL *R*-VALUE[g] | MASS WALL *R*-VALUE[h] | FLOOR *R*-VALUE | BASEMENT[c, g] WALL *R*-VALUE | SLAB[d] *R*-VALUE & DEPTH | CRAWL SPACE[c, g] WALL *R*-VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 1 | NR | 0.75 | 0.25 | 30 | 13 or 0 + 10 | 3/4 | 13 | 0 | 0 | 0 |
| 2 | 0.40 | 0.65 | 0.25 | ~~38~~ 49 | 13 or 0 + 10 | 4/6 | 13 | 0 | 0 | 0 |
| 3 | ~~0.32~~.30 | 0.55 | 0.25 | ~~38~~ 49 | 20 or ~~13+5~~[h]13 + 5ci or 0 + 15 | 8/13 | 19 | ~~5/13~~[f]5ci or 13[f] | ~~0~~10ci, 2 ft | ~~5/13~~5ci or 13[f] |
| 4 except Marine | ~~0.32~~.30 | 0.55 | 0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5~~[h] 13 + 10ci or0 + 15 | 8/13 | 19 | ~~10/13~~10ci or 13 | 10ci, ~~2~~4 ft | ~~10/13~~10ci or 13 |
| 5 and Marine 4 | 0.30[i] | 0.55 | ~~NR~~0.40 | ~~49~~ 60 | 20 + 5 or ~~13+5~~[h] 13 + 10ci or0 + 15 | 13/17 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, ~~2~~4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 6 | 0.30[i] | 0.55 | NR | ~~49~~ 60 | ~~20+5~~[h] ~~or 13+10~~[h] 20 + 5ci or13 + 10ci or0 + 20 | 15/20 | 30 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |
| 7 and 8 | 0.30[i] | 0.55 | NR | ~~49~~ 60 | ~~20 + 5 or 13 + 10~~ 20 + 5ci or13 + 10ci or0 + 20 | 19/21 | 38 | ~~15/19~~15ci or 19 or13 + 5ci | 10ci, 4 ft | ~~15/19~~15ci or 19or 13 + 5ci |

# BUILDING THERMAL ENVELOPE: R402 (2018 EDITION)

- Revision in sections of Table R402.4.1.1:

**TABLE R402.4.1.1**

**AIR BARRIER AND INSULATION INSTALLATION**[a]

| COMPONENT | AIR BARRIER CRITERIA | INSULATION INSTALLATION CRITERIA |
|---|---|---|
| General requirements | A continuous air barrier shall be installed in the building envelope.<br><br>The exterior thermal envelope contains a continuous air barrier.<br><br>Breaks or joints in the air barrier shall be sealed. | Air-permeable insulation shall not be used as a sealing material. |
| Ceiling/attic | The air barrier in any dropped ceiling ~~/or~~ soffit shall be aligned with the insulation and any gaps in the air barrier shall be sealed.<br><br>Access openings, drop down stairs or knee wall doors to unconditioned attic spaces shall be sealed. | The insulation in any dropped ceiling/soffit shall be aligned with the air barrier. |
| Walls | The junction of the foundation and sill plate shall be sealed.<br><br>The junction of the top plate and the top of exterior walls shall be sealed.<br><br>Knee walls shall be sealed. | Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance *R*-value of not less than R-3 per inch ~~minimum~~. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier. |
| Windows, skylights and doors | The space between ~~window/door jambs and~~ framing ~~,~~ and skylights, and the jambs of windows and doors ~~framing~~ shall be sealed. | ≡ |
| Rim joists | Rim joists shall include the air barrier. | Rim joists shall be insulated. |

HOUSTON PUBLIC WORKS

# BUILDING THERMAL ENVELOPE: R402 (2018 EDITION)

- Revision in sections of Table R402.4.1.1:

| | | |
|---|---|---|
| Floors ~~(~~including ~~above garage and~~ cantilevered floors and floors above garages~~)~~ | The air barrier shall be installed at any exposed edge of insulation. | Floor framing cavity insulation shall be installed to maintain permanent contact with the underside of subfloor decking~~, or~~ . Alternatively floor framing cavity insulation shall be permitted to be in contact with the top side of sheathing, or continuous insulation installed on the underside of floor framing; and shall extend~~s~~ from the bottom to the top of all perimeter floor framing members. |
| Crawl space walls | Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped. | Crawl space insulation ~~W~~where provided instead of floor insulation, insulation shall be permanently attached to the crawlspace walls. |
| Shafts, penetrations | Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed. | = |
| Narrow cavities | = | Batts to be installed in narrow cavities shall be cut to fit~~,~~ or narrow cavities shall be filled ~~by~~with insulation that on installation readily conforms to the available cavity space. |
| Garage separation | Air sealing shall be provided between the garage and conditioned spaces. | = |
| Recessed lighting | Recessed light fixtures installed in the building thermal envelope shall be sealed to the ~~drywall~~finished surface. | Recessed light fixtures installed in the building thermal envelope shall be air tight and IC rated. |

# BUILDING THERMAL ENVELOPE: R402 (2018 EDITION)

- Revision in sections of Table R402.4.1.1:

| | | |
|---|---|---|
| Plumbing and wiring | = | In exterior walss, ~~S~~batt insulation shall be cut neatly to fit around wiring and plumbing, ~~in exterior walls,~~ or insulation, that on installation readily conforms to available space, shall extend behind piping and wiring. |
| Shower/tub on exterior wall | The air barrier installed at exterior walls adjacent to showers and tubs shall separate the~~m~~ wall from the shower~~s and~~ tub~~s~~. | Exterior walls adjacent to showers and tubs shall be insulated. |
| Electrical/phone box on exterior walls | The air barrier shall be installed behind electrical ~~or~~ and communication boxes. Alternatively, ~~or~~ air-sealed boxes shall be installed. | = |
| HVAC register boots | HVAC supply and return register boots that penetrate building thermal envelope shall be sealed to the subfloor ~~or~~, ~~drywall~~wall covering or ceiling penetrated by the boot. | = |
| Concealed sprinklers | Whe~~n~~re required to be sealed, concealed fire sprinklers shall only be sealed in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings. | = |

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revision in section of Table R402.4.1.1:

**TABLE R402.4.1.1**
**AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION[a]**

| | | |
|---|---|---|
| Rim joists | Rim joists shall include ~~the~~ an exterior air barrier.[b] The junctions of the rim board to the sill plate and the rim board and the subfloor shall be air sealed. | Rim joists shall be insulated so that the insulation maintains permanent contact with the exterior rim board.[b] |

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revisions in R402.4.1.2:

**R402.4.1.2 Testing.** The *building* or *dwelling unit* shall be tested ~~and verified as having an air leakage rate not exceeding five air changes per hour in *Climate Zones* 1 and 2, and three air changes per hour in *Climate Zones* 3 through 8~~ for air leakage. The maximum air leakage rate for any *building* or *dwelling unit* under any compliance path shall not exceed 5.0 air changes per hour or 0.28 cubic feet per minute (CFM) per square foot [0.0079 $m^3/(s \times m^2)$] of dwelling unit enclosure area. Testing shall be conducted in accordance with **ANSI/RESNET/ICC 380**, **ASTM E779** or **ASTM E1827** and reported at a pressure of 0.2 inch w.g. (50 Pascals). Where required by the *code official*, testing shall be conducted by an *approved* third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the *code official*. Testing shall be performed at any time after creation of all penetrations of the *building thermal envelope* have been sealed.

**Exception:** For heated, attached private garages and heated, detached private garages accessory to one- and two-family dwellings and townhouses not more than three stories above *grade plane* in height, building envelope tightness and insulation installation shall be considered acceptable where the items in **Table R402.4.1.1**, applicable to the method of construction, are field verified. Where required by the code official, an *approved* third party independent from the installer shall inspect both air barrier and insulation installation criteria. Heated, attached private garage space and heated, detached private garage space shall be thermally isolated from all other habitable, *conditioned spaces* in accordance with **Sections R402.2.12** and **R402.3.5**, as applicable.

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revisions in R402.4.1.2:

During testing:

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed, beyond the intended weatherstripping or other infiltration control measures.
2. Dampers including exhaust, intake, makeup air, backdraft and flue dampers shall be closed, but not sealed beyond intended infiltration control measures.
3. Interior doors, where installed at the time of the test, shall be open.
4. Exterior or interior terminations for continuous ventilation systems shall be sealed.
5. Heating and cooling systems, where installed at the time of the test, shall be turned off.
6. Supply and return registers, where installed at the time of the test, shall be fully open.

**Exception:** When testing individual *dwelling units*, an air leakage rate not exceeding 0.30 cubic feet per minute per square foot [0.008 $m^3/(s \times m^2)$] of the dwelling unit enclosure area, tested in accordance with **ANSI/RESNET/ICC 380**, **ASTM E779** or **ASTM E1827** and reported at a pressure of 0.2 inch w.g. (50 Pa), shall be an accepted alternative permitted in all climate zones for:

1. Attached single-family and multiple-family building *dwelling units*.
2. Buildings or *dwelling units* that are 1,500 square feet (139.4 $m^2$) or smaller.

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Addition in R402.4.6:

**R402.4.6 Electrical and communication outlet boxes (air-sealed boxes).** Electrical and communication outlet boxes installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces. Electrical and communication outlet boxes shall be tested in accordance with **NEMA OS 4**, *Requirements for Air-Sealed Boxes for Electrical and Communication Applications*, and shall have an air leakage rate of not greater than 2.0 cubic feet per minute (0.944 L/s) at a pressure differential of 1.57 psf (75 Pa). Electrical and communication outlet boxes shall be marked "NEMA OS 4" or "OS 4" in accordance with **NEMA OS 4**. Electrical and communication outlet boxes shall be installed per the manufacturer's instructions and with any supplied components required to achieve compliance with **NEMA OS 4**.

# BUILDING THERMAL ENVELOPE: R402 (2021 EDITION)

- Revisions in R402.5:

- Decreases mandatory backstops for fenestration U-Factors and SHGCs
  - Sets area-weighted average maximum fenestration U-factor to 0.40 in Climate Zones 4 & 5
  - Sets area-weighted average maximum fenestration U-factor to 0.35 in Climate Zones 6 - 8
  - Sets area-weighted average maximum fenestration SHGC to 0.40 in Climate Zones 1 - 3

**R402.5 Maximum fenestration U-factor and SHGC ~~(Mandatory)~~.** The area-weighted average maximum fenestration *U*-factor permitted using tradeoffs from **Section R402.1.5** or **R405** shall be 0.48 in Climate Zones 4 and 5 and 0.40 in Climate Zones 6 through 8 for vertical fenestration, and 0.75 in Climate Zones 4 through 8 for skylights. The area-weighted average maximum fenestration SHGC permitted using tradeoffs from **Section R405** in *Climate Zones* ~~1~~ 0 through 3 shall be ~~0.50~~ **0.40**.

**Exception:** The maximum *U*-factor and solar heat gain coefficient (SHGC) for fenestration shall not be required in storm shelters complying with **ICC 500**.

# SYSTEMS: R403 (2021 EDITION)

- Revisions in R403.3.2:

**~~R403.3.7~~R403.3.2 Ducts located in conditioned space.** For ~~ducts~~ ductwork to be considered ~~as~~ inside a *conditioned space*, ~~such ducts~~ it shall comply with ~~either~~ one of the following:

1. The duct system shall be located completely within the *continuous air barrier* and within the building thermal envelope.
2. ~~The ducts shall~~Ductwork in ventilated attic spaces shall be buried within ceiling insulation in accordance with **Section R403.3.3** and all of the following conditions shall exist:
    - 2.1. The air handler is located completely within the *continuous air barrier* and within the *building thermal envelope*.
    - 2.2. The duct leakage, as measured either by a rough-in test of the ducts or a post-construction total system leakage test to outside the *building thermal envelope* in accordance with **Section R403.3.6**, is less than or equal to 1.5 cubic feet per minute (42.5 L/min) per 100 square feet (9.29 $m^2$) of *conditioned floor area* served by the duct system.
    - 2.3. The ceiling insulation *R*-value installed against and above the insulated duct is greater than or equal to the proposed ceiling insulation *R*-value, less the *R*-value of the insulation on the duct.

# SYSTEMS: R403 (2021 EDITION)

- Additions in R403.3.2:

3. Ductwork in floor cavities located over unconditioned space shall comply with all of the following:
    3.1. A *continuous air barrier* installed between unconditioned space and the duct.
    3.2. Insulation installed in accordance with **Section R402.2.7**.
    3.3. A minimum R-19 insulation installed in the cavity width separating the duct from unconditioned space.
4. Ductwork located within *exterior walls* of the *building thermal envelope* shall comply with the following:
    4.1. A *continuous air barrier* installed between unconditioned space and the duct.
    4.2. Minimum R-10 insulation installed in the cavity width separating the duct from the outside sheathing.
    4.3. The remainder of the cavity insulation shall be fully insulated to the drywall side.

# SYSTEMS: R403 (2021 EDITION)

- Revisions in R403.3.5:

~~R403.3.3~~R403.3.5 Duct testing ~~(Mandatory)~~. Ducts shall be pressure tested in accordance with ANSI/RESNET/ICC 380 or ASTM E1554 to determine air leakage by one of the following methods:

1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure if installed at the time of the test. Registers shall be taped or otherwise sealed during the test.
2. Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.

~~Exceptions:~~ Exception:

~~1. A duct air-leakage test shall not be required where the ducts and air handlers are located entirely within the *building thermal envelope*.~~

~~2.~~ A duct air-leakage test shall not be required for ducts serving ~~heat or energy recovery ventilators~~heating, cooling or ventilation systems that are not integrated with ducts serving heating or cooling systems.

# SYSTEMS: R403 (2018 EDITION)

- Addition in R403.3.6:

R403.3.6 Ducts buried within ceiling insulation.
Where supply and return air ducts are partially or completely buried in ceiling insulation, such ducts shall comply with all of the following:

1. The supply and return ducts shall have an insulation *R*-value not less than R-8.

2. At all points along each duct, the sum of the ceiling insulation *R*-value against and above the top of the duct, and against and below the bottom of the duct, shall be not less than R-19, excluding the *R*-value of the duct insulation.

3. In *Climate Zones* 1A, 2A and 3A, the supply ducts shall be completely buried within ceiling insulation, insulated to an *R*-value of not less than R-13 and in compliance with the vapor retarder requirements of Section 604.11 of the *International Mechanical Code* or Section M1601.4.6 of the *International Residential Code*, as applicable.

   Exception: Sections of the supply duct that are less than 3 feet (914 mm) from the supply outlet shall not be required to comply with these requirements.

# SYSTEMS: R403 (2018 EDITION)

- Revision in Table R403.6.1:

**TABLE R403.6.1**

**WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM FAN EFFICACY[a]**

| FAN LOCATION | AIR FLOW RATE MINIMUM (CFM) | MINIMUM EFFICACY (CFM/WATT) | AIR FLOW RATE MAXIMUM (CFM) |
|---|---|---|---|
| HRV or ERV | Any | 1.2 cfm/watt | Any |
| Range hoods | Any | 2.8 cfm/watt | Any |
| In-line fan | Any | 2.8 cfm/watt | Any |
| Bathroom, utility room | 10 | 1.4 cfm/watt | < 90 |
| Bathroom, utility room | 90 | 2.8 cfm/watt | Any |

For SI: 1 cfm = 28.3 L/min.

a. When tested in accordance with HVI Standard 916

# SYSTEMS: R403 (2021 EDITION)

- Revisions in R403.6 and R403.6.2, and addition in R403.6.1:

**R403.6 Mechanical ventilation ~~(Mandatory)~~.** ~~The *building*~~ *Buildings* and *dwelling units* shall be provided with mechanical *ventilation* that complies with the requirements of the International Residential Code or *International Mechanical Code*, as applicable, or with other *approved* means of *ventilation*. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the *ventilation* system is not operating.

**R403.6.1 Heat or energy recovery ventilation.** *Dwelling units* shall be provided with a heat recovery or energy recovery ventilation system in Climate Zones 7 and 8. The system shall be balanced with a minimum sensible heat recovery efficiency of 65 percent at 32°F (0°C) at a flow greater than or equal to the design airflow.

**~~R403.6.1~~R403.6.2 Whole-~~house~~dwelling mechanical ventilation system fan efficacy.** Fans used to provide whole-~~house~~dwelling mechanical ventilation shall meet the efficacy requirements of **Table R403.6.2** at one or more rating points. Fans shall be tested in accordance with **HVI 916** and listed. The airflow shall be reported in the product listing or on the label. Fan efficacy shall be reported in the product listing or shall be derived from the input power and airflow values reported in the product listing or on the label. Fan efficacy for fully ducted HRV, ERC, balanced, and in-line fans shall be determined at a static pressure of not less than 0.2 inch w.c. (49.85 Pa). Fan efficacy for ducted range hoods, bathroom and utility room fans shall be determined at a static pressure of not less than 0.1 inch w.c. (24.91 Pa).

~~**Exception:**~~

~~Where an air handler that is integral to tested and *listed* HVAC equipment is used to provide whole-house mechanical ventilation, the air handler shall be powered by an electronically commutated motor.~~

# SYSTEMS: R403 (2021 EDITION)

- Revisions in Table R403.6.2:

~~TABLE R403.6.1~~TABLE R403.6.2
WHOLE-~~HOUSE~~DWELLING MECHANICAL VENTILATION SYSTEM FAN EFFICACY[a]

| FAN LOCATION | AIRFLOW RATE MINIMUM (CFM) | MINIMUM EFFICACY (CFM/WATT) | ~~AIR FLOW RATE MAXIMUM (CFM)~~ |
|---|---|---|---|
| HRV, ~~or~~ ERV | Any | 1.2 cfm/watt | ~~Any~~ |
| ~~Range hoods~~ | ~~Any~~ | ~~2.8 cfm/watt~~ | ~~Any~~ |
| In-line supply or exhaust fan | Any | 3.8 ~~2.8~~ cfm/watt | ~~Any~~ |
| ~~Bathroom, utility room~~ Other exhaust fan | ~~10~~ < 90 | 2.8 ~~1.4~~ cfm/watt | ~~< 90~~ |
| ~~Bathroom, utility room~~ Other exhaust fan | ≥ 90 | 3.5 ~~2.8~~ cfm/watt | ~~Any~~ |
| Air-handler that is integrated to tested and *listed* HVAC equipment | Any | 1.2 cfm/watt | |

For SI: 1 cubic foot per minute = 28.3 L/min.

a. ~~When tested in accordance with HVI Standard 916.~~ Design outdoor airflow rate/watts of fan used.

# SYSTEMS: R403 (2021 EDITION)

- Addition in R403.6.3:

**R403.6.3 Testing.** Mechanical ventilation systems shall be tested and verified to provide the minimum ventilation flow rates required by **Section R403.6**. Testing shall be performed according to the ventilation *equipment* manufacturer's instructions, or by using a flow hood or box, flow grid, or other airflow measuring device at the mechanical ventilation fan's inlet terminals or grilles, outlet terminals or grilles, or in the connected ventilation ducts. Where required by the code official, testing shall be conducted by an *approved* third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official.

**Exception:** Kitchen range hoods that are ducted to the outside with 6-inch (152 mm) or larger duct and not more than one 90-degree (1.57 rad) elbow or equivalent in the duct run.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: R404 (2018 EDITION)

- Revisions in R404.1:

**R404.1 Lighting equipment (Mandatory).**
Not less than ~~75~~90 percent of the ~~lamps in~~ permanently installed lighting fixtures shall ~~be high-efficacy lamps or not less than 75 percent of the permanently installed lighting fixtures shall~~ contain only high-efficacy lamps.

~~Exception: Low-voltage lighting~~.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: R404 (2021 EDITION)

- Revisions in R404.1 and addition of R404.1.1:

**R404.1 Lighting equipment ~~(Mandatory)~~.** ~~Not less than 90 percent of the~~ All permanently installed lighting fixtures, excluding kitchen appliance lighting fixtures, shall contain only high-efficacy lighting sources ~~lamps~~.

**R404.1.1 Exterior lighting.** Connected exterior lighting for residential buildings shall comply with Section C405.4.

**Exceptions:**

1. Detached one- and two- family dwellings.
2. Townhouses.
3. Solar-powered lamps not connected to any electrical service.
4. Luminaires controlled by a motion sensor.
5. Lamps and luminaires that comply with Section R404.1.

# ELECTRICAL POWER AND LIGHTING SYSTEMS: R404 (2021 EDITION)

- Additions of R404.2 and R404.3:

**R404.2 Interior lighting controls.** Permanently installed lighting fixtures shall be controlled with either a dimmer, an occupant sensor control or other control that is installed or built into the fixture.

**Exception:** Lighting controls shall not be required for the following:

1. Bathrooms.
2. Hallways.
3. Exterior lighting fixtures.
4. Lighting designed for safety or security.

**R404.3 Exterior lighting controls.** Where the total permanently installed exterior lighting power is greater than 30 watts, the permanently installed exterior lighting shall comply with the following:

1. Lighting shall be controlled by a manual on and off switch which permits automatic shut-off actions.

   **Exception:** Lighting serving multiple *dwelling units*.

2. Lighting shall be automatically shut off when daylight is present and satisfies the lighting needs.
3. Controls that override automatic shut-off actions shall not be allowed unless the override automatically returns automatic control to its normal operation within 24 hours.

# TOTAL BUILDING PERFORMANCE: R405 (2021 EDITION)

- Revision of R405.2:

**R405.2 ~~Mandatory requirements~~ Performance-based compliance.** Compliance ~~with this section~~ based on total building performance requires that a *proposed design* meets all of the following: ~~the mandatory provisions identified in Section R401.2 be met. Supply and return ducts not completely inside the *building thermal envelope* shall be insulated to an *R*-value of not less than R-6.~~

1. The requirements of the sections indicated within **Table R405.2**.
2. The building thermal envelope greater than or equal to levels of efficiency and solar heat gain coefficients in Table R402.1.1 or R402.1.3 of the 2009 *International Energy Conservation Code*.
3. An annual energy cost that is less than or equal to the annual energy cost of the *standard reference design*. Energy prices shall be taken from a source *approved* by the *code official*, such as the Department of Energy, Energy Information

   Administration's State Energy Data System Prices and Expenditures reports. Code officials shall be permitted to require time-of-use pricing in energy cost calculations.

   **Exception:** The energy use based on source energy expressed in Btu or Btu per square foot of *conditioned floor area* shall be permitted to be substituted for the energy cost. The source energy multiplier for electricity shall be 3.16. The source energy multiplier for fuels other than electricity shall be 1.1.

# TOTAL BUILDING PERFORMANCE: R405 (2021 EDITION)

- Revision of Table R405.4.2(1):

**TABLE R405.5.2(1) [IRC N1105.5.2(1)]**
**SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS**

Portions of table not shown remain unchanged.

<table>
<tr><th>BUILDING COMPONENT</th><th>STANDARD REFERENCE DESIGN</th><th colspan="3">PROPOSED DESIGN</th></tr>
<tr><td rowspan="8">Service water heating[d, g]</td><td rowspan="8">As proposed.<br>~~Use: same as proposed design.~~Use, in units of gal/day = 30 + (10 × $N_{br}$)<br>where:<br>$N_{br}$ = number of bedrooms.</td><td colspan="3">As proposed<br>Use, in units of gal/day = ~~30~~ 25.5 + (~~10~~ 8.5 × $N_{br}$) × (1 – HWDS)<br>where:<br>$N_{br}$ = number of bedrooms.<br>HWDS = factor for the compactness of the hotwater distribution system.</td></tr>
<tr><td colspan="2">Compactness ratio[i] factor</td><td>HWDS</td></tr>
<tr><td>1 story</td><td>2 or more stories</td><td></td></tr>
<tr><td>> 60%</td><td>> 30%</td><td>0</td></tr>
<tr><td>> 30% to ≤ 60%</td><td>> 15% to ≤ 30%</td><td>0.05</td></tr>
<tr><td>> 15% to ≤ 30%</td><td>> 7.5% to ≤ 15%</td><td>0.10</td></tr>
<tr><td>< 15%</td><td>< 7.5%</td><td>0.15</td></tr>
<tr><td colspan="4"></td></tr>
</table>

# TOTAL BUILDING PERFORMANCE: R405 (2021 EDITION)

- Revision of Table R405.4.2(1):

**TABLE R405.5.2(1) [IRC N1105.5.2(1)]**
**SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS**

Portions of table not shown remain unchanged.

| | | |
|---|---|---|
| Dehumidistat | Where a mechanical ventilation system with latent heat recov-ery is not specified in the proposed design:<br>None.<br>Where the proposed design utilizes a mechanical ventilationsystem with latent heat recovery:<br>Dehumidistat type: manual, setpoint = 60% relative humidity.<br>Dehumidifier: whole-dwelling with integrated energyfactor = 1.77 liters/kWh. | Same as standard reference design. |

# ENERGY RATING INDEX COMPLIANCE ALTERNATIVE: R406 (2021 EDITION)

- Addition of R406.3.1 and R406.3.2:

**R406.3.1 On-site renewables are not included.** Where on-site renewable energy is not included for compliance using the ERI analysis of **Section R406.4**, the proposed total building thermal envelope UA, which is sum of *U*-factor times assembly area, shall be less than or equal to the building thermal envelope UA using the prescriptive *U*-factors from **Table R402.1.2** multiplied by 1.15 in accordance with **Equation 4-1**. The area-weighted maximum fenestration SHGC permitted in Climate Zones 0 through 3 shall be 0.30.

$$UA_{\text{Proposed design}} = 1.15 \times UA_{\text{Prescriptive reference design}} \qquad \textbf{(Equation 4-1)}$$

**R406.3.2 On-site renewables are included.** Where on-site renewable energy is included for compliance using the ERI analysis of **Section R406.4**, the building thermal envelope shall be greater than or equal to the levels of efficiency and SHGC in **Table R402.1.2** or Table R402.1.4 of the 2015 *International Energy Conservation Code*.

# ENERGY RATING INDEX COMPLIANCE ALTERNATIVE: R406 (2021 EDITION)

- Revision of R406.4:

**~~R406.3~~R406.4 Energy Rating Index.** The Energy Rating Index (ERI) shall be determined in accordance with **RESNET/ICC 301** except for buildings covered by the *International Residential Code*, the ERI reference design ventilation rate shall be in accordance with **Equation 4-2**.

Ventilation rate, CFM = (0.01 × total square foot area of house) + [7.5 × (number of bedrooms + 1)]

Energy used to recharge or refuel a vehicle used for transportation on ~~1~~ **(Equation 4-2)** roads that are not on the building site shall not be included in the *ERI reference design* or the *rated design*. For compliance purposes, any reduction in energy use of the rated design associated with on-site renewable energy shall not exceed 5 percent of the total energy use.

# ENERGY RATING INDEX COMPLIANCE ALTERNATIVE: R406 (2018 EDITION)

- Revision of Table R406.4:

**TABLE R406.4**
**MAXIMUM ENERGY RATING INDEX**

| CLIMATE ZONE | ENERGY RATING INDEX |
|---|---|
| 1 | ~~52~~57 |
| 2 | ~~52~~57 |
| 3 | ~~51~~57 |
| 4 | ~~54~~62 |
| 5 | ~~55~~61 |
| 6 | ~~54~~61 |
| 7 | ~~53~~58 |
| 8 | ~~53~~58 |

a. Where on-site renewable energy is included for compliance using the ERI analysis of Section R406.4, the building shall meet the mandatory requirements of SectionR406.2, and the building thermal envelope shall be greater than or equal to the levels of efficiency and SHGC in Table R402.1.2 or Table R402.1.4 of the 2015 International Energy Conservation Code.

# ENERGY RATING INDEX COMPLIANCE ALTERNATIVE: R406 (2021 EDITION)

- Revision of Table R406.5:

~~TABLE R406.4~~TABLE R406.5
MAXIMUM ENERGY RATING INDEX

| CLIMATE ZONE | ENERGY RATING INDEX[a] |
|---|---|
| 0-1 | ~~57~~ 52 |
| 2 | ~~57~~ 52 |
| 3 | ~~57~~ 51 |
| 4 | ~~62~~ 54 |
| 5 | ~~61~~ 55 |
| 6 | ~~61~~ 54 |
| 7 | ~~58~~ 53 |
| 8 | ~~58~~ 53 |

# ADDITIONAL EFFICIENCY PACKAGE OPTIONS: R408 (2021 EDITION)

- Addition of R408.2.1 and R408.2.2:

**R408.2.1 Enhanced envelope performance option.** The total *building thermal envelope* UA, the sum of *U*-factor times assembly area, shall be less than or equal to 95 percent of the total UA resulting from multiplying the *U*-factors in **Table R402.1.2** by the same assembly area as in the proposed building. The UA calculation shall be performed in accordance with **Section R402.1.5**. The area-weighted average SHGC of all glazed fenestration shall be less than or equal to 95 percent of the maximum glazed fenestration SHGC in **Table R402.1.2**.

**R408.2.2 More efficient HVAC equipment performance option.** Heating and cooling *equipment* shall meet one of the following efficiencies:

1. Greater than or equal to 95 AFUE natural gas furnace and 16 SEER air conditioner.
2. Greater than or equal to 10 HSPF/16 SEER air source heat pump.
3. Greater than or equal to 3.5 COP ground source heat pump.

For multiple cooling systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the cooling design load. For multiple heating systems, all systems shall meet or exceed the minimum efficiency requirements in this section and shall be sized to serve 100 percent of the heating design load.

# ADDITIONAL EFFICIENCY PACKAGE OPTIONS: R408 (2021 EDITION)

- Addition of R408.2.3 and R408.2.4:

**R408.2.3 Reduced energy use in service water-heating option.** The hot water system shall meet one of the following efficiencies:

1. Greater than or equal to 82 EF fossil fuel service water-heating system.
2. Greater than or equal to 2.0 EF electric service water-heating system.
3. Greater than or equal to 0.4 solar fraction solar water-heating system.

**R408.2.4 More efficient duct thermal distribution system option.** The thermal distribution system shall meet one of the following efficiencies:

1. 100 percent of ducts and air handlers located entirely within the *building thermal envelope*.
2. 100 percent of ductless thermal distribution system or hydronic thermal distribution system located completely inside the *building thermal envelope*.
3. 100 percent of duct thermal distribution system located in *conditioned space* as defined by **Section R403.3.2**.

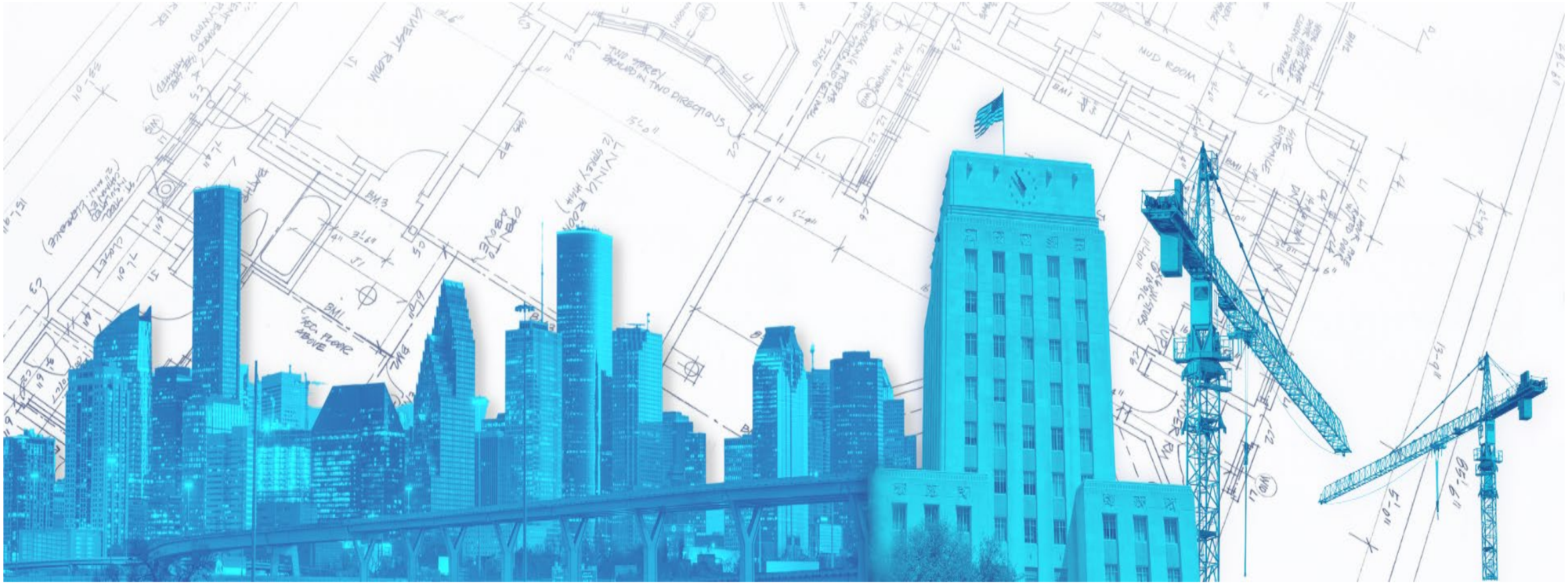
# ADDITIONAL EFFICIENCY PACKAGE OPTIONS: R408 (2021 EDITION)

- Addition of R408.2.5:

**R408.2.5 Improved air sealing and efficient ventilation system option.** The measured air leakage rate shall be less than or equal to 3.0 ACH50, with either an Energy Recovery Ventilator (ERV) or Heat Recovery Ventilator (HRV) installed. Minimum HRV and ERV requirements, measured at the lowest tested net supply airflow, shall be greater than or equal to 75 percent Sensible Recovery Efficiency (SRE), less than or equal to 1.1 cubic feet per minute per watt (0.03 $m^3$/min/watt) and shall not use recirculation as a defrost strategy. In addition, the ERV shall be greater than or equal to 50 percent Latent Recovery/Moisture Transfer (LRMT).

HOUSTON PUBLIC WORKS

# IECC APPENDIX RC ZERO ENERGY RESIDENTIAL BUILDING PROVISIONS



# ZERO ENERGY RESIDENTIAL BUILDING PROVISIONS: APPENDIX RC (2021 EDITION)

## APPENDIX RC ZERO ENERGY RESIDENTIAL BUILDING PROVISIONS

*The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.*

**User note:**

***About this appendix:*** *This appendix provides requirements for residential buildings intended to result in net zero energy consumption over the course of a year. Where adopted by ordinance as a requirement,* ***Section RC101*** *language is intended to replace* ***Section R401.2****.*

### SECTION RC101
### COMPLIANCE

**RC101.1 Compliance.** Existing residential buildings shall comply with **Chapter 5**. New residential buildings shall comply with **Section RC102**.

### SECTION RC102
### ZERO ENERGY RESIDENTIAL BUILDINGS

**RC102.1 General.** New *residential buildings* shall comply with **Section RC102.2**.

**RC102.2 Energy Rating Index zero energy score.**
Compliance with this section requires that the rated design be shown to have a score less than or equal to the values in **Table RC102.2** when compared to the Energy Rating Index (ERI) reference design determined in accordance with **RESNET/ICC 301** for both of the following:

1. ERI value not including on-site power production (OPP) calculated in accordance with **RESNET/ICC 301**.
2. ERI value including on-site power production calculated in accordance with **RESNET/ICC 301** with the OPP in Equation 4.1.2 of **RESNET/ICC 301** adjusted in accordance with Equation RC-1.

$$\text{Adjusted OPP} = \text{OPP} + \text{CREF} + \text{REPC} \qquad \text{(Equation RC-1)}$$

where:

**CREF = Community Renewable Energy Facility power production—the yearly energy, in kilowatt hour equivalent (kWheq), contracted from a community renewable energy facility that is qualified under applicable state and local utility statutes and rules, and that allocates bill credits to the rated home.**

**REPC = Renewable Energy Purchase Contract power production—the yearly energy, in kilowatt hour equivalent (kWheq), contracted from an energy facility that generates energy with photovoltaic, solar thermal, geothermal energy or wind systems, and that is demonstrated by an energy purchase contract or lease with a duration of not less than 15 years.**

**TABLE RC102.2**
**MAXIMUM ENERGY RATING INDEX[a]**

| CLIMATE ZONE | ENERGY RATING INDEX NOT INCLUDING OPP | ENERGY RATING INDEX INCLUDING ADJUSTED OPP (as proposed) |
|---|---|---|
| 1 | 43 | 0 |
| 2 | 45 | 0 |
| 3 | 47 | 0 |
| 4 | 47 | 0 |
| 5 | 47 | 0 |
| 6 | 46 | 0 |
| 7 | 46 | 0 |
| 8 | 46 | 0 |

a. The building shall meet the requirements of **Table R406.2**, and the building thermal envelope shall be greater than or equal to the levels of efficiency and SHGC in **Table R402.1.2** or **R402.1.3**.

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