

CHAPTER R4

RESIDENTIAL ENERGY EFFICIENCY

SECTION ECC R401 GENERAL

R401.1 Scope. This chapter applies to *residential buildings*.

R401.2 Application. *Residential buildings* shall comply with Section R401.2.1, R401.2.2 or R401.2.3.

Exception: Additions, alterations, repairs and changes of occupancy to existing buildings complying with Chapter 5.

R401.2.1 Prescriptive Compliance Option. The Prescriptive Compliance Option requires compliance with Sections R401 through R404 and R408.

R401.2.2 Simulated Building Performance Option. The Simulated Building Performance Option requires compliance with Section R405.

R401.2.3 Energy Rating Index Option. The *Energy Rating Index* (ERI) Option requires compliance with Section R406.

R401.3 Certificate. A permanent certificate shall be completed by the builder or other approved party and posted on a wall in the space where the furnace is located, a utility room or an approved location inside the building. Where 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. The certificate shall indicate the following:

1. The predominant R-values of insulation installed in or on ceilings, roofs, walls, foundation components such as slabs, below-grade walls, crawl space walls and floors and ducts outside conditioned spaces.
2. U-factors of fenestration and the solar heat gain coefficient (SHGC) of fenestration. Where there is more than one value for any component of the building thermal envelope, the certificate shall indicate both the value covering the largest area and the area weighted average value if available.
3. The results from any required duct system and building thermal envelope air leakage testing performed on the building.
4. The types, sizes and efficiencies of heating, cooling and service water-heating equipment. Where a gas-fired unvented room heater, electric furnace or baseboard electric heater is installed in the residence, the certificate shall indicate "gas-fired unvented room heater," "electric furnace" or "baseboard electric heater," as appropriate. An efficiency shall not be indicated for gas-fired unvented room heaters, electric furnaces and electric baseboard heaters.
5. Where on-site photovoltaic panel systems have been installed, the array capacity, inverter efficiency, panel tilt and orientation shall be noted on the certificate.
6. For buildings where an Energy Rating Index score is determined in accordance with Section R406, the Energy Rating Index score, both with and without any on-site generation, shall be listed on the certificate.
7. The code edition under which the structure was permitted, and the compliance path used and, where applicable, the additional efficiency measures selected for compliance with Section R408.
8. The location and dimensions of a solar-ready zone where one is provided.

SECTION ECC R402 BUILDING THERMAL ENVELOPE

R402.1 General. The *building thermal envelope* shall comply with the requirements of one of the following:

1. Sections R402.1.1 through R402.1.4, Section R402.1.6, and R402.2 through R402.7.
2. Sections R402.1.1, R402.1.5, R402.1.6, and R402.2 through R402.7.

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 $3.4 \text{ Btu/h} \times \text{ft}^2$ (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.

R402.1.1 Vapor retarder. Wall assemblies in the building thermal envelope shall comply with the vapor retarder requirements of the New York City Building Code, as applicable.

R402.1.2 Insulation and fenestration criteria. The *building thermal envelope* shall meet the requirements of Table R402.1.2, based on the *climate zone* specified in Chapter 3. Assemblies shall have a *U-factor* or *F-factor* equal to or less than that specified in Table R402.1.2. *Fenestration* shall have a *U-factor* and glazed fenestration SHGC equal to or less than that specified in Table R402.1.2.

R402.1.3 R-value alternative. Assemblies with an *R-value* of insulation materials equal to or greater than that specified in Table R402.1.3 shall be an alternative to the *U-factor* or *F-factor* in Table R402.1.2.

**TABLE R402.1.2
MAXIMUM ASSEMBLY U-FACTORS AND FENESTRATION REQUIREMENTS^a**

Climate Zone	4	5	6
VERTICAL FENESTRATION <i>U</i> -FACTOR	0.27	0.27 ^c	0.27 ^c
SKYLIGHT <i>U</i> -FACTOR	0.50	0.50	0.50
GLAZED VERTICAL FENESTRATION SHGC ^{c,d,f}	0.40	NR	NR
SKYLIGHT SHGC ^d	0.40	NR	NR
CEILING <i>U</i> -FACTOR	0.026	0.026	0.026
INSULATION ENTIRELY ABOVE ROOF DECK	0.032	0.032	0.032
WOOD FRAME WALL <i>U</i> -FACTOR	0.045	0.045	0.045
MASS WALL <i>U</i> -FACTOR ^b	0.056	0.060	0.060
FLOOR <i>U</i> -FACTOR	0.033	0.033	0.033
BELOW-GRADE WALL <i>U</i> -FACTOR	0.050	0.050	0.050
UNHEATED SLAB <i>F</i> -FACTOR ^d	0.48	0.48	0.48
HEATED SLAB <i>F</i> -FACTOR ^d	0.55	0.55	0.55
CRAWL SPACE WALL <i>U</i> -FACTOR	0.042	0.055	0.055

For SI: 1 foot = 304.8 mm.

- a. Nonfenestration U-factors and F-factors shall be obtained from measurement, calculation, an approved source, or Appendix RF where such appendix is adopted or approved.
- b. Mass walls shall be in accordance with Section R402.2.6. Where more than half the insulation is on the interior, the mass wall U-factor shall not exceed 0.56.
- c. Reserved
- d. F-factors for slabs shall correspond to the R-values of Table R402.1.3 and the installation conditions of Section R402.2.10.1.

**TABLE R402.1.3
INSULATION MINIMUM R-VALUES AND FENESTRATION REQUIREMENTS BY
COMPONENT^a**

Climate Zone	4	5	6
VERTICAL FENESTRATION <i>U</i> -FACTOR ^f	0.27	0.27	0.27
SKYLIGHT ^b <i>U</i> -FACTOR	0.50	0.50	0.50
GLAZED VERTICAL FENESTRATION SHGC ^h	0.40	NR	NR
SKYLIGHT SHGC	0.40	NR	NR
CEILING <i>R</i> -VALUE ^g	49 ca	49ca	49ca
INSULATION ENTIRELY ABOVE ROOF DECK	30ci	30ci	30ci
WOOD FRAME WALL <i>R</i> -VALUE ^d	30ca or 20ca +5ci or 13ca+10ci or 20ci	30ca or 20ca+5ci or 13ca+10ci or 20ci	30ca or 20ca+5ci or 13ca+10ci or 20ci
MASS WALL <i>R</i> -VALUE ^e	15ci/20ci	15ci/20ci	15ci/20ci
FLOOR <i>R</i> -VALUE ^g	30ca or 19ca+7.5ci or 20ci	30ca or 19ca+7.5ci or 20ci	30ca or 19ca+7.5ci or 20ci
BELOW-GRADE WALL <i>R</i> -VALUE ^b	15ci or 19ca or 13ca +5ci	15ci or 19ca or 13ca +5ci	15ci or 19ca or 13ca +5ci
UNHEATED SLAB <i>R</i> -VALUE & DEPTH ^c	10ci, 4 ft.	10ci, 4 ft.	10ci, 4 ft.
HEATED SLAB <i>R</i> -VALUE & DEPTH ^c	10ci 4 ft and R-10 full slab	10ci, 4ft and R-10 full slab	10ci, 4ft and R-10 full slab
CRAWL SPACE WALL <i>R</i> -VALUE ^b	15ci or 19ca or 13ca +5ci	15ci or 19ca or 13ca +5ci	15ci or 19ca or 13ca +5ci

- a. *R*-values are minimums. *U*-factors and *SHGC* are maximums. Where insulation is installed in a cavity that is less than the label or design thickness of the insulation, the installed *R*-value of the insulation shall be not less than the *R*-value specified in the table.
- b. "15ci or 19ca" means R-15 *continuous insulation* (ci) on the interior or exterior surface of the wall or R-19 *cavity insulation* on the interior side of the wall. 13ca+5ci means R-13 *cavity insulation* on the interior of the basement wall plus R-5 *continuous insulation* on the interior or exterior of the home.
- c. Slab insulation shall be installed in accordance with Section R402.2.9.1.
- d. The first value is *cavity insulation*, the second value is *continuous insulation*. Therefore, as an example, "13ca+10ci" means R-13 *cavity insulation* plus R-10 *continuous insulation*.
- e. Mass walls shall be in accordance with Section R402.2.5. The second *R*-value applies where more than half of the insulation is on the interior of the mass wall.
- f. Reserved
- g. "30ca or 20ca+5ci or 20ci" means R-30- *cavity insulation* alone or R-20 *cavity insulation* with R-5 *continuous insulation* or R-20 *continuous insulation* alone

R402.1.4 R-value computation. *Cavity insulation* alone shall be used to determine compliance with the *cavity insulation R-value* requirements in Table R402.1.3. Where *cavity insulation* is installed in multiple layers, the *R-values* of the *cavity insulation* layers shall be summed to determine compliance with the *cavity insulation R-value* requirements. The manufacturer's settled *R-value* shall be used for blown-in insulation. *Continuous insulation* (ci) alone shall be used to determine compliance with the *continuous insulation R-value* requirements in Table R402.1.3. Where *continuous insulation* is installed in multiple layers, the *R-values* of the *continuous insulation* layers 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 R402.1.3. Computed *R-values* shall not include an *R-value* for other building materials or air films. Where *insulated siding* is used for the purpose of complying with the *continuous insulation* requirements of Table R402.1.3, the manufacturer's *labeled R-value* for the *insulated siding* shall be reduced by R-0.6.

R402.1.5 Component performance alternative. Where the proposed total *building thermal envelope* thermal conductance (TC_p) is less than or equal to the reference total *building thermal envelope* thermal conductance (TC_r) using factors in Table R402.1.2, the *building* shall be considered to be in compliance with Table R402.1.2. The total thermal conductance (TC) shall be determined in accordance with Equation 4-1. Proposed *U-factors* and slab-on-grade *F-factors* shall be taken from 2025 NYC ASHRAE Standard 90.1 Appendix A or determined using a method consistent with the ASHRAE *Handbook of Fundamentals* and shall include the thermal bridging effects of framing materials. In addition to TC compliance, the SHGC requirements of Table R402.1.2 and the maximum *fenestration U-factors* of Section R402.6 shall be met.

Equation 4-1 $TC_p \leq TC_r$

where:

$$TC_p = U_pA + F_pP \quad TC_r = U_rA + F_rP$$

U_pA = the sum of proposed *U-factors* times the assembly areas in the proposed building.

F_pP = the sum of the proposed *F-factors* times the slab-on-grade perimeter lengths in the proposed building.

U_rA = the sum of *U-factors* in Table R402.1.2 times the same assembly areas as in the proposed building.

F_rP = the sum of *F-factors* in Table R402.1.2 times the same slab-on-grade perimeter lengths as in the proposed building.

R402.1.6 Rooms containing fuel-burning appliances. In Climate Zones 3 through 8, where open combustion air ducts provide combustion air to open combustion fuel-burning appliances, the appliances and combustion air opening shall be located outside the building thermal envelope or enclosed in a room that is isolated from inside the building thermal envelope. Such rooms shall be sealed and insulated in accordance with the building thermal envelope requirements of Table R402.1.3, where the walls, floors and ceilings shall meet a minimum of the below-grade wall *R-value* requirement. The door into the room shall be fully gasketed and any water lines and ducts in the room insulated in accordance with Section R403. The combustion air duct shall be insulated where it passes through conditioned space to an *R-value* of not less than R-8.

Exceptions:

1. Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.
Fireplaces and stoves complying with Section R402.4.2 and the New York City Mechanical Code.

R402.2 Specific insulation requirements. In addition to the requirements of Section R402.1, insulation shall meet the specific requirements of Sections R402.2.1 through R402.2.13.

R402.2.1 Ceilings with attics. Where Section R402.1.3 requires R-49 insulation in the ceiling or attic, installing R-38 over 100 percent of the ceiling or attic area requiring insulation shall satisfy the requirement for R-49 insulation wherever the full height of uncompressed R-38 insulation extends over the wall top plate at the eaves. This reduction shall not apply to the insulation and *fenestration* criteria in Section R402.1.2 and the component performance alternative in Section R402.1.5.

R402.2.2 Ceilings without attics. Where Section R402.1.3 requires insulation *R-values* greater than R-38 in the interstitial space above a ceiling and below the structural roof deck, and the design of the roof/ceiling assembly does not allow sufficient space for the required insulation, the minimum required insulation *R-value* for such roof/ceiling assemblies shall be R-38. Insulation shall extend over the top of the wall plate to the outer edge of such plate and shall not be compressed. This reduction of insulation from the requirements of Section R402.1.3 shall be limited to 500 square feet (46 m²) or 20 percent of the total insulated ceiling area, whichever is less. This reduction shall not apply to the component performance alternative in Section R402.1.5.

R402.2.3 Attic knee wall. Wood attic *knee wall* assemblies that separate *conditioned space* from unconditioned attic spaces shall comply with Table R402.1.3 for wood-framed walls. Steel attic knee wall assemblies shall comply with Section R402.2.7. Such *knee walls* shall have an *air barrier* between conditioned and unconditioned space.

R402.2.3.1 Roof truss framing separating conditioned and unconditioned space. Where wood vertical roof truss framing members are used to separate *conditioned space* and unconditioned space, they shall comply with Table R402.1.3 for wood-framed walls. Steel frame vertical roof truss framing members used to separate *conditioned space* and unconditioned space shall comply with Section R402.2.7.

R402.2.4 Eave baffle. For air-permeable insulation in vented attics, a baffle shall be installed adjacent to soffit and eave vents. Baffles shall maintain a net free area opening equal to or greater than the size of the vent. The baffle shall extend over the top of the attic insulation. The baffle shall be permitted to be any solid material. The baffle shall be installed to the outer edge of the *exterior wall* top plate so as to provide maximum space for attic insulation coverage over the top plate. Where soffit venting is not continuous, baffles shall be installed continuously to prevent *ventilation air* in the eave soffit from bypassing the baffle.

R402.2.5 Access hatches and doors. Access hatches and doors from conditioned to unconditioned spaces such as attics and crawl spaces shall be insulated to the same *R-value* required by Table R402.1.3 for the wall or ceiling in which they are installed.

Exceptions:

1. Vertical doors providing access from *conditioned spaces* to unconditioned spaces that comply with the *fenestration* requirements of Table R402.1.3 based on the applicable *climate zone* specified in Chapter 3.
2. Horizontal pull-down, stair-type access hatches in ceiling assemblies that provide access from conditioned to unconditioned spaces in Climate Zone 4 shall not be required to comply with the insulation level of the surrounding surfaces provided the hatch meets all of the following:
 - 2.1. The average *U-factor* of the hatch shall be less than or equal to U-0.10 or have an average insulation *R-value* of R-10 or greater.
 - 2.2. Not less than 75 percent of the panel area shall have an insulation *R-value* of R-13 or greater.
 - 2.3. The net area of the framed opening shall be less than or equal to 13.5 square feet (1.25 m²).
 - 2.4. The perimeter of the hatch edge shall be weather-stripped.

The reduction shall not apply to the component performance alternative in Section R402.1.5.

R402.2.5.1 Access hatches and door insulation installation and retention.

Vertical or horizontal access hatches and doors from *conditioned spaces* to unconditioned spaces such as attics and crawl spaces shall be weather-stripped. Access that prevents damaging or compressing the insulation shall be provided to all equipment. Where loose-fill insulation is installed, a wood-framed or equivalent baffle, retainer or dam shall be installed to prevent loose-fill insulation from spilling into *living space* from higher to lower sections of the attic and from attics covering *conditioned spaces* to unconditioned spaces. The baffle or retainer shall provide a permanent means of maintaining the installed *R-value* of the loose-fill insulation.

R402.2.6 Mass walls. Mass walls where used as a component of the *building thermal envelope* shall be one of the following:

1. Above-ground walls of concrete block, concrete, insulated concrete form, masonry cavity, brick but not brick veneer, adobe, compressed earth block, rammed earth, solid timber, mass timber or solid logs.
2. Any wall having a heat capacity greater than or equal to 6 Btu/ft² × °F (123 kJ/m² × K).

R402.2.7 Steel-frame ceilings, walls and floors. Steel-frame ceilings, walls, and floors shall comply with the ceiling, wood frame wall and floor U-factor requirements of Table R402.1.2, R-values in table R402.1.3 may not be applied. The calculation of the U-factor for steel-framed ceilings and walls in a building thermal envelope assembly shall be determined in accordance with section RF102.3.

R402.2.8 Floors. Floor *insulation* shall be installed in accordance with all of the following:

1. Table R402.1.2 or R402.1.3 and manufacturer's instructions.
2. Floor framing members that are part of the *building thermal envelope* shall be air sealed to maintain a *continuous air barrier*.
3. One of the following methods:
 - 3.1. *Cavity insulation* shall be installed to maintain permanent contact with the underside of the subfloor decking.
 - 3.2. *Cavity insulation* shall be installed to maintain contact with the top side of

sheathing separating the cavity and the unconditioned space below. Insulation shall extend from the bottom to the top of all perimeter floor framing members.

- 3.3. A combination of *cavity insulation* and *continuous insulation* shall be installed such that the *cavity insulation* maintains contact with the top side of the *continuous insulation* and the *continuous insulation* maintains contact with the underside of the structural floor system. Insulation shall extend from the bottom to the top of all perimeter floor framing members.
- 3.4. *Continuous insulation* shall be installed to maintain contact with the underside of the structural floor system. Insulation shall extend from the bottom to the top of all perimeter floor framing members.

R402.2.9 Below-grade walls. *Below-grade walls* shall be insulated in accordance with Table R402.1.3.

Exception: *Below-grade walls* associated with unconditioned basements or cellars where the following requirements are met:

1. The floor overhead, including the underside stairway stringer leading to the basement or cellar, is insulated in accordance with Section R402.1.3 and applicable provisions of Sections R402.2 and R402.2.8.
2. There are no uninsulated ductwork, domestic hot water piping, or hydronic heating surfaces exposed to the basement or cellar.
3. There are no HVAC supply or return diffusers serving the basement or cellar.
4. The walls surrounding the stairway and adjacent to conditioned space are insulated in accordance with Section R402.1.3 and applicable provisions of Section R402.2.
5. The door(s) leading to the basement or cellar from conditioned spaces are insulated in accordance with Section R402.1.3 and applicable provisions of Section R402.2, and weather-stripped in accordance with Section R402.5.
6. The building thermal envelope separating the basement or cellar from adjacent conditioned spaces complies with Section R402.5.

R402.2.9.1 Below-grade wall insulation installation. Where below-grade walls are insulated, the insulation shall be installed from the top of the below-grade wall down to 10 feet (3048 mm) below grade or to the basement or cellar floor, whichever is less, or in accordance with the proposed design or the rated design, as applicable.

R402.2.10 Slab-on-grade floors. Slab-on-grade floors with a floor surface within 24 inches (610 mm) above or below grade shall be insulated in accordance with Section R402.2.10.1 or R402.2.10.2.

Exception: Slab-edge insulation is not required in jurisdictions designated by the *building official* as having a very heavy termite infestation probability.

R402.2.10.1 Slab-on-grade floor insulation installation. For buildings complying with Section R401.2.1, the slab edge continuous insulation shall extend downward from the top of the slab on the outside or inside of the foundation wall. Insulation located below grade shall be extended the vertical distance provided in Table R402.1.3, but need not exceed the footing depth in accordance with chapter 18 of the New York City Building Code. Where a proposed design includes insulation extending away from the building, it shall be protected by pavement or by not less than 10 inches (254 mm) of soil. The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the exterior wall. Full-slab insulation shall be

continuous under the entire area of the slab-on-grade floor, except at structural column locations and service penetrations. Slab edge insulation required at the heated slab perimeter shall not be required to extend below the bottom of the heated slab and shall be continuous with the full slab insulation.

R402.2.10.2 Alternative slab-on-grade insulation configurations. For *buildings* complying with Section R405 or R406, slab-on-grade insulation shall be installed in accordance with the *proposed design* or *rated design*.

R402.2.11 Crawl space walls. *Crawl space walls* shall be insulated in accordance with Section R402.2.11.1 or R402.2.11.2.

Exception: *Crawl space walls* associated with a crawl space that is vented to the outdoors and the floor overhead is insulated in accordance with Table R402.1.3 and Section R402.2.8.

R402.2.11.1 Crawl space wall insulation installations. Where installed, *crawl space wall* insulation shall be secured to the wall and extend downward from the sill plate to not less than the top of the foundation wall footing.

Exception: Where the *crawl space wall* insulation is installed on the interior side of the wall and the crawl space floor is more than 24 inches (610 mm) below the exterior grade, the crawl space wall insulation shall be permitted to extend downward from the sill plate at the top of the foundation wall to not less than the interior floor of the crawl space.

Exposed earth in crawl space foundations shall be covered with a continuous Class I vapor retarder in accordance with New York City Building Code, as applicable. Joints of the vapor retarder shall overlap by 6 inches (153 mm) and be sealed or taped. The edges of the vapor retarder shall extend not less than 6 inches (153 mm) up stem walls and shall be attached to the stem walls.

R402.2.11.2 Alternative crawl space wall insulation configurations. For *buildings* complying with Section R405 or R406, *crawl space wall* insulation shall be installed in accordance with the *proposed design* or *rated design*.

R402.2.12 Masonry veneer. Insulation shall not be required on the horizontal portion of a foundation that supports a masonry veneer.

R402.2.13 Sunroom and heated garage insulation. *Sunrooms* enclosing *conditioned space* and heated garages shall meet the insulation requirements of this code.

Exception: For *sunrooms* and heated garages provided with *thermal isolation*, and enclosing *conditioned space*, the following exceptions to the insulation requirements of this code shall apply:

1. The minimum ceiling insulation *R*-values shall be R-19 in *Climate Zone 4* and R-24 in *Climate Zones 5* and 6.
2. The minimum wall insulation *R*-value shall be R-13 in all *climate zones*. Walls separating a *sunroom* or heated garage with *thermal isolation* from *conditioned space* shall comply with the *building thermal envelope* requirements of this code.

R402.3 Radiant barriers. Where installed, radiant barriers shall comply with the requirements of ASTM C1313/C1313M and shall be installed in accordance with ASTM C1743.

R402.4 Fenestration. In addition to the requirements of Section R402, *fenestration* shall comply with Sections R402.4.1 through R402.4.5.

R402.4.1 U-factor. An *area-weighted average* of *fenestration* products shall be permitted to satisfy the *U-factor* requirements.

R402.4.2 Glazed fenestration SHGC. An *area-weighted average* of *fenestration* products more than 50 percent glazed shall be permitted to satisfy the SHGC requirements.

Dynamic glazing shall be permitted to satisfy the SHGC requirements of Table R402.1.2 provided that the ratio of the higher to lower *labeled SHGC* is greater than or equal to 2.4, and the dynamic glazing is automatically controlled to modulate the amount of solar gain into the space in multiple steps. Dynamic glazing shall be considered separately from other *fenestration*, and *area-weighted averaging* with other *fenestration* that is not dynamic glazing shall be prohibited.

Exception: Dynamic glazing shall not be required to comply with this section where both the lower and higher *labeled SHGC* comply with the requirements of Table R402.1.2.

R402.4.3 Glazed fenestration exemption. Not greater than 15 square feet (1.4 m²) of glazed *fenestration* per *dwelling unit* shall be exempt from the *U-factor* and SHGC requirements in Section R402.1.2. This exemption shall not apply to the component performance alternative in Section R402.1.5.

R402.4.4 Opaque door exemption. One side-hinged *opaque door* assembly not greater than 24 square feet (2.22 m²) in area shall be exempt from the *U-factor* requirement in Section R402.1.2. This exemption shall not apply to the component performance alternative in Section R402.1.5.

R402.4.5 Sunroom and heated garage fenestration. *Sunrooms* and heated garages enclosing *conditioned space* shall comply with the *fenestration* requirements of this code.

Exception: For *sunrooms* and heated garages with *thermal isolation* and enclosing *conditioned space*, the *fenestration U-factor* shall not exceed 0.45 and the skylight *U-factor* shall not exceed 0.70.

New *fenestration* separating a *sunroom* or heated garage with *thermal isolation* from *conditioned space* shall comply with the *building thermal envelope* requirements of this code.

R402.5 Air leakage. The *building thermal envelope* shall be constructed to limit air leakage in accordance with the requirements of Sections R402.5.1 through R402.5.4.

R402.5.1 Building thermal envelope. The *building thermal envelope* shall comply with Sections R402.5.1.1 through R402.5.1.4 The sealing methods between dissimilar materials shall allow for differential expansion and contraction.

R402.5.1.1 Installation. The components of the *building thermal envelope* as indicated in Table R402.5.1.1 shall be installed in accordance with the manufacturer's instructions and the criteria indicated in Table R402.5.1.1, as applicable to the method of construction. Where required by the *building official*, an *approved* agency shall inspect all components and verify compliance. The inspection shall include an open wall visual inspection of all components included in Table R402.5.1.1 and shall be installed so that the insulation material uniformly fills each cavity side-to-side and top-to-bottom,

without gaps or voids around obstructions, and is split, installed, or fitted tightly around wiring and other penetrations in the cavity. No more than 2 percent of the total insulated area shall contain gaps or voids in the insulation or be compressed below the thickness required to attain the labeled R-value.

**TABLE R402.5.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION^a**

COMPONENT	AIR BARRIER, AIR SEALING CRITERIA	INSULATION INSTALLATION CRITERIA
General requirements	<p>A continuous air barrier shall be installed in the building thermal envelope.</p> <p>Breaks or joints in the air barrier shall be sealed.</p>	<p>Air-permeable insulation shall not be used as a sealing material.</p> <p>Insulation shall be installed so that the insulation material uniformly fills each cavity side-to-side and top-to-bottom, without substantial gaps or voids around obstructions, and is split, installed, or fitted tightly around wiring and other penetrations in the cavity. Not more than 2 percent of the total insulated area shall be compressed below the thickness required to attain the labeled R-value or contain gaps or voids in the insulation.</p>
Ceiling/attic	<p>An air barrier shall be installed in any dropped ceiling or soffit to separate it from unconditioned space.</p> <p>Access openings, drop down stairs or knee wall doors to unconditioned attic spaces shall be sealed with gasketing materials that allow for repeated entrance over time.</p>	<p>The insulation in any dropped ceiling/soffit shall be aligned with the air barrier. Access hatches and doors shall be installed and insulated in accordance with Section R402.2.5.</p> <p>Eave baffles shall be installed in accordance with Section R402.2.4.</p>
Walls	<p>The junction of the foundation and sill plate shall be sealed.</p> <p>The junction of the top plate and the top of exterior walls shall be sealed.</p> <p>Knee walls shall be sealed.</p>	<p>Cavities within corners and headers of frame walls shall be insulated by completely filling the cavity with a material having a thermal resistance, <i>R</i>-value, of not less than <i>R</i>-3 per inch.</p> <p>Exterior building thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier.</p>
Knee wall	<p>Knee walls shall have an air barrier between conditioned and unconditioned space</p>	<p>Insulation installed in a knee wall assembly shall be installed in accordance with Section R402.2.3.</p> <p>Air-permeable insulation shall be enclosed inside an air barrier assembly.</p>
Windows, skylights and doors	<p>The rough opening gap between framing and the frames of skylights, windows and doors, shall be sealed in accordance with fenestration manufacturer's instructions.</p>	<p>Insulation shall not be required in the rough opening gap except as required by the fenestration manufacturer's instructions.</p>
Rim joists	<p>Rim joists shall include an air barrier.^b</p> <p>The junctions of the rim board to the sill plate and the rim board and the subfloor shall be air sealed.</p>	<p>Rim joists shall be insulated so that the insulation maintains permanent contact with the exterior rim board.</p>

TABLE R402.5.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION^a
(CONTINUED)

Floors, including cantilevered floors and floors above garages	Floor framing members that are part of the <i>building thermal envelope</i> shall be air sealed to maintain a continuous air barrier. Air permeable floor cavity insulation shall be enclosed.	Floor insulation shall be installed in accordance with the requirements of Section R402.2.8.
Basement or cellar, crawl space and slab foundations	Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder/air barrier in accordance with Section R402.2.11. Penetrations through concrete foundation walls and slabs shall be air sealed. Class 1 vapor retarders shall not be used as an air barrier on below-grade walls and shall be installed in accordance with the New York City Building Code	Crawl space insulation, where provided instead of floor insulation, shall be installed in accordance with Section R402.2.11. Conditioned basement or cellar foundation wall insulation shall be installed in accordance with Section R402.2.9.1. Slab-on-grade floor insulation shall be installed in accordance with Section R402.2.10.
Shafts, penetrations	Duct and flue shafts to exterior or unconditioned space shall be sealed. Utility penetrations of the air barrier shall be caulked, gasketed or otherwise sealed and shall allow for expansion, contraction of materials and mechanical vibration.	Insulation shall be fitted tightly around utilities passing through shafts and penetrations in the building thermal envelope to maintain required <i>R</i> -value
Narrow cavities	Narrow cavities of 1 inch or less that are not able to be insulated shall be air sealed.	Batts to be installed in narrow cavities shall be cut to fit or narrow cavities shall be filled 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.	Insulated portions of the garage separation assembly shall be installed in accordance with Sections R303 and R402.2.8.
Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be air sealed in accordance with Section R402.4.5.	Recessed light fixtures installed in the building thermal envelope shall be airtight and IC rated and shall be buried in or surrounded with insulation.
Plumbing, wiring or other obstructions	All holes created by wiring, plumbing or other obstructions in the air barrier assembly shall be air sealed.	Insulation shall be installed to fill the available space and surround wiring, plumbing, or other obstructions, unless the required <i>R</i> -value can be met by installing insulation and air barrier systems completely to the exterior side of the obstructions.
Showers, tubs and fireplaces adjacent to the building thermal envelope	An air barrier shall separate insulation in the building thermal envelope from the shower, tub or fireplace assemblies.	Exterior framed walls adjacent to showers, tubs and fireplaces shall be insulated.
Electrical, communication and other equipment boxes, housings and enclosures	Boxes, housing and enclosures that penetrate the air barrier shall be caulked, taped, gasketed or otherwise sealed to the air barrier element being penetrated. All concealed openings into the box, housing or enclosure shall be sealed. Alternatively, air-sealed boxes shall be installed in accordance with Section R402.5.5.	Boxes, housing and enclosures shall be buried in or surrounded by insulation.

**TABLE R402.5.1.1
AIR BARRIER, AIR SEALING AND INSULATION INSTALLATION^a
(CONTINUED)**

HVAC register boots	HVAC supply and return register boots shall be sealed to the subfloor, wall covering or ceiling penetrated by the boot.	HVAC supply and return register boots located within a building thermal envelope assembly shall be buried in or surrounded by insulation.
Concealed sprinklers	Where 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.	
Common walls or double walls separating attached single-family dwellings or townhouses	An interior air barrier shall be provided. Air sealing at the intersections with building thermal envelope shall be provided. Where installed in a fire resistance-rated wall assembly, air sealing materials shall comply with one of the following: 1. Be in accordance with an approved design for the fire-resistance-rated assembly. 2. Be supported by approved data that shows the assembly as installed complies with the required fire resistance rating.	Insulation materials recognized in the approved common wall or double-wall design and installed in accordance with the approved design shall be permitted to be used.

- a. Inspection of log walls shall be in accordance with the provisions of ICC 400.
- b. Insulation full enclosure is not required in unconditioned/ventilated attic spaces and at rim joists.

R402.5.1.2 Air leakage testing. The building shall be tested for air leakage in accordance with Sections R402.5.1.3 and R402.5.1.4. Where required by the building 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 building official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope have been sealed.

Exception: For heated sunrooms and 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 thermal envelope tightness and insulation installation shall be considered acceptable where the items in Table R402.5.1.1, applicable to the method of construction, are field verified. Where required by the building 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 R402.2.13 and R402.4.5, as applicable.

R402.5.1.3 Maximum air leakage rate. The maximum air leakage rate for any building under any compliance path shall not exceed 3.0 air changes per hour. Testing shall be conducted in accordance with ANSI/RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure differential of 0.2 inch water gauge (50 Pa).

Exception: Buildings over 50,000 square feet may comply with the testing requirements of section C402.6.

R402.5.1.4 Testing procedure. Testing shall be conducted by an approved agency. A written report of the results of the test shall be signed by the party conducting the test and provided to the building official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope have been sealed. The written report shall include:

1. The name and place of business of the party conducting the test;
2. The address of the building that was tested;
3. The conditioned floor area of the dwelling, calculated in accordance with ANSI/BOMA Z65.1, except that conditioned floor area shall include areas where the ceiling height is less than 5 feet (1524 mm);
4. Measurement of the air volume lost at an internal pressurization of 0.2 inches water gauge (50 Pa);
5. The air leakage rate in air changes per hour or cubic feet per minute per square foot of dwelling unit enclosure area;
6. The date(s) of the test;
7. A certification by the party conducting the test of the accuracy of the test results; and
8. The signature of the party conducting the test.

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 and heat recovery ventilators shall be closed and 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.

R402.5.2 Fireplaces. New wood-burning fireplaces shall have tight-fitting flue *dampers* or doors, and outdoor combustion air. Where using tight-fitting doors on factory-built fireplaces *listed* and *labeled* in accordance with UL 127, the doors shall be tested and *listed* for the fireplace.

R402.5.3 Fenestration air leakage. Windows, *skylights* and sliding glass doors shall have an air *infiltration* rate of not greater than 0.3 cubic feet per minute per square foot (1.5 L/s/m²), and for swinging doors, not greater than 0.5 cubic feet per minute per square foot (2.6 L/s/m²), when tested in accordance with NFRC 400 or AAMA/WDMA/CSA 101/I.S.2/A440 by an accredited, independent laboratory and *listed* and *labeled* by the manufacturer.

Exception: Site-built *windows, skylights* and *doors*.

R402.5.4 Recessed lighting. Recessed luminaires installed in the *building thermal envelope* shall be sealed to limit air leakage between conditioned and *unconditioned spaces*. Recessed luminaires shall be IC-rated and *labeled* as having an air leakage rate of not greater than 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E283 at a pressure differential of 1.57 psf (75 Pa). Recessed luminaires shall be sealed with a gasket or caulked between the housing and the interior wall or ceiling covering.

R402.5.5 Air-sealed electrical and communication outlet boxes. Air-sealed electrical and communication outlet boxes that penetrated the *air barrier* of the *building thermal envelope* shall be caulked, taped, gasketed or otherwise sealed to the *air barrier* element being penetrated. Air-sealed boxes shall be buried in or surrounded by insulation. Air-sealed boxes shall be tested and marked in accordance with NEMA OS 4. Air-sealed boxes shall be installed in accordance with the manufacturer's instructions.

R402.5.6 Tenant separation walls. Wall and floor assemblies between *dwelling units* in two-family dwellings and *townhouses* shall be insulated to no less than R-10 and air sealed in accordance with Section R402.5.1.1 and Table R402.5.1.1. Where installed in a fire-resistance-rated wall or floor assembly, insulation shall comply with one of the following:

1. Be in accordance with an approved design for the fire-resistance-rated assembly.
2. Be supported by approved data that shows the assembly as installed complies with the required fire-resistance rating.

R402.6 Maximum fenestration U-factor. The area-weighted average maximum fenestration U-factor permitted using tradeoffs from Section R402.1.5 or R405 shall be 0.40 for vertical fenestration, and 0.72 for skylights.

Exception: The maximum U-factor for fenestration shall not be required in storm shelters complying with ICC 500.

R402.7 Thermal bridges. Applications for construction document approval shall include documentation of thermal bridges.

R402.7.1 Clear field thermal bridges. Where otherwise not included in pre-calculated assembly U-factors, C-factors, or F-factors outlined in Appendix A of 2025 NYC ASHRAE 90.1, clear field thermal bridges in a wall, roof, or floor assembly shall be noted as such in the drawings.

R402.7.2 Point thermal bridges. Point thermal bridges greater than or equal in area to 8 in² (5161 mm²) and not associated with HVAC or electrical systems shall be noted as thermal bridges in the drawings.

R402.7.3 Linear thermal bridges. Construction documents shall include the following documentation in tabular format for linear thermal bridges listed in Table R402.7:

1. Linear thermal bridge type.
 2. Aggregate length of each type of linear thermal bridge.
 3. Relevant detail in the construction documents showing a cross-section through the thermal bridge.
- . Ψ -value for each thermal bridge from Table R402.7.

Exception: Where linear thermal bridges have been tested or modeled using methods approved by the department, alternate values may be used as long as supporting documentation is provided

**Table R402.7
AVERAGE THERMAL TRANSMITTANCE FOR UNMITIGATED LINEAR THERMAL
BRIDGES**

Type of Thermal Bridge	Ψ -value ^a [Btu/hr • ft • °F]	Ψ -value ^a W/mK
Steel Frame, Steel Stud, Poured-in-place Concrete, Concrete Block, Curtain-wall		
Balcony	0.50	0.871
Floor ^b	0.44	0.755
Slab to Ground	n/a	n/a
Fenestration Perimeter Transition ^c	0.32	0.550
Parapet	0.42	0.735
Eaves	n/a	n/a
Shelf Angle	0.41	0.713
Wood Frame Construction		
Balcony	n/a	n/a
Floor ^b	0.336	0.582
Slab to Ground	n/a	n/a
Fenestration Perimeter Transition ^c	0.15	0.26
Parapet	0.032	0.056
Eaves	n/a	n/a
Shelf Angle	0.186	0.322

- a. Ψ -values are derived from the ASHRAE Research Project 1365 and BC Hydro Building Envelope Thermal Bridging Guide Version 1.2 - September 2018, and are based on poor performing details.
- b. This value is for an intermediate floor. Ground to Slab thermal bridging is applicable for all buildings.
- c. Fenestration Perimeter Transition is the thermal bridge between any fenestration frame and the typical wall, roof or floor assembly it abuts or is mounted within. For each unique window or door installation type, provide a minimum of one typical-installation detail showing either the head, jamb or sill detail of the window or door frame and the abutting wall, roof or floor construction, including all structural and insulation layers, blocking, flashing, and cladding.

SECTION ECC R403 SYSTEMS

R403.1 Controls. Not less than one *thermostat* shall be provided for each separate heating and cooling system.

R403.1.1 Programmable thermostat. The *thermostat* controlling the primary heating or cooling system of the *dwelling unit* shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature set points at different times of day and different days of the week. This *thermostat* shall include the capability to set back or temporarily operate the system to maintain *zone* temperatures of not less than 55°F (13°C) to not greater than 85°F (29°C). The *thermostat* shall be programmed initially by the manufacturer with a heating temperature setpoint of not greater than 70°F (21°C) and a cooling temperature setpoint of not less than 78°F (26°C).

R403.1.2 Heat pump supplementary heat. Where permitted, heat pumps having supplementary electric-resistance, *fuel gas* or *liquid fuel* heating systems shall have controls that are configured to prevent supplemental heat operation when the capacity of the heat pump compressor can meet the heating load. Supplemental heat operation shall be limited to only where one of the following applies:

1. The vapor compression cycle cannot provide the necessary heating energy to satisfy the *thermostat* setting.
2. The heat pump is operating in defrost mode.
3. The vapor compression cycle malfunctions.
4. The *thermostat* malfunctions.

R403.2 Hot water boiler temperature reset. Other than where equipped with tankless domestic water heating coils, the manufacturer shall equip each gas, *liquid fuel* and electric boiler with *automatic* means of adjusting the water temperature supplied by the boiler so that incremental change of the inferred heat load will cause an incremental change in the temperature of the water supplied by the boiler. This can be accomplished with outdoor reset, indoor reset or water temperature sensing.

R403.3 Duct systems. *Duct systems* shall be installed in accordance with Sections R403.3.1 through R403.3.9. The *duct system* in new buildings and *additions* shall be located in *conditioned space* in accordance with Section R403.3.4.

Exception: *Ventilation ductwork* that is not integrated with *duct systems* serving heating or cooling systems.

R403.3.1 Duct system design. *Duct systems* serving one or two *dwelling units* or *sleeping units* shall be designed and sized in accordance with ANSI/ACCA Manual D based on calculations made in accordance with Section R403.7. *Duct systems* serving more than two *dwelling units* or *sleeping units* shall be sized in accordance with the ASHRAE *Handbook of Fundamentals*, ANSI/ACCA Manual D or other equivalent computation procedure based on calculations made in accordance with Section R403.7.

R403.3.2 Building cavities. *Building* framing cavities shall not be used as ductwork or plenums.

R403.3.3 Ductwork located outside conditioned space. New ductwork shall not be located outside conditioned space. Existing and return ductwork located outside conditioned space shall be insulated to an R-value of not less than R-8 for ducts 3 inches (76 mm) in diameter and larger and not less than R-6 for ducts smaller than 3 inches (76 mm) in diameter. Ductwork buried beneath a building shall be insulated, as required per this section or have an equivalent thermal distribution efficiency. Underground ductwork utilizing the thermal distribution efficiency method shall be listed and labeled to indicate the R-value equivalency.

R403.3.4 Duct systems located in conditioned space. For *duct systems* to be considered inside a *conditioned space*, the *space conditioning equipment* shall be located completely on the conditioned side of the *building thermal envelope*. The *ductwork* shall comply with the following, as applicable:

1. The *ductwork* shall be located completely on the conditioned side of the *building thermal envelope*.
2. *Ductwork* in ventilated attic spaces or unvented attics with vapor diffusion ports shall be buried within ceiling insulation in accordance with Section R403.3.5 and shall comply with the following:
 - 2.1. The ductwork leakage, as measured either by a rough-in test of the supply and return *ductwork* or a post-construction *duct system* leakage test to outside the *building thermal envelope* in accordance with Section R403.3.7, is not greater than 1.5 cubic feet per minute (42.5 L/min) per 100 square feet (9.29 m²) of *conditioned floor area* served by the *duct system*.
 - 2.2. The ceiling insulation *R-value* installed against and above the insulated *ductwork* is greater than or equal to the proposed ceiling insulation *R-value*, less the *R-value* of the insulation on the *ductwork*.
3. *Ductwork* contained within wall or floor assemblies separating unconditioned from *conditioned space* shall comply with the following:
 - 3.1. A *continuous air barrier* shall be installed as part of the building assembly between the *ductwork* and the unconditioned space.
 - 3.2. *Ductwork* shall be installed in accordance with Section R403.3.3.

Exception: Where the building assembly cavities containing *ductwork* have been air sealed in accordance with Section R402.5.1 and insulated in accordance with Item 3.3, *duct* insulation is not required.
 - 3.3. Not less than R-10 insulation, or not less than 50 percent of the required insulation *R-value* specified in Table R402.1.3, whichever is greater, shall be located between the *ductwork* and the unconditioned space.
 - 3.4. Segments of *ductwork* contained within these building assemblies shall not be considered completely inside *conditioned space* for compliance with Section R405 or R406.

R403.3.5 Ductwork buried within ceiling insulation. Where supply and return *ductwork* is partially or completely buried in ceiling insulation, such *ductwork* shall comply with the following:

1. The supply and return *ductwork* shall be insulated with not less than R-8 insulation.
2. At all points along the *ductwork*, the sum of the ceiling insulation *R-value* against and above the top of the *ductwork*, and against and below the bottom of the *ductwork*, shall be not less than R-19, excluding the *R-value* of the duct insulation.

R403.3.5.1 Effective R-value of deeply buried ducts. Where complying using Section R405, sections of *ductwork* that are installed in accordance with Section R403.3.5 surrounded with blown-in attic insulation having an *R-value* of R-30 or greater and located such that the top of the *ductwork* is not less than 3.5 inches (89 mm) below the top of the insulation shall be considered as having an effective duct insulation *R-value* of R-25.

R403.3.6 Sealing. *Ductwork, air-handling units and filter boxes shall be sealed. Joints and seams shall comply with either the New York City Mechanical Code, as applicable.*

R403.3.6.1 Sealed air-handling unit. *Air-handling units shall have a manufacturer's designation for an air leakage of not greater than 2 percent of the design airflow rate when tested in accordance with ASHRAE 193.*

R403.3.7 Duct system testing. Each *duct system* shall be tested for air leakage in accordance with ANSI/RESNET/ICC 380 or ASTM E1554. Total leakage shall be measured with a pressure differential of 0.1 inch water gauge (25 Pa) across the *duct system* and shall include the measured leakage from the supply and return *ductwork*. A written report of the test results shall be signed by the party conducting the test and provided to the *building official*. *Duct system* leakage testing at either rough-in or post construction shall be permitted with or without the installation of registers or grilles. Where installed, registers and grilles shall be sealed during the test. Where registers and grilles are not installed, the face of the register boots shall be sealed during the test.

Exceptions:

1. Testing shall not be required for *duct systems* serving *ventilation* systems that are not integrated with *duct systems* serving heating or cooling systems.
2. Testing shall not be required where there is not more than 10 feet (3048 mm) of total *ductwork* external to the *space conditioning equipment* and both the following are met:
 - 2.1. The *duct system* is located entirely within *conditioned space*.
 - 2.2. The *ductwork* does not include *plenums* constructed of building cavities or gypsum board.
3. Where the *space conditioning equipment* is not installed, testing shall be permitted. The total measured leakage of the supply and return *ductwork* shall be less than or equal to 3.0 cubic feet per minute (85 L/min) per 100 square feet (9.29 m²) of *conditioned floor area*.
4. Where tested in accordance with Section R403.3.9, testing of each *duct system* is not required.

R403.3.8 Duct system leakage. The total measured *duct system* leakage shall not be greater than the values in Table R403.3.8, based on the *conditioned floor area*, number of ducted returns, and location of the *duct system*. For *buildings* complying with Section R405 or R406, where *duct system* leakage to outside is tested in accordance with ANSI/RESNET/ICC 380 or ASTM E1554, the leakage to outside value shall not be used for compliance with this section, but shall be permitted to be used in the calculation procedures of Section R405 and R406.

**TABLE R403.3.8
MAXIMUM TOTAL DUCT SYSTEM LEAKAGE**

EQUIPMENT AND DUCT CONFIGURATION	DUCT SYSTEMS SERVING MORE THAN 1,000 FT ² OF CONDITIONED FLOOR AREA		DUCT SYSTEMS SERVING 1,000 FT ² OR LESS OF CONDITIONED FLOOR AREA
	cfm/100 ft ²		cfm
	Number of ducted returns ^a		
	< 3	≥ 3	Any
Space conditioning equipment is not installed ^{b, c}	3	4	30
All components of the duct system are installed ^c	4	6	40
Space conditioning equipment is not installed, but the ductwork is located entirely in conditioned space ^{c, d}	6	8	60
All components of the duct system are installed and entirely located in conditioned space ^c	8	12	80

For SI: 1 cubic foot per minute per square foot = 0.0033 LPM/m², 1 cubic foot per minute = 28.3 LPM.

- A ducted return is a duct made of sheet metal or flexible duct that connects one or more return grilles to the return-side inlet of the air-handling unit. Any other method to convey air from return or transfer grilles to the air-handling unit does not constitute a ducted return for the purpose of determining maximum total duct system leakage allowance.
- Duct system testing is permitted where space conditioning equipment is not installed, provided that the return ductwork is installed and the measured leakage from the supply and return ductwork is included.
- For duct systems to be considered inside a conditioned space, where the ductwork is located in ventilated attic spaces or unvented attics with vapor diffusion ports, duct system leakage to outside must comply with Item 2.1 of Section R403.3.4.
- Prior to the issuance of a certificate of occupancy, where the air-handling unit is not verified as being located in conditioned space, the total duct system leakage must be retested.

R403.3.9 Unit sampling. For *buildings* with eight or more *dwelling units* or *sleeping units*, the *duct systems* in the greater of seven or 20 percent of the *dwelling units* or *sleeping units* shall be tested, including a top floor unit, a ground floor unit, a middle floor unit and the unit with the largest *conditioned floor area*. Where buildings have fewer than eight *dwelling units* or *sleeping units*, the *duct systems* in each unit shall be tested. Where the leakage of a *duct system* is greater than the maximum permitted *duct system* leakage, corrective actions shall be made to the *duct system* and the *duct system* shall be system retested until it passes. For each tested *dwelling unit* or *sleeping unit* that has a greater total duct system leakage than the maximum permitted *duct system* leakage, an additional three *dwelling units* or *sleeping units*, including the corrected unit, shall be tested.

R403.4 Mechanical system piping insulation. Piping serving as part of a heating or cooling system capable of carrying fluids greater than 105°F (41°C) or less than 60°F (15°C) shall be thermally insulated in accordance with Table R403.4. The thickness and conductivity of the insulation must result in an R-value of not less than R-3.

R403.4.1 Protection of piping insulation. Piping insulation exposed to weather shall be protected from damage, including that caused by sunlight, moisture, physical contact and wind. The protection shall provide shielding from solar radiation that can cause degradation of the material and shall be removable not less than 6 feet (1828 mm) from the equipment for maintenance. Adhesive tape shall be prohibited.

**TABLE R403.4.1
MINIMUM PIPE INSULATION THICKNESS (in inches)^{a, c}**

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY		INCHES OR R-VALUE	NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity Btu × in./h × ft ² × °F ^b	Mean Rating Temperature, °F		< 1	1 to < 1½	1½ to < 4	4 to < 8	> 8
> 350	0.32–0.34	250	Inches	4.5	5.0	5.0	5.0	5.0
			R-value	R-32	R-36	R-34	R-26	R-21
251–350	0.29–0.32	200	Inches	3.0	4.0	4.5	4.5	4.5
			R-value	R-20	R-29	R-32	R-24	R-20
201–250	0.27–0.30	150	Inches	2.5	2.5	2.5	3.0	3.0
			R-value	R-17	R-17	R-17	R-15	R-13
141–200	0.25–0.29	125	Inches	1.5	1.5	2.0	2.0	2.0
			R-value	R-9	R-9	R-11	R-10	R-9
105–140	0.21–0.28	100	Inches	1.0	1.0	1.5	1.5	1.5
			R-value	R-5	R-9	R-8	R-8	R-7
40–60	0.21–0.27	75	Inches	0.5	0.5	1.0	1.0	1.0
			R-value	R-2	R-2	R-5	R-5	R-4
< 40	0.20–0.26	50	Inches	0.5	1.0	1.0	1.0	1.5
			R-value	R-6	R-9	R-9	R-8	R-7

For SI: 1 inch = 25.4 mm, °C = [(°F) – 32]/1.8.

- a. For piping smaller than 1½ inches and located in partitions within conditioned spaces, reduction of these thicknesses by 1 inch shall be permitted (before thickness adjustment required in Note b) but not to a thickness less than 1 inch.
- b. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

$$T = r[(1 + t/r)^{K/k} - 1]$$

where:

T = Minimum insulation thickness.

r = Actual outside radius of pipe.

t = Insulation thickness listed in the table for applicable fluid temperature and pipe size.

K = Conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu × in/h × ft² × °F).

k = The upper value of the conductivity range listed in the table for the applicable fluid temperature.

- c. For direct-buried heating and hot water system piping, reduction of these thicknesses by 1½ inches (38 mm) shall be permitted (before thickness adjustment required in Note b) but not to thicknesses less than 1 inch.

**TABLE R403.4.2
MINIMUM PIPE INSULATION R-Value^a**

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	NOMINAL PIPE OR TUBE SIZE (inches)				
	<1	1 TO <1 1/2	1 1/2 TO <4	4 TO <8	≥8
	Minimum Insulation R-Value				
>350	R32	R36	R34	R26	R21
251-350	R20	R29	R32	R24	R20
201-250	R17	R17	R17	R15	R13
141-200	R9	R9	R11	R10	R9
105-140	R5	R9	R8	R8	R7
40-60	R2	R2	R5	R5	R4
<40	R6	R9	R9	R8	R7

For SI: R-1 = RSI-0.176228, °C = [(°F)-32]/1.8.

a. The R-value of cylindrical piping insulation shall be determined as follows:

$$R = (ro(\ln(ro/ri)))/k$$

where:

R = The interior R-value of the cylindrical piping insulation in Btu x ft² x °F/h

ro = The outer radius of the piping insulation in inches

ri = The inner radius of the piping insulation in inches

k = the thermal conductivity of the insulation material in Btu x in/h x ft² x °F

R403.5 Service hot water systems. Energy conservation measures for service hot water systems shall be in accordance with Sections R403.5.1 through R403.5.3.

R403.5.1 Heated water circulation and temperature maintenance systems. Heated water circulation systems shall be in accordance with Section R403.5.1.1. Heat trace temperature maintenance systems shall be in accordance with Section R403.5.1.2. *Automatic* controls, temperature sensors and pumps shall be in a location with access. *Manual* controls shall be in a location with *ready access*.

R403.5.1.1 Circulation systems. Heated water circulation systems shall be provided with a circulation pump. Gravity and thermosyphon circulation systems shall be prohibited. Controls for *circulating hot water system* pumps shall automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is no demand for hot water. The system return pipe shall be a dedicated return pipe or a cold water supply pipe. Where a cold water supply pipe is used as the return pipe, a temperature sensor connected to the controls shall be located on the hot water supply not more than two feet (305 mm) from the connection to the cold water supply pipe. The controls shall limit the temperature of the water entering the cold water piping to not greater than 104°F (40°C).

R403.5.1.1.1 Demand recirculation water systems. *Demand recirculation water systems* shall have controls that start the pump upon receiving a signal from the action of a user of a fixture or appliance, sensing the presence of a user of a fixture or sensing the flow of hot or tempered water to a fixture fitting or appliance. The controls shall limit pump operation by:

1. Shutting off the pump when the temperature sensor detects one of the

following:

- 1.1. An increase in the water temperature of not more than 10°F (5.6°C) above the initial temperature of the water in the pipe.
- 1.2. The temperature of the water in the pipe reaches 104°F (40°C).
2. Limiting pump operation to a maximum of 5 minutes following activation.
3. Not activating the pump for at least 5 minutes following shutoff or when the temperature of the water in the pipe exceeds 104°F (40°C).

R403.5.1.2 Heat trace systems. Electric heat trace systems shall comply with IEEE 515.1 or UL 515. Controls for such systems shall automatically adjust the energy input to the heat tracing to maintain the desired water temperature in the piping in accordance with the times when heated water is used in the occupancy.

R403.5.2 Hot water pipe insulation. Insulation for service hot water piping shall comply with Table R403.5.2 and be applied to the following:

1. Piping ¾ inch (19.1 mm) and larger in nominal diameter located inside the *conditioned space*.
2. Piping located outside the *conditioned space*.
3. Piping from the water heater to a distribution manifold.
4. Piping located under a floor slab.
5. Buried piping.
6. Supply and return piping in circulating hot water systems.

Exception: Cold water returns in *demand recirculation water systems*.

**TABLE R403.5.2
MINIMUM PIPE INSULATION THICKNESS**

FLUID OPERATING TEMPERATURE RANGE AND USAGE(°F)	INSULATION CONDUCTIVITY		MINIMUM PIPE INSULATION THICKNESS (inches)
	Conductivity Btu × in/(h × ft ² × °F) ^a	Mean rating temperature (°F)	
141–200	0.25–0.29	125	1.0
105–140	0.21–0.28	100	1.0

For SI: 1 inch = 25.4 mm, °C = (°F – 32)/1.8.

- a. For insulation outside the stated conductivity range listed in this table, the minimum thickness (T) listed in this table shall be determined as follows:

$$T = r[(1 + t/r)^{kk} - 1]$$

where:

T = Minimum insulation thickness.

r = Actual outside radius of pipe.

t = Insulation thickness listed in the table for applicable fluid temperature and pipe size (1 inch).

K = Conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu × in/h × ft² × °F).

k = The upper value of the conductivity range listed in this table for the applicable fluid temperature.

R403.5.3 Drain water heat recovery units. Where installed, drain water heat recovery units shall have a minimum efficiency of 40 percent if installed for equal flow or a minimum efficiency of 52 percent if installed for unequal flow. Drain water heat recovery units shall comply with CSA B55.2 and be tested and labeled in accordance with CSA B55.1. Potable water-side pressure loss of drain water heat recovery units shall be less than 3 psi (20.7 kPa) for individual units connected to one or two showers. Potable water-side pressure loss of drain water heat recovery units shall be less than 2 psi (13.8 kPa) for individual units connected to three or more showers.

R403.5.4 Demand responsive water heating. All electric storage water heaters with a rated water storage volume of 40 gallons (150L) to 120 gallons (450L) and a nameplate input rating equal to or less than 12kW shall be provided with *demand responsive controls* in accordance with Table R403.5.4.

Exceptions:

1. Water heaters that are capable of delivering water at a temperature of 180°F (82°C) or greater.
2. Water heaters that comply with Section IV, Part HLW or Section X of the ASME Boiler and Pressure Vessel Code.
3. Water heaters that use 3-phase electric power.

**TABLE R403.5.4
DEMAND RESPONSIVE CONTROLS FOR WATER HEATING**

EQUIPMENT TYPE	CONTROLS	
	MANUFACTURED BEFORE 7/1/2025	MANUFACTURED ON OR AFTER 7/1/2025
Electric storage water heaters	AHRI Standard 1430 (I-P) or ANSI/CTA-2045-B Level 1 and also capable of initiating water heating to meet the temperature set point in response to a demand response signal	AHRI Standard 1430 (I-P)

R403.5.5 Supply of heated water. In new buildings, heated water supply piping shall be in accordance with one of the following:

1. **Maximum allowable pipe length method.** The maximum allowable pipe length from the nearest source of heated water to the termination of the fixture supply pipe shall be in accordance with the maximum pipe length in Table R403.5.5. Where the length contains more than one size of pipe, the largest size shall be used for determining the maximum allowable length of the piping in Table R403.5.5.
2. **Maximum allowable pipe volume method.** The water volume in the piping shall be calculated in accordance with Table R403.5.5. The maximum volume of hot or tempered water in the piping to public lavatory faucets shall be 2 ounces. For fixtures other than public lavatory faucets, the maximum volume shall be 64 ounces for hot or tempered water from a water heater or boiler; and 24 ounces for hot or tempered water from a circulation loop pipe or an electrically heat-traced pipe
3. **Drain water heat recovery units.** New buildings shall include a drain water heat recovery unit in accordance with R403.5.3.

4. **Recirculation Systems.** Projects shall include a recirculation system with no more than 0.5 gallon (1.9 liter) storage. The storage limit shall be measured from the point where the branch feeding the fixture branches off the recirculation loop to the fixture. Recirculation systems must be based on an occupant-controlled switch or an occupancy sensor, installed in each bathroom which is located beyond a 0.5 gallon stored-volume range from the water heater.

**Table R403.5.5
Pipe Volume and Maximum Piping Lengths**

Nominal Pipe or Tube Size (inch)	VOLUME (Liquid Ounces Per Foot Length)	Maximum Pipe or Tube Length	
		System without a circulation loop or heat-traced line (feet)	System with a circulation loop or heat-traced line (feet)
1/4 ^a	0.33	50	16
5/16 ^a	0.5	50	16
3/8 ^a	0.75	50	16
1/2	1.5	43	16
5/8	2	32	12
3/4	3	21	8
7/8	4	16	6
1	5	13	5
1 1/4	8	8	3
1 1/2	11	6	2
2 or larger	18	4	1

a. The flow rate for 1/4-inch size pipe or tube is limited to 0.5 gpm (0.032 L/s); for 5/16-inch size, it is limited to 1 gpm (0.063 L/s); for 3/8-inch size, it is limited to 1.5 gpm (0.095 L/s).

b. The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters and manifolds between the source of hot water and the termination of the fixture supply pipe. The volume contained within fixture shutoff valves, flexible water supply connectors to a fixture fitting, or within a fixture fitting shall not be included in the water volume determination. Where hot or tempered water is supplied by a circulation loop pipe or a heat-traced pipe, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

R403.6 Mechanical ventilation. The *buildings and dwelling units* complying with Section R402.5.1.1 shall be provided with mechanical ventilation that complies with the requirements of the New York City 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 installed per manufacturer's instructions.*

Exception: A balanced ventilation system complying with the New York City Mechanical Code and sections R403.6.1.1 through R403.6.1.3 using the return side of the building's heating and/or cooling system air handler to supply outdoor air, shall be permitted to comply with this section. When the outdoor air supply is ducted to the heating and/or cooling system air handler, the mixed air temperature shall not be less than that permitted by the heating equipment manufacturer's installation instructions. Heating and/or cooling system air handlers used to distribute outdoor air shall be field-verified to not exceed an efficacy of 45 W/CFM if using furnaces for heating and 58 W/CFM if using other forms of heating. In the balanced system design, an equivalent exhaust air flow rate shall be provided simultaneously by one or more exhaust fans, located remotely from the source of supply air. The balanced system's exhaust and supply fans shall be interlocked for operation, sized to provide equivalent air flow at a rate greater than or equal to that determined by Table R403.6.1(1) and shall have their fan capacities adjusted for intermittent run time per Table R403.6.1(2). Continuous operation of the balanced ventilation system shall not be permitted.

R403.6.1.1 Whole-house mechanical ventilation (balanced ventilation option) system design. The whole-house ventilation system shall consist of one or more supply or exhaust fans, or a combination of such, and associated ducts and controls. Local exhaust or supply fans are permitted to serve as such as system. Outdoor air ducts connected to the return side of an air handler shall be considered as providing supply ventilation.

R403.6.1.2 System controls. The whole-house ventilation system shall be provided with controls that enable manual override.

R403.6.1.3 Mechanical ventilation rate. The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25 percent of each 4hour segment and the ventilation rate prescribed in Table R403.6.1 (1) is multiplied by the factor determined in accordance with Table R403.6.1(2).

**TABLE R403.6.1(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS**

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0 – 1	2 – 3	4 – 5	6 – 7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 – 3,000	45	60	75	90	105
3,001 – 4,500	60	75	90	105	120
4,501 – 6,000	75	90	105	120	135
6,001 – 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

For SI: 1 square foot = 0.0929 m², 1 cubic foot per minute = 0.0004719 m³/s

**TABLE R403.6.1(2)
INTERMITTENT WHOLE-HOUSE MECHANICAL VENTILATION RATE FACTORS^{a,b}**

RUN-TIME PERCENTAGE IN EACH 4-HOUR SEGMENT	25%	33%	50%	66%	75%	100%
Factor ^a	4	3	2	1.5	1.3	1.0

a. For ventilation system run time values between those given, the factors are permitted to be determined by interpolation.

b. Extrapolation beyond the table is prohibited.

R403.6.2 Fan efficacy for whole-house mechanical ventilation systems and outdoor air ventilation systems. Fans used to provide whole-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 the test procedure referenced by Table R403.6.2 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, ERV, balanced ventilation systems and in-line fans shall be determined at a static pressure of not less than 0.2 inch water gauge (50 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 water gauge (25 Pa).

**TABLE R403.6.2
FAN EFFICACY FOR WHOLE-HOUSE MECHANICAL VENTILATION SYSTEMS AND
OUTDOOR AIR VENTILATION SYSTEMS^a**

SYSTEM TYPE	AIRFLOW RATE (CFM)	MINIMUM EFFICACY (CFM/WATT)	TEST PROCEDURE
HRV or ERV	Any	1.2 ^a	CAN/CSA C439
Balanced ventilation system without heat or energy recovery	Any	1.2 ^a	ANSI/AMCA 210-ANSI/ASHRAE 51
Range hood	Any	2.8	
In-line supply or exhaust fan	Any	3.8	ANSI/AMCA 210-ANSI/ASHRAE 51
Other exhaust fan	< 90	2.8	
	90 and < 200	3.5	
	200	4.0	
Air-handling unit that is integrated to tested and listed HVAC equipment	Any	1.2	Outdoor airflow as specified. Air-handling unit fan power determined in accordance with the applicable US Department of Energy Code of Federal Regulations DOE10 CFR 430 or other approved test method.

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

a. For balanced ventilation systems, HRVs and ERVs, determine the efficacy as the outdoor airflow divided by the total fan power.

R403.6.3 Testing. Mechanical *ventilation* systems shall be tested and verified to provide the minimum *ventilation* flow rates required by Section R403.6, in accordance with ANSI/RESNET/ICC 380. Where required by the *building official*, testing shall be conducted by an *approved* agency. A written report of the results of the test shall be signed by the party conducting the test and provided to the *building official*.

Exceptions:

1. Kitchen range hoods that are ducted to the outside with ducting having a diameter of 6 inches (152 mm) or larger, a length of 10 feet (3028 mm) or less, and not more than two 90-degree (1.57 rad) elbows or equivalent shall not require testing.
2. A test by an approved agency shall not be required where the ventilation system has an integrated diagnostic tool used for airflow measurement, and a user interface that communicates the installed airflow rate.
3. Where tested in accordance with Section R403.6.4, testing of each mechanical ventilation system is not required.

R403.6.4 Unit sampling. For *buildings* with eight or more *dwelling units* or *sleeping units*, the mechanical *ventilation* systems in the greater of seven units or 20 percent of the total units shall be tested. Tested systems shall include systems in a top floor unit, systems in a ground floor unit, systems in a middle floor unit, and the systems in the *dwelling unit* or *sleeping unit* with the largest *conditioned floor area*. Where *buildings* have fewer than eight *dwelling units* or *sleeping units*, the mechanical *ventilation* systems in each unit shall be tested. Where the *ventilation* flow rate of a mechanical *ventilation* system is less than the minimum permitted rate, corrective actions shall be taken and the system retested until it passes. For each tested *dwelling unit* or *sleeping unit* system with a *ventilation* flow rate lower than the minimum permitted, three additional systems, including the corrected system, shall be tested.

R403.6.5 Intermittent exhaust control for bathrooms and toilet rooms. Where an exhaust system serving a bathroom or toilet room is designed for intermittent operation, the exhaust system controls shall include one or more of the following:

1. A timer control with one or more delay setpoints that automatically turns off exhaust fans when the selected setpoint is reached. Not fewer than one delay-off setpoint shall be 30 minutes or less.
2. An *occupant sensor control* with one or more delay setpoints that automatically turns off exhaust fans in accordance with the selected delay setpoint after all occupants have vacated the space. Not fewer than one delay-off setpoint shall be 30 minutes or less.
3. A humidity control with an adjustable setpoint ranging between 50 percent or more and 80 percent or less relative humidity that automatically turns off exhaust fans when the selected setpoint is reached.
4. A contaminant control that responds to a particle or gaseous concentration and automatically turns off exhaust fans when a design setpoint is reached.

Manual off functionality shall not be used in lieu of the minimum setpoint functionality required by this section.

Exception: Bathroom and toilet room exhaust systems serving as an integral component of an outdoor air *ventilation* system or a whole-house mechanical *ventilation* system.

R403.7 Equipment sizing and efficiency rating. Heating and cooling *equipment* shall be sized in accordance with ACCA Manual S based on *building* loads calculated in accordance with ACCA Manual J or other *approved* heating and cooling calculation methodologies. New or replacement heating and cooling equipment shall have an efficiency rating equal to or greater than the minimum required by federal law for the geographic location where the equipment is installed.

R403.7.1 Electric-resistance space heating. *Dwelling units*, *sleeping units*, and other *occupiable spaces* within the *building* using electric-resistance space heating shall limit the total installed heating capacity of all electric-resistance space heating serving the *dwelling unit* to not more than 2.0 kW or shall install a heat pump in the largest space that is not used as a bedroom.

R403.8 Systems serving multiple dwelling units. Except for systems complying with Section R403.9, systems serving multiple dwelling units shall comply with Sections C403, C404 and C408 of the New York City Energy Conservation Code instead of Section R403.

Exception: Systems complying with Section R403.9.

R403.9 Mechanical systems located outside of the building thermal envelope. Mechanical systems providing heat outside of the *building thermal envelope* of a *building* shall comply with Sections R403.9.1 through R403.9.4.

R403.9.1 Heating outside a building. Systems installed to provide heat outside a *building* shall be radiant systems. Such heating systems shall be controlled by an occupancy-sensing device or a timer switch, so that the system is automatically de-energized when occupants are not present.

R403.9.2 Snow melt and ice system controls. Snow- and ice-melting systems, supplied through energy service to the *building*, shall include *automatic* controls capable of shutting off the system when the pavement temperature is greater than 50°F (10°C) and precipitation is not falling, and an *automatic* or *manual* control that will allow shutoff when the outdoor temperature is greater than 40°F (4.8°C).

R403.9.3 Roof and gutter deicing controls. Roof and gutter deicing systems, including but not limited to self-regulating cable, shall include *automatic* controls that are configured to shut off the system when the outdoor temperature is above 40°F (4.4°C) and shall include one of the following:

1. A moisture sensor configured to shut off the system in the absence of moisture.
2. A daylight sensor or other means configured to shut off the system between sunset and sunrise.

R403.9.4 Freeze protection system controls. Freeze protection systems, such as heat tracing of outdoor piping and *heat exchangers*, including self-regulating heat tracing, shall include *automatic* controls configured to shut off the systems when outdoor air temperatures are above 40°F (4.4°C) or when the conditions of the protected fluid will prevent freezing.

R403.10 Energy consumption of pools and spas. The energy consumption of pools and permanent spas shall be controlled by the requirements in Sections R403.10.1 through R403.10.3.

R403.10.1 Heaters. The electric power to heaters shall be controlled by an on-off switch that is an integral part of the heater mounted on the exterior of the heater in a location with *ready access*, or external to and within 3 feet (914 mm) of the heater. Operation of such switch shall not change the setting of the heater *thermostat*. Such switches shall be in addition to a circuit breaker for the power to the heater. Gas-fired heaters shall not be equipped with continuously burning ignition pilots.

R403.10.2 Time switches. Time switches or other control methods that can automatically turn heaters and pump motors off and on according to a preset schedule shall be installed for heaters and pump motors. Heaters and pump motors that have built-in time switches shall be in compliance with this section.

Exceptions:

1. Where public health standards require 24-hour pump operation.
2. Pumps that operate *on-site renewable energy* and waste-heat-recovery pool heating systems.

R403.10.3 Covers. Outdoor heated pools and outdoor permanent spas shall be provided with a vapor-retardant cover or other *approved* vapor-retardant means. Outdoor heated pools and outdoor heated permanent spas heated to more than 90 °F (32 °C) shall have a pool cover with a minimum insulation value of R-12.

Exception: Where more than 75 percent of the energy for heating, computed over an operation season of not fewer than 3 calendar months, is from a heat pump or an *on-site renewable energy* system, covers or other vapor-retardant means shall not be required.

R403.11 Portable spas. The energy consumption of electric-powered portable spas that are accessory to detached one- and two-family *dwellings* and *townhouses* three stories or less in height above grade plane and that are available only to the household and its guests shall be controlled by the requirements of APSP 14.

R403.12 Residential pools and permanent residential spas. Where installed, the energy consumption of residential swimming pools and permanent residential spas shall be controlled in accordance with the requirements of APSP 15.

R403.13 Gas fireplaces. Where permitted, gas fireplace systems shall not be equipped with a *continuous pilot* and shall be equipped with an *on-demand pilot*, *intermittent ignition* or *interrupted ignition*, as defined by ANSI Z21.20.

Exception: Gas-fired appliances using pilots within a *listed* combustion safety device.

R403.13.1 Gas fireplace efficiency. Vented gas fireplace heaters shall have a fireplace efficiency (FE) rating not less than 50 percent as determined in accordance with CSA P.4.1, and shall be *listed* and *labeled* in accordance with CSA/ANSI Z21.88. Vented gas fireplaces (decorative appliances) shall be *listed* and *labeled* in accordance with CSA/ANSI Z21.50.

SECTION ECC R404 ELECTRICAL POWER AND LIGHTING SYSTEMS

R404.1 Lighting equipment. All permanently installed luminaires shall be capable of operation with an efficacy of not less than 45 lumens per watt or shall contain lamps capable of operation with an efficacy of not less than 65 lumens per watt.

Exceptions:

1. Appliance lamps.
2. Antimicrobial lighting used for the sole purpose of disinfecting.
3. General service lamps complying with DOE 10 CFR, Part 430.32.
4. Luminaires with a rated electric input of not greater than 3.0 watts.

R404.1.1 Exterior lighting. Connected exterior lighting for Group R-2, R-3 and R-4 *residential buildings* shall comply with Sections R404.1.2 through R404.1.5.

Exceptions:

1. Detached one- and two- family dwellings.
2. Townhouses.
3. Group R-3 *buildings* that do not contain more than two *dwelling units*.
4. Solar-powered lamps not connected to any electrical service.
5. Luminaires controlled by a motion sensor.
6. Lamps and luminaires that comply with Section R404.1.

R404.1.2 Exterior lighting power requirements. The total exterior connected lighting power shall be not greater than the exterior lighting power allowance calculated in accordance with Section R404.1.3. The total exterior connected lighting power shall be the total maximum rated wattage of all lighting that is powered through the energy service for the building.

Exceptions: Lighting used for the following applications shall not be included.

1. Lighting *approved* for safety reasons.
2. Emergency lighting that is automatically off during normal operations.
3. Exit signs.
4. Specialized signal, directional and marker lighting associated with transportation.
5. Lighting for athletic playing areas.
6. Temporary lighting.
7. Lighting used to highlight features of art, public monuments and the national flag.
8. Lighting for water features and swimming pools.
9. Lighting controlled from within *sleeping units* and *dwelling units*.
10. Lighting of the exterior means of egress as required by the New York City Building Code.

R404.1.3 Exterior lighting power allowance. The total area or length of each area type multiplied by the value for the area type in Table R404.1 shall be the lighting power (watts) allowed for each area type. For area types not listed, the area type that most closely represents the proposed use of the area shall be selected. The total exterior lighting power allowance (watts) shall be the sum of the base site allowance plus the watts from each area type.

**TABLE R404.1
LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS**

BASE SITE ALLOWANCE	280 WATTS
Uncovered parking areas and drives	0.026 W/ft ²
Building grounds	
Walkways and ramps	0.50 W/linear foot
Plaza areas	0.049 W/ft ²
Dining areas	0.273 W/ft ²
Stairways	Exempt
Pedestrian tunnels	0.110 W/ft ²
Landscaping	0.025 W/ft ²
Building entrances and exits	
Pedestrian and vehicular entrances and exits	9.8 W/linear foot of opening
Entry canopies	0.126 W/ft ²

For SI: 1 watt per square foot = 10.76 w/m², 1 foot = 304.8 mm.

R404.1.4 Additional exterior lighting power. Additional exterior lighting power allowances shall be available for the building facades at 0.075 W/ft² (0.807 w/m²) of gross *above-grade wall* area. These additional power allowances shall be used only for the luminaires serving the facade and shall not be used to increase any other lighting power allowance.

R404.1.5 Gas lighting. Gas-fired lighting appliances shall not be equipped with a *continuous pilot* and shall be equipped with an *on-demand pilot*, *intermittent ignition* or *interrupted ignition* as defined by ANSI Z21.20.

R404.2 Interior lighting controls. All permanently installed luminaires shall be controlled as required in Sections R404.2.1 and R404.2.2.

Exception: Lighting controls shall not be required for safety or security lighting.

R404.2.1 Habitable spaces. All permanently installed luminaires in habitable spaces shall be controlled with a manual dimmer or with an automatic shutoff control that automatically turns off lights within 15 minutes after all occupants have left the space and shall incorporate a manual control to allow occupants to turn the lights on or off.

R404.2.2 Specific locations. All permanently installed luminaires in garages, unfinished basements, laundry rooms and utility rooms shall be controlled by an *automatic* shutoff control that automatically turns off lights within 15 minutes after all occupants have left the space and shall incorporate a *manual* control to allow occupants to turn the lights on or off.

R404.3 Exterior lighting controls. Exterior lighting controls shall comply with Section R404.3.1.

R404.3.1 Controls for individual dwelling units. 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* shutoff actions.
2. Lighting shall be automatically shut off when daylight is present and satisfies the lighting needs.
3. Controls that override *automatic* shutoff actions shall not be allowed unless the override automatically returns *automatic* control to its normal operation within 24 hours.

R404.4 Renewable energy certificate (REC) documentation. Where renewable energy generation is used to comply with this code, a signed attestation shall be provided to the *building official* by the property owner or owner's authorized agent demonstrating that where renewable energy certificates (RECs) or energy attributable certificates (EACs) are associated with that portion of renewable energy used to comply with this code, the owner has entered into a REC or EAC agreement that complies with the applicable provisions of this code, including that the RECs or EACs shall be retained, or retired, on behalf of the property owner.

R404.5 Dwelling electrical meter. In all *buildings* having individual dwelling units, provisions shall be made to determine the electrical energy consumed by each unit by separately metering individual dwelling units.

R404.6 Electrical vehicle service equipment capable. One or two-family dwellings and townhouses with parking area provided on the building site shall provide a 208/240V 40-amp outlet for each dwelling unit or panel capacity and conduit for the future installation of such an outlet. Outlet or conduit termination shall be adjacent to the parking area. For residential occupancies where there is a common parking area, provide either:

1. Panel capacity and conduit for the future installation of 208/240V 40-amp outlets for 5 percent of the total parking spaces, but not less than one outlet, or
2. 208/240V 40-amp outlets for 5 percent of the total parking spaces, but not less than one outlet.

SECTION ECC R405 SIMULATED BUILDING PERFORMANCE

R405.1 Scope. This section establishes criteria for compliance using *simulated building performance* analysis. Such analysis shall include heating, cooling, mechanical *ventilation* and service water-heating energy only. Such analysis shall be limited to *dwelling units* and *sleeping units*. *Common areas* shall comply with Sections R402 through R404.

R405.2 Simulated building performance compliance. Compliance based on simulated building performance analysis requires that a building comply with the following:

1. The requirements of the sections indicated within Table R405.2.
2. The proposed total building thermal envelope thermal conductance (TC_p) shall be less than or equal to the required total building thermal envelope TC_r using the prescriptive U-factors and F-factors from Table R402.1.2 multiplied by 1.15 in accordance with Equation 4-2 and Section R402.1.5.

$$\text{Equation 4-2 } TC_{\text{Proposed design}} \leq 1.15 \times TC_{\text{Prescriptive reference design}}$$

3. For each dwelling unit with one or more fuel-burning appliances for space heating, water heating, or both, the annual energy cost of the dwelling unit shall be less than or equal to 80 percent of the annual energy cost of the standard reference design. For all other dwelling units, the annual energy cost of the proposed design shall be less than or equal to 85 percent of the annual energy cost of the standard reference design. For each dwelling unit with greater than 5,000 square feet (465 m²) of living space located above grade plane, the annual site energy use expressed in Btu or Btu per square foot of conditioned floor area of the dwelling unit shall be reduced by an additional 5 percent of annual site energy use expressed in Btu or Btu per square foot of conditioned floor area of the standard reference design.

Exceptions:

1. 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 2.51. The source energy multipliers shall be 1.09 for natural gas, 1.15 for propane, 1.19 for fuel oil, and 1.30 for imported liquified natural gas.
2. The energy use based on site energy expressed in Btu or Btu per square foot of conditioned floor area shall be permitted to be substituted for the energy cost.

**TABLE R405.2
REQUIREMENTS FOR SIMULATED BUILDING PERFORMANCE**

SECTION ^a	TITLE
General	
R401.3	Certificate
Building Thermal Envelope	
R402.1.1	Vapor retarder
R402.1.6	Rooms containing fuel-burning appliances
R402.2.3	Attic knee wall
R402.2.4	Eave baffle
R402.2.5.1	Access hatches and door insulation installation and retention
R402.2.10	Slab-on-grade floors
R402.2.11	Crawl space walls
R402.5.1.1	Installation
R402.5.1.2	Air leakage testing
R402.5.1.3	Maximum air leakage rate
R402.5.2	Fireplaces
R402.5.3	Fenestration air leakage
R402.5.4	Recessed lighting
R402.5.5	Air-sealed electrical and communication outlet boxes
R402.6	Maximum fenestration <i>U</i> -factor and SHGC
Mechanical	
R403.1	Controls
R403.2	Hot water boiler temperature reset
R403.3	Duct systems
R403.4	Mechanical system piping insulation
R403.5	Service hot water systems
R403.6	Mechanical ventilation
R403.7, except Section R403.7.1	Equipment sizing and efficiency rating
R403.8	Systems serving multiple dwelling units
R403.9.2	Snow melt and ice system controls
R403.10	Energy consumption of pools and spas
R403.11	Portable spas
R403.12	Residential pools and permanent residential spas
R403.13	Gas fireplaces
Electrical Power and Lighting Systems	
R404.1	Lighting equipment
R404.2	Interior lighting controls
R404.5	Dwelling unit electrical meter

a. Reference to a code section includes all the relative subsections except as indicated in the table.

R405.3 Compliance documentation. The following compliance reports, which document that the performance of the *proposed design* and the performance of the as-built *dwelling unit* comply with the requirements of Section R405, shall be submitted to the *building official*.

1. A compliance report in accordance with Section R405.5.4.1 shall be submitted with the application for the building permit.
2. A compliance report in accordance with Section R405.5.4.2 shall be submitted before a certificate of occupancy is issued.

R405.4 Calculation procedure. Performance calculations shall be in accordance with Sections R405.4.1 through R405.4.3. Except as specified by this section, the *standard reference design* and *proposed design* shall be configured and analyzed using identical methods and techniques.

R405.4.1 General. Calculation procedures used to comply with Section R405 shall use a software tool, *approved* in accordance with Section R405.5, capable of calculating the annual energy consumption of all building elements that differ between the *standard reference design* and the *proposed design*.

R405.4.2 Residence specifications. The *standard reference design*, *proposed design* and as-built *dwelling unit* shall be configured and analyzed as specified by Table R405.4.2(1). Table R405.4.2(1) shall include, by reference, all notes contained in Table R402.1.3. Proposed *U*-factors and slab-on-grade *F*-factors shall be taken from Appendix RF, *2025 NYC ASHRAE 90.1* Appendix A, or determined using a method consistent with the *ASHRAE Handbook of Fundamentals* and shall include the thermal bridging effects of framing materials.

**TABLE R405.4.2(1)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS**

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Above-grade walls	Type: mass where the proposed wall is a mass wall; otherwise wood frame.	As proposed.
	Gross area: same as proposed.	As proposed.
	<i>U</i> -factor: as specified in Table R402.1.2.	As proposed.
	Solar reflectance = 0.25.	As proposed.
	Emittance = 0.90.	As proposed.
Basement, cellar and crawl space walls	Type: same as proposed.	As proposed.
	Gross area: same as proposed.	As proposed.
	<i>U</i> -factor: as specified in Table R402.1.2, with the insulation layer on the interior side of the walls.	As proposed.
Above-grade floors	Type: wood frame.	As proposed.
	Gross area: same as proposed.	As proposed.
	<i>U</i> -factor: as specified in Table R402.1.2.	As proposed.
Ceilings	Type: wood frame.	As proposed.
	Gross area: same as proposed.	As proposed.
	<i>U</i> -factor: as specified in Table R402.1.2.	As proposed.

TABLE R405.4.2(1)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS
(CONTINUED)

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Roofs	Type: composition shingle on wood sheathing.	As proposed.
	Gross area: same as proposed.	As proposed.
	Solar reflectance = 0.25.	As proposed.
	Emittance = 0.90.	As proposed.
Attics	Type: vented with an aperture of 1 ft ² per 300 ft ² of ceiling area.	As proposed.
Foundations	Type: same as proposed.	As proposed.
	Foundation wall extension above and below grade: same as proposed. Foundation wall or slab perimeter length: same as proposed. Soil characteristics: same as proposed.	As proposed.
	Foundation wall <i>U</i> -factor and slab <i>F</i> -factor: as specified in Table R402.1.2.	
Opaque doors	Area: 40 ft ² .	As proposed.
	Orientation: North.	As proposed.
	<i>U</i> -factor: same as fenestration as specified in Table R402.1.2.	As proposed.
Vertical fenestration other than opaque doors	Total area ^h = (a) The proposed glazing area, where the proposed glazing area is less than 15 percent of the conditioned floor area. (b) 15 percent of the conditioned floor area, where the proposed glazing area is 15 percent or more of the conditioned floor area.	As proposed.
	Orientation: equally distributed to four cardinal compass orientations (N, E, S & W).	As proposed.
	<i>U</i> -factor: as specified in Table R402.1.2.	As proposed.
	SHGC: as specified in Table R402.1.2 except for climate zones without an SHGC requirement, the SHGC shall be equal to 0.40.	As proposed.
	Interior shade fraction: 0.92 – (0.21 × SHGC for the standard reference design).	Interior shade fraction: 0.92 – (0.21 × SHGC as proposed).
	External shading: none	As proposed.
Skylights	None	As proposed.
Thermally isolated sunrooms	None	As proposed.
Air leakage rate	For detached one-family dwellings, the air leakage rate at a pressure of 0.2 inch water gauge (50 Pa) shall be as follows: Climate Zones 4 and 5: 3.0 air changes per hour. Climate Zone 6: 2.5 air changes per hour. For detached one-family dwellings that are 1,500 ft ² or smaller and attached dwelling units or sleeping units, the air leakage rate at a pressure of 0.2 inch water gauge (50 Pa) shall be 0.27 cfm/ft ² of the testing unit enclosure area.	The measured air leakage rate. ^a

TABLE R405.4.2(1)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS
(CONTINUED)

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN
Mechanical ventilation rate	<p>The mechanical ventilation rate shall be in addition to the air leakage rate and shall be the same as in the proposed design, but not greater than $B \times M$ where:</p> <p>$B = 0.01 \times CFA + 7.5 \times (N_{br} + 1)$, cfm.</p> <p>$M = 1.0$ where the measured air leakage rate is 3.0 air changes per hour at 50 Pascals, and otherwise, $M = \text{minimum}(1.7, Q/B)$.</p> <p>$Q =$ the proposed mechanical ventilation rate, cfm.</p> <p>$CFA =$ conditioned floor area, ft².</p> <p>$N_{br} =$ number of bedrooms.</p>	The measured mechanical ventilation rate ^b (Q) shall be in addition to the measured air leakage rate.
Mechanical ventilation fan energy	<p>The mechanical ventilation system type shall be the same as in the proposed design. Heat recovery or energy recovery shall be modeled for mechanical ventilation where required by Section R403.6.1. Heat recovery or energy recovery shall not be modeled for mechanical ventilation where not required by Section R403.6.1. Where mechanical ventilation is not specified in the proposed design: None</p> <p>Where mechanical ventilation is specified in the proposed design, the annual vent fan energy use, in units of kWh/yr, shall equal $(8.76 \times B \times M)/e_f$ where:</p> <p>B and M are determined in accordance with the air exchange mechanical ventilation rate row of this table.</p> <p>$e_f =$ the minimum fan efficacy, as specified in Table R403.6.2, corresponding to the system type at a flow rate of $B \times M$.</p>	As proposed.
Internal gains	<p>I_{Gain}, in units of Btu/day per dwelling unit, shall equal $17,900 + 23.8 \times CFA + 4,104 \times N_{br}$ where:</p> <p>$CFA =$ conditioned floor area, ft².</p> <p>$N_{br} =$ number of bedrooms.</p>	Same as standard reference design.
Internal mass	Internal mass for furniture and contents: 8 pounds per square foot of floor area.	Same as standard reference design, plus any additional mass specifically designed as a thermal storage element ^c but not integral to the building thermal envelope or structure.

TABLE R405.4.2(1)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS
(CONTINUED)

BUILDING COMPONENT	STANDARD REFERENCE DESIGN	PROPOSED DESIGN		
Structural mass	For masonry floor slabs: 80 percent of floor area covered by R-2 carpet and pad, and 20 percent of floor directly exposed to room air.	As proposed.		
	For masonry basement walls: as proposed, but with insulation as specified in Table R402.1.3, located on the interior side of the walls.	As proposed.		
	For other walls, ceilings, floors, and interior walls: wood-framed construction.	As proposed.		
Heating systems ^{d, e, j, k}	Fuel type/capacity: same as proposed design.	As proposed.		
	Product class: same as proposed design.	As proposed.		
	Efficiencies:			
	Heat pump: complying with 10 CFR §430.32.	As proposed.		
	Fuel gas and liquid fuel furnaces: complying with 10 CFR §430.32.	As proposed.		
	Fuel gas and liquid fuel boilers: complying with 10 CFR §430.32.	As proposed.		
Cooling systems ^{d, f, k}	Fuel type: electric. Capacity: Same as proposed design.	As proposed.		
	Efficiencies: complying with 10 CFR §430.32.	As proposed.		
Service water heating ^{d, g, k}	Use, in units of gal/day = $25.5 + (8.5 \times N_{br})$ where: N_{br} = number of bedrooms.	Use, in units of gal/day = $25.5 + (8.5 \times N_{br}) \times (1 - HWDS)$ where: N_{br} = number of bedrooms. $HWDS$ = factor for the compactness of the hot water distribution system.		
		Compactness ratioⁱ		
		factor	HWDS	
		1 story	2 or more stories	
		> 60%	> 30%	0
		> 30% to 60%	> 15% to 30%	0.05
		> 15% to 30%	> 7.5% to 15%	0.10
	< 15%	< 7.5%	0.15	
	Fuel type: same as proposed design.	As proposed.		
	Rated storage volume: same as proposed design.	As proposed.		
Draw pattern: same as proposed design.	As proposed.			
Efficiencies: Uniform Energy Factor complying with 10 CFR §430.32.	As proposed.			
Tank temperature: 120°F (48.9°C).	Same as standard reference design.			

TABLE R405.4.2(1)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS
(CONTINUED)

BUILDING COMPONENT	STANDARD REFERENCE DESIGN				PROPOSED DESIGN
Thermal distribution systems	Duct insulation: in accordance with Section R403.3.3.				Duct insulation: as proposed. ^m
	Duct location:				Duct location: as proposed. ^l
	Foundation type	Slab on grade	Unconditioned crawl space	Basement or conditioned crawl space	—
	Duct location (supply and return)	One-story building: 100% in unconditioned attic. All other: 75% in unconditioned attic and 25% inside conditioned space.	One-story building: 100% in unconditioned crawl space. All other: 75% in unconditioned crawl space and 25% inside conditioned space.	75% inside conditioned space. 25% unconditioned attic.	Duct system leakage to outside: The measured total duct system leakage rate shall be entered into the software as the duct system leakage to outside rate. Exceptions: 1. Where duct system leakage to outside is tested in accordance ANSI/RESNET/ICC 380 or ASTM E1554, the measured value shall be permitted to be entered. 2. Where total duct system leakage is measured without space conditioning equipment installed, the simulation value shall be 4 cfm per 100 ft ² of conditioned floor area.
	Duct system leakage to outside: for duct systems serving > 1,000 ft ² of conditioned floor area, the duct leakage to outside rate shall be 4 cfm per 100 ft ² of conditioned floor area. 1, 2 of conditioned floor area, the duct leakage to outside rate shall be 40 cfm.				
	Distribution system efficiency (DSE): for hydronic systems and ductless systems, a thermal DSE of 0.88 shall be applied to both the heating and cooling system efficiencies.				Distribution system efficiency (DSE): for hydronic systems and ductless systems, DSE shall be as specified in Table R405.4.2(2).
Thermostat	Type: Manual, cooling temperature setpoint = 75°F; Heating temperature setpoint = 72°F.				Same as standard reference design.
Dehumidistat	Where a mechanical ventilation system with latent heat recovery is not specified in the proposed design: None. Where the proposed design utilizes a mechanical ventilation system with latent heat recovery: Dehumidistat type: manual, setpoint = 60% relative humidity. Dehumidifier: whole-dwelling with integrated energy factor = 1.77 liters/kWh.				Same as standard reference design.

For SI: 1 square foot = 0.93 m², 1 British thermal unit = 1055 J, 1 pound per square foot = 4.88 kg/m², 1 gallon (US) = 3.785 L, °C = (°F – 32)/1.8, 1 degree = 0.79 rad, 1 cubic foot per minute = 28.317 L/min.

- a. Hourly calculations as specified in the ASHRAE *Handbook of Fundamentals*, or the equivalent, shall be used to determine the energy loads resulting from infiltration.
- b. The combined air exchange rate for infiltration and mechanical ventilation shall be determined in accordance with Equation 40 of 2021 ASHRAE *Handbook of Fundamentals*, and the “Whole-house Ventilation” provisions of 2021 ASHRAE *Handbook of Fundamentals*, for intermittent mechanical ventilation.

TABLE R405.4.2(1)
SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS
(CONTINUED)

- c. Thermal storage element shall mean a component that is not part of the floors, walls or ceilings that is part of a passive solar system, and that provides thermal storage such as enclosed water columns, rock beds, or phase-change containers. A thermal storage element shall be in the same room as fenestration that faces within 15 degrees (0.26 rad) of true south, or shall be connected to such a room with pipes or ducts that allow the element to be actively charged.
- d. For a proposed design with multiple heating, cooling or water heating systems using different fuel types, the applicable standard reference design system capacities and fuel types shall be weighted in accordance with their respective loads as calculated by accepted engineering practice for each equipment and fuel type present.
- e. For a proposed design without a proposed heating system, a heating system having the prevailing federal minimum efficiency shall be assumed for both the standard reference design and proposed design.
- f. For a proposed design without a proposed cooling system, an electric air conditioner having the prevailing federal minimum efficiency shall be assumed for both the standard reference design and the proposed design.
- g. For a proposed design without a proposed water heater, the following assumptions shall be made for both the proposed design and standard reference design. For a proposed design with a heat pump water heater, the following assumptions shall be made for the standard reference design, except the fuel type shall be electric.
Fuel type: same as the predominant heating fuel type
Rated storage volume: 40 gallons
Draw pattern: medium
Efficiency: Uniform Energy Factor complying with 10 CFR § 430.32
- h. For residences with conditioned basements, R-2 and R-4 residences, and for townhouses, the following formula shall be used to determine glazing area:
$$AF = A_s \times FA \times F$$
where:
 AF = Total glazing area.
 A_s = Standard reference design total glazing area.
 FA = (Above-grade thermal boundary gross wall area)/(above-grade boundary wall area + 0.5 × below-grade boundary wall area).
 F = (above-grade thermal boundary wall area)/(above-grade thermal boundary wall area + common wall area) or 0.56, whichever is greater. and where:
- Thermal boundary wall is any wall that separates conditioned space from unconditioned space or ambient conditions.
- Above-grade thermal boundary wall is any thermal boundary wall component not in contact with soil.
- Below-grade boundary wall is any thermal boundary wall in soil contact.
- Common wall area is the area of walls shared with an adjoining dwelling unit.
- i. The factor for the compactness of the hot water distribution system is the ratio of the area of the rectangle that bounds the source of hot water and the fixtures that it serves (the "hot water rectangle") divided by the floor area of the dwelling.
1. Sources of hot water include water heaters, or in multiple-family buildings with central water heating systems, circulation loops or electric heat traced pipes.
 2. The hot water rectangle shall include the source of hot water and the points of termination of all hot water fixture supply piping.
 3. The hot water rectangle shall be shown on the floor plans and the area shall be computed to the nearest square foot.
 4. Where there is more than one water heater and each water heater serves different plumbing fixtures and appliances, it is permissible to establish a separate hot water rectangle for each hot water distribution system and add the area of these rectangles together to determine the compactness ratio.
 5. The basement or attic shall be counted as a story when it contains the water heater.
 6. Compliance shall be demonstrated by providing a drawing on the plans that shows the hot water distribution system rectangle(s), comparing the area of the rectangles(s) to the area of the dwelling and identifying the appropriate compactness ratio and *HWDS* factor.
- j. For a proposed design with electric resistance heating, a split system heat pump complying with 10 CFR §430.32 (2021) shall be assumed modeled in the standard reference design.
- k. For heating systems, cooling systems, or water heating systems not included in this table, the standard reference design shall be the same as proposed design.
- l. Only sections of ductwork that are installed in accordance with Section R403.3.4, Items 1 and 2 are assumed to be located completely inside conditioned space. All other sections of ductwork are not assumed to be located completely inside conditioned space.
- m. Sections of ductwork installed in accordance with Section R403.3.5.1 are assumed to have an effective duct insulation *R*-value of R-25.

TABLE R405.4.2(2)
DEFAULT DISTRIBUTION SYSTEM EFFICIENCIES FOR PROPOSED DESIGNS^a

DISTRIBUTION SYSTEM CONFIGURATION AND CONDITION	FORCED AIR SYSTEMS	HYDRONIC SYSTEMS ^b
Distribution system components located in unconditioned space	NA	0.95
Distribution system components entirely located in conditioned space ^c	NA	1
Ductless systems ^d	1	NA

NA = Not Applicable.

- a. Default values in this table are for untested distribution systems, which must still comply with Section R403.
- b. Hydronic systems mean those systems that distribute heating and cooling energy directly to individual spaces using liquids pumped through closed-loop piping and that do not depend on ducted, forced airflow to maintain space temperatures.
- c. Entire system in conditioned space means that no component of the distribution system is located outside of the conditioned space.

Ductless systems are allowed to have forced airflow across a coil but must not have any ducted airflow external to the space conditioning equipment.

R405.4.3 Input values. When calculations require input values not specified by Sections R402, R403, R404 and R405, those input values shall be taken from an *approved* source.

R405.5 Calculation software tools. Performance analysis tools meeting the applicable provisions of Sections R405.5.1 through R405.5.4 shall be permitted to be *approved*. Tools are permitted to be *approved* based on meeting a specified threshold for a jurisdiction. The *building official* shall be permitted to approve such tools for a specified application or limited scope.

R405.5.1 Minimum capabilities. *Approved* software tools shall include the following capabilities:

1. Computer generation of the *standard reference design* using only the input for the *proposed design*. The calculation procedure shall not allow the user to directly modify the building component characteristics of the *standard reference design*.
2. Calculation of whole-dwelling unit (as a single *zone*) sizing for the heating and cooling equipment in the *standard reference design* residence in accordance with Section R403.7.
3. Hourly calculations of building operation for a full calendar year (8,760 hours).
4. Calculations that account for hourly variations of indoor and outdoor temperatures and part-load ratios on the performance of heating, ventilating and air-conditioning equipment based on climate and equipment sizing.
5. Printing of a *building official* inspection checklist listing each of the *proposed design* component characteristics from Table R405.4.2(1) determined by the analysis to provide compliance, along with their respective performance ratings such as *R-value*, *U-factor*, SHGC, HSPF2, AFUE, SEER2 and UEF.

R405.5.2 Testing required by software vendors. Prior to approval, software tools shall be tested by the software vendor in accordance with ANSI/ASHRAE 140 Class II, Tier 1 test procedures. During testing, hidden inputs that are not normally available to the user shall be permitted to avoid introducing source code changes strictly used for testing. Software vendors shall publish, on a publicly available website, the following ANSI/ASHRAE 140 test results, input files and modeler reports for each tested version of a software tool:

1. Test results demonstrating the software tool was tested in accordance with ANSI/ASHRAE 140.
2. The modeler report in ANSI/ASHRAE 140, Annex A2, Attachment A2.7.

R405.5.3 Algorithms not tested. Algorithms not tested in accordance with Section R405.5.2 shall be permitted in accordance with ANSI/RESNET/ICC 301. Numerical settings not tested, such as timestep duration and tolerances, shall be permitted where they represent a higher resolution than the numerical settings used for testing.

R405.5.4 Compliance reports. *Approved* software tools shall generate compliance reports in accordance with Sections R405.5.4.1 and R405.5.4.2.

R405.5.4.1 Compliance report for permit application. A compliance report generated for submission with the application for building permit shall include the following:

1. Building street address or other *building site* identification.
2. The name of the individual performing the analysis and generating the compliance report.
3. The name and version of the compliance software tool.
4. Documentation of all inputs to the software used to produce the results for the *standard reference design* and the *proposed design*.
5. A certificate indicating that the *proposed design* complies with Section R405.2. The certificate shall document the building components' energy specifications that are included in the calculation including: component-level insulation *R*-values or *U*-factors; *duct system* and *building thermal envelope* air leakage testing assumptions; and the type and rated efficiencies of proposed heating, cooling, mechanical *ventilation* and service water-heating equipment to be installed. Where *on-site renewable energy* systems will be installed, the certificate shall report the type and production size of the proposed system.
6. Where a site-specific report is not generated, the *proposed design* shall be based on the worst-case orientation and configuration of the rated *dwelling unit*.

R405.5.4.2 Compliance report for certificate of occupancy. A compliance report generated for submission prior to obtaining the certificate of occupancy shall include the following:

1. Building street address, or other *building site* identification.
2. Declaration of the *simulated building performance* path on the title page of the energy report and the title page of the building plans.
3. A statement, bearing the name of the individual performing the analysis and generating the report, indicating that the as-built *building* complies with Section R405.2.
4. The name and version of the compliance software tool.
5. A site-specific *energy analysis* report that is in compliance with the requirements of Section R405.4, where all inputs for the *proposed design* have been replaced in the simulation with confirmed energy features of the as-built *dwelling unit*.
6. A final confirmed certificate indicating compliance based on inspection, and a statement indicating that the as-built *building*

complies with Section R405.2. The certificate shall report the energy features that were confirmed to be in the *building*, including component-level insulation *R-values* or *U-factors*; results from any required *duct system* and *building thermal envelope* air leakage testing; and the type and rated efficiencies of the heating, cooling, mechanical *ventilation* and service water-heating equipment installed.

7. When *on-site renewable energy* systems have been installed, the certificate shall report the type and production size of the installed system.

**SECTION ECC R406
ENERGY RATING INDEX COMPLIANCE ALTERNATIVE**

R406.1 Scope. This section establishes criteria for compliance using an *Energy Rating Index* (ERI) analysis. Such analysis shall be limited to *dwelling units* and *sleeping units*. *Common areas* in *residential buildings* shall comply with Sections R402 through R404. *Common areas* in *commercial buildings* shall comply with Sections C402 through C406, and Section C408.

R406.2 ERI compliance. Compliance based on the *ERI* requires that the *rated design* and as-built *dwelling unit* or *sleeping unit* meet all of the following:

1. The requirements of the sections indicated within Table R406.2.
2. Maximum *ERI* values indicated in Table R406.5.

**TABLE R406.2
REQUIREMENTS FOR ENERGY RATING INDEX**

SECTION ^a	TITLE
General	
R401.3	Certificate
Building thermal envelope	
R402.1.1	Vapor retarder
R402.1.6	Rooms containing fuel-burning appliances
R402.2.4	Eave baffle
R402.2.5.1	Access hatches and door insulation installation and retention
R402.2.10	Slab-on-grade floors
R402.2.11	Crawl space walls
R402.5.1.1	Installation
R402.5.1.2	Air leakage testing
R402.5.1.3	Maximum air leakage rate
R402.5.2	Fireplaces
R402.5.3	Fenestration air leakage
R402.5.4	Recessed lighting
R402.5.5	Air-sealed electrical and communication outlet boxes
R406.3	Building thermal envelope
Mechanical	
R403.1	Controls
R403.2	Hot water boiler temperature reset
R403.3	Duct systems
R403.4	Mechanical system piping insulation
R403.5	Service hot water systems
R403.6	Mechanical ventilation
R403.7, except Section R403.7.1	Equipment sizing and efficiency rating
R403.8	Systems serving multiple dwelling units
R403.9.2	Snow melt and ice system controls
R403.10	Energy consumption of pools and spas
R403.11	Portable spas
R403.12	Residential pools and permanent residential spas
R403.13	Gas fireplaces
Electrical power and lighting systems	
R404.1	Lighting equipment

**TABLE R406.2
REQUIREMENTS FOR ENERGY RATING INDEX
(CONTINUED)**

SECTION ^a	TITLE
R404.2	Interior lighting controls
R404.5	Dwelling unit electrical meter

a. Reference to a code section includes all of the relative subsections except as indicated in the table.

R406.3 Building thermal envelope. The proposed total *building thermal envelope* thermal conductance (TC_p) shall be less than or equal to the reference total *building thermal envelope* thermal conductance (TC_r) using the prescriptive *U*-factors and *F*-factors from Table R402.1.2 multiplied by 1.15, in accordance with Equation 4-2 and Section R402.1.5.

R406.4 Energy Rating Index. The *Energy Rating Index* (ERI) shall be determined in accordance with ANSI/RESNET/ICC 301. The mechanical *ventilation* rates used for the purpose of determining the *ERI* shall not be construed to establish minimum *ventilation* requirements for compliance with this code.

Energy used to recharge or refuel a vehicle used for transportation on roads that are not on the *building* site shall not be included in the *ERI reference design* or the *rated design*.

R406.5 ERI-based compliance. Compliance based on an *ERI* analysis requires that the *rated design* and each confirmed as-built *dwelling unit* or *sleeping unit* be shown to have an *ERI* less than or equal to the appropriate value indicated in Table R406.5 where compared to the *ERI reference design* as follows:

1. Where on-site renewables are not installed, the values under ENERGY RATING INDEX NOT INCLUDING OPP apply.
2. Where on-site renewables are installed, the values under ENERGY RATING INDEX WITH OPP apply.

Exceptions:

1. Where the *ERI* analysis excludes on-site power production (OPP), the values under ENERGY RATING INDEX NOT INCLUDING OPP shall be permitted to be applied.
2. For buildings with 20 or more *dwelling units* or *sleeping units*, where *approved* by the *building official*, compliance shall be permitted using the Average Dwelling Unit *Energy Rating Index*, as calculated in accordance with ANSI/RESNET/ICC 301.

**TABLE R406.5
MAXIMUM ENERGY RATING INDEX**

CLIMATE ZONE	ENERGY RATING INDEX NOT INCLUDING OPP	ENERGY RATING INDEX WITH OPP
4	53	40
5	54	43
6	53	43

R406.6 Verification by approved agency. Verification of compliance with Section R406 as outlined in Sections R406.5 and R406.7 shall be completed by an *approved* third party. Verification of compliance with Section R406.2 shall be completed by the *authority having jurisdiction* or an *approved* third-party inspection agency in accordance with Section R106.1.

R406.7 Documentation. Documentation of the software used to determine the *ERI* and the parameters for the *ERI reference design* shall be in accordance with Sections R406.7.1 through R406.7.4.

R406.7.1 Compliance software tools. Software tools used for determining *ERI* shall be *approved* software rating tools as defined by ANSI/RESNET/ICC 301. Software vendors shall publish, on a publicly available website, documentation that the software tool has been validated using the Class II, Tier 1 test procedure in ANSI/ASHRAE 140.

R406.7.2 Compliance report. Compliance software tools shall generate a report that documents that the *ERI* of the *rated design* and *as-built dwelling unit* or *sleeping unit* complies with Sections R406.2 through R406.5. Compliance documentation shall be created for the proposed design and shall be submitted with the application for the building permit. Confirmed compliance documents of the *as-built dwelling unit* or *sleeping unit* shall be created and submitted to the *building official* for review before a certificate of occupancy is issued. Compliance reports shall include information in accordance with Sections R406.7.2.1 and R406.7.2.2.

R406.7.2.1 Proposed compliance report for permit application. Compliance reports submitted with the application for a building permit shall include the following:

1. Building street address, or other *building site* identification.
2. Declare *ERI* on title page and building plans.
3. The name of the individual performing the analysis and generating the compliance report.
4. The name and version of the compliance software tool.
5. Documentation of all inputs entered into the software used to produce the results for the *ERI reference design* and the *rated design*.
6. A certificate indicating that the proposed design has an *ERI* less than or equal to the appropriate score indicated in Table R406.5 when compared to the *ERI reference design*. The certificate shall document the building component energy specifications that are included in the calculation, including: component level insulation *R-values* or *U-factors*; assumed *duct system* and *building thermal envelope* air leakage testing results; and the type and rated efficiencies of proposed heating, cooling, mechanical *ventilation* and service water-heating equipment to be installed. Where *on-site renewable energy* systems will be installed, the certificate shall report the type and production size of the proposed system.
7. When a site-specific report is not generated, the proposed design shall be based on the worst-case orientation and configuration of the *rated dwelling unit* or *sleeping unit*.

R406.7.2.2 Confirmed compliance report for a certificate of occupancy. A confirmed compliance report submitted for obtaining the certificate of occupancy shall be made site and address specific and include the following:

1. Building street address or other *building site* identification.
2. Declaration of *ERI* on title page and on building plans.
3. The name of the individual performing the analysis and generating the report.
4. The name and version of the compliance software tool.
5. Documentation of all inputs entered into the software used to produce the results for the *ERI reference design* and the as-built *dwelling unit* or *sleeping unit*.
6. A final confirmed certificate indicating that the as-built *building* complies with Sections R406.2, R406.4 and R406.5. The certificate shall report the energy features that were confirmed to be in the *building*, including: component-level insulation *R-values* or *U-factors*; results from any required *duct system* and *building thermal envelope* air leakage testing; and the type and rated efficiencies of the heating, cooling, mechanical *ventilation*, and service water-heating equipment installed. Where *on-site renewable energy* systems have been installed on or in the *building*, the certificate shall report the type and production size of the installed system.

R406.7.3 Renewable energy certificate (REC) documentation. Where renewable energy power production is included in the calculation of an *ERI*, documentation shall comply with Section R404.4.

R406.7.4 Additional documentation. The *building official* shall be permitted to require the following documents:

1. Documentation of the building component characteristics of the *ERI reference design*.
2. A certification signed by the builder providing the building component characteristics of the *rated design*.
3. Documentation of the actual values used in the software calculations for the *rated design*.

R406.7.5 Specific approval. Performance analysis tools meeting the applicable subsections of Section R406 shall be *approved*. Documentation demonstrating the approval of performance analysis tools in accordance with Section R406.7.1 shall be provided.

R406.7.6 Input values. Where calculations require input values not specified by Sections R402, R403, R404 and R405, those input values shall be taken from ANSI/RESNET/ICC 301.

**SECTION ECC R407
RESERVED**

SECTION ECC R408 ADDITIONAL EFFICIENCY REQUIREMENTS

R408.1 Scope. This section provides additional efficiency measures and credits required to comply with Section R401.2.1.

R408.2 Additional energy efficiency credit requirements. Residential buildings shall earn not less than 10 credits from not less than two measures specified in Table R408.2. Five additional credits shall be earned for buildings with more than 5,000 square feet (465 m²) of living space located above grade plane. To earn credit as specified in Table R408.2 for the applicable climate zone, each measure selected for compliance shall comply with the applicable subsections of Section R408. Each dwelling unit or sleeping unit shall comply with the selected measure to earn credit. Interpolation of credits between measures shall not be permitted.

**TABLE R408.2
CREDITS FOR ADDITIONAL ENERGY EFFICIENCY**

MEASURE NUMBER	MEASURE DESCRIPTION	Climate Zone 4	Climate Zone 5	Climate Zone 6
R408.2.1.1(1)	2.	1	1	1
R408.2.1.1(2)		2	2	2
R408.2.1.1(3)	> 7.5% reduction in total TC	2	2	3
R408.2.1.1(4)	> 10% reduction in total TC	3	4	4
R408.2.1.1(5)	> 15% reduction in total TC	4	5	6
R408.2.1.1(6)	> 20% reduction in total TC	5	7	8
R408.2.1.1(7)	> 30% reduction in total TC	8	11	12
R408.2.1.2(1)	U-factor and SHGC for vertical fenestration per Table R408.2.1.2	2	1	1
R408.2.1.4	Reduced air leakage	2	3	NA
R408.2.2(1) ^b	Ground source heat pump	15	15	17
R408.2.2(2) ^b	High Performance Cooling (Option 1)	2	1	1
R408.2.2(3) ^b	High Performance Cooling (Option 2)	2	1	1
R408.2.2(10) ^b	High Performance Heat pump with electric resistance backup (Option 1)	12	NA	NA
R408.2.2(14) ^b	High Performance Heat pump with electric resistance backup (Option 2)	12	12	13
R408.2.3(3) ^d	Electric water heaters (Option 1)	7	4	3
R408.2.3(4) ^d	Electric water heaters (Option 2)	6	4	3
R408.2.3(5)(a) ^d	Electric water heaters (Option 3)	6	5	4
R408.2.3(5)(b) ^d	Electric water heaters (Option 4)	7	5	5
R408.2.3(6) ^d	Electric water heaters (Option 5)	7	4	3
R408.2.3(7)(a) ^d	Solar hot water heating system (Option 1)	9	5	4
R408.2.3(7)(b) ^d	Solar hot water heating system (Option 2)	6	6	5
R408.2.4(1) ^c	Ductless or hydronic thermal distribution	7	10	10
R408.2.4(2) ^c	100% of duct systems in conditioned space	6	9	9
R408.2.4(3) ^c		5	7	7
R408.2.4(4) ^c	Reduced total duct system leakage	1	1	2
R408.2.5(2) ^c	2. installed	4	8	5
R408.2.5(4) ^c	1.	6	10	9
R408.2.5(5) ^c	1.	7	12	12
R408.2.6 ^a	Embodied Carbon	1	1	0
R408.2.7	On-site renewable energy measures	11	9	8
R408.2.8 ^c	Demand responsive thermostat	1	1	1

NA = Not Applicable.

- Where the measure is selected, each dwelling unit, sleeping unit and common area where the measure is applicable must have the measure installed.
- Where multiple heating or cooling systems are installed, credits shall be determined using a weighted average of the square footage served by each system.

**TABLE R408.2
CREDITS FOR ADDITIONAL ENERGY EFFICIENCY
(Continued)**

- c. Where the measure is selected, each dwelling unit and sleeping unit must comply with the measure.
- d. Where the measure is selected, each dwelling unit shall be served by a water heater meeting the applicable requirements. Where multiple service water heating systems are installed, credits shall be determined using a weighted average of the square footage served by each system.
- e. Eleven credits are available for Climate Zone 4 where the following measure is used: gas furnace and heat pump (Option 3): greater than or equal to 95% AFUE fuel gas furnace and 7.8 HSPF2, 15.2 SEER2 and 10.0 EER2 air source heat pump.

R408.2.1 Enhanced building thermal envelope options. The *building thermal envelope* shall comply with one or more of the following:

1. Section R408.2.1.1 or R408.2.1.2. Credit shall be permitted from only one measure.
2. Section R408.2.1.3.
3. Section R408.2.1.4.

R408.2.1.1 Enhanced building thermal envelope performance. The proposed total *building thermal envelope* thermal conductance (TC_p) shall be calculated in accordance with Section R402.1.5 and shall be reduced by not less than the percentage indicated in Table R408.2 in comparison to the reference total *building thermal envelope* thermal conductance (TC_r).

R408.2.1.2 Improved fenestration. The area weighted average *U-factor* and SHGC of all vertical *fenestration* shall be equal to or less than the values specified in Table R408.2.1.2.

**TABLE R408.2.1.2
IMPROVED FENESTRATION**

CLIMATE ZONE	U-FACTOR	SHGC
4	0.25	0.40
5	0.25	NR
6	0.25	NR

NR = No Requirement.

R408.2.1.3 Roof solar reflectance index. Reserved.

R408.2.1.4 Reduced air leakage. The *building* shall have a measured air leakage rate not less than 2.0 ACH50 and not greater than 2.5 ACH50 or the *dwelling units* in the *building* shall have an average measured air leakage rate not greater than 0.24 cubic feet per minute per square foot [1.2 L/(s × m²)].

R408.2.2 More efficient HVAC equipment performance options. Heating and cooling equipment shall meet one of the following measures as applicable for the climate zone where heating and cooling efficiencies are represented by Annual Fuel Utilization Efficiency (AFUE), Coefficient of Performance (COP), Energy Efficiency Ratio (EER and EER2), Heating Season Performance Factor (HSPF2) and Seasonal Energy Efficiency Ratio (SEER2). Where multiple heating or cooling systems are installed serving different zones, credits shall be earned based on the weighted average of square footage of the zone served by the system.

HVAC options:

1. Ground source heat pump: Greater than or equal to 16.1 EER and 3.1 COP ground source heat pump.
2. Cooling (Option 1): Greater than or equal to 15.2 SEER2 and 12.0 EER2 air conditioner.
3. Cooling (Option 2): Greater than or equal to 16.0 SEER2 and 12.0 EER2 air conditioner.
4. Heat pump (Option 2): Greater than or equal to 8.1 HSPF2 and 15.2 SEER2 air capacity at 5°F (-15°C) versus rated heating capacity at 47°F (8.3°C).

R408.2.2.1 More efficient HVAC equipment for Climate Zone 4. For Climate Zone 4, the following HVAC options shall also apply:

1. Heat pump (Option 1): Greater than or equal to 7.8 HSPF2, 15.2 SEER2 and 11.7 EER2 air source heat pump.

R408.2.3 Reduced energy use in service water-heating options. For measure numbers R408.2.3(1) through R408.2.3(7), the installed hot water system shall meet one of the Uniform Energy Factors (UEF) or Solar Uniform Energy Factors (SUEF) in Table R408.2.3. For measure number R408.2.3(8), the hot water distribution system shall comply with Section R408.2.3.1.

**TABLE R408.2.3
SERVICE WATER HEATING EFFICIENCIES**

MEASURE NUMBER	WATER HEATER	SIZE AND DRAW PATTERN	TYPE	EFFICIENCY
R408.2.3(3)	Electric water heaters (Option 1)	All storage volumes, low, medium, or high	Integrated HPWH	.
R408.2.3(4)	Electric water heaters (Option 2)	All storage volumes, low, medium, or high	Integrated HPWH, 120 volt/15 amp circuit	2.2
R408.2.3(5)(a)	Electric water heaters (Option 3)	All storage volumes, low, medium, or high	Split-system HPWH	2.2
R408.2.3(5)(b)	Electric water heaters (Option 4)	All storage volumes, low, medium, or high	Split-system HPWH	.
R408.2.3(6)	Electric water heaters (Option 5)	Rated input capacity > 12 kW	—	.
R408.2.3(7)(a)	Solar water heaters (Option 1)	All storage volumes, all draw patterns	Electric backup	.
R408.2.3(7)(b)	Solar water heaters (Option 2)	All storage volumes, all draw patterns	Gas backup	1.

For SI: 1 British thermal unit per hour = 0.2931 W.

UEF = Uniform Energy Factor, Et = Thermal Efficiency, COP = Coefficient of Performance.

R408.2.3.1 Compact hot water distribution system option. Reserved.

R408.2.4 More efficient thermal distribution system options. The thermal distribution system shall comply with one of the following:

1. The ductless thermal distribution system or hydronic thermal distribution system is located completely on the conditioned side of the *building thermal envelope*.
2. The *space conditioning equipment* is located inside *conditioned space*. In addition, 100 percent of the *ductwork* is located completely inside *conditioned space* as defined by Section R403.3.4, Items 1 and 2.
3. The *space conditioning equipment* is located inside *conditioned space* and not less than 80 percent of *ductwork* is located completely inside *conditioned space* as defined by Section R403.3.4, Items 1 and 2. In addition, not more than 20 percent of *ductwork* is contained within building assemblies separating unconditioned from *conditioned space* as defined by Section R403.3.4, Item 3.
4. Where *ductwork* is located outside conditioned space, the total leakage of the *duct system* measured in accordance with Section R403.3.7 is one of the following:
 - 4.1. Where the *space conditioning equipment* is installed at the time of testing, total leakage is not greater than 2.0 cubic feet per minute (0.94 L/s) per 100 square feet (9.29 m²) of *conditioned floor area*.
 - 4.2. Where the *space conditioning equipment* is not installed at the time of testing, total leakage is not greater than 1.75 cubic feet per minute (0.83 L/s) per 100 square feet (9.29 m²) of *conditioned floor area*.

R408.2.5 Improved air sealing and efficient ventilation system options. The measured air leakage rate and *ventilation* system shall meet one of the following:

1. Either an Energy Recovery Ventilator (ERV) or a Heat Recovery Ventilator (HRV) installed.
2. Less than or equal to 2.0 ACH50, with either an ERV or HRV installed.
3. Less than or equal to 2.0 ACH50, with a *balanced ventilation system*.
4. Less than or equal to 1.5 ACH50, with either an ERV or HRV installed.
5. Less than or equal to 1.0 ACH50, with either an ERV or HRV installed.

In addition, for measures requiring either an ERV or HRV, HRV and ERV Sensible Recovery Efficiency (SRE) shall be not less than 75 percent at 32°F (0°C) at the lowest *listed* net airflow. ERV Latent Recovery/Moisture Transfer (LRMT) shall be not less than 50 percent at the lowest *listed* net airflow.

R408.2.6 Embodied Energy/Carbon Tracking. Where the following building materials are used, the applicant shall provide documentation as described below in order to obtain a credit for additional energy efficiency;

1. Concrete Masonry Units . To obtain a credit for Embodied Energy/Carbon Tracking for Concrete Masonry Units, the applicant shall include the following information as part of the Energy Analysis submitted with the construction documentation:
 - 1.1 Environmental Product Declaration (EPD) for the proposed product showing the embodied carbon of the CMU product (Units: kgCO₂e/m³)
 - 1.2 The listed embodied carbon of the CMU product per the EPD (Units: kgCO₂e/m³);

- 1.3 The total quantity (Units: m³) of the CMU in the project;
- 1.4 The total embodied carbon of CMU (listed embodied carbon multiplied by quantity) in the project versus the baseline embodied carbon of CMU (industry wide baseline embodied carbon multiplied by quantity);
 - 1.4.1 Industry Wide Baseline Embodied Carbon for Concrete Masonry Unit: 177 kgCO₂e/yr
- 1.5 The application does NOT need to demonstrate a reduction in embodied carbon from the baseline in order to obtain the credit;
2. Poured in Place Concrete: To obtain a credit for Embodied Energy/Carbon Tracking for Poured in Place Concrete, the applicant shall include the following information as part of the Energy Analysis submitted with the construction documentation:
 - 2.1 The type and specified compressive strength (psi) of the poured in place concrete
 - 2.2 Environmental Product Declaration (EPD) for the proposed concrete showing the embodied carbon of the CMU product (Units: Units: kgCO₂e/m³)
 - 2.3 The listed embodied carbon of the poured in place concrete per the EPD (Units: kgCO₂e/m³);
 - 2.4 The total quantity (Units: y³) of the poured in place concrete in the project;
 - 2.5 The total embodied carbon of poured in place concrete (listed embodied carbon multiplied by quantity) in the project versus the baseline embodied carbon of poured in place concrete (industry wide baseline embodied carbon multiplied by quantity);
 - 2.5.1 Industry Wide Baseline Embodied Carbon for Poured in Place Concrete (Ready Mix)
 - 0-2500 psi: 175 kgCO₂e/y³
 - 2501-3000 psi: 194 kgCO₂e/y³
 - 3001-4000 psi: 238 kgCO₂e/y³
 - 4001-5000 psi: 289 kgCO₂e/y³
 - 5001-6000 psi: 304 kgCO₂e/y³
 - 6001-8000 psi: 353kgCO₂e/y³
 - 2.5.2 Industry Wide Baseline Embodied Carbon for Poured in Place Concrete (Lightweight Concrete)
 - 0-3000 psi: 365 kgCO₂e/y³
 - 3001-4000 psi: 417 kgCO₂e/y³
 - 4001-5000 psi: 461 kgCO₂e/y³
 - 2.6 The application does NOT need to demonstrate a reduction in embodied carbon from the baseline in order to obtain the credit;

R408.2.7 Renewable energy. *Renewable* energy resources shall be permanently installed and have the rated capacity to produce not less than 1.0 watt of on-site renewable energy per square foot of conditioned floor area. To qualify for this option, renewable energy certificate (REC) documentation shall meet the requirements of Section R404.4. This credit is only applicable for renewable energy infrastructure that exceeds the requirements of any current state or local law, rule or regulation.

R408.2.8 Demand response. The *thermostat* controlling the primary heating or cooling system of each *dwelling unit* shall be provided with a *demand responsive control* capable of communicating with the Virtual End Node (VEN) using a wired or wireless bi-directional communication pathway that provides the occupant the ability to voluntarily participate in utility demand response programs, where available. The *thermostat* shall be capable of executing the following actions in response to a *demand response signal*:

1. Automatically increasing the zone operating cooling set point by the following values: 1°F (0.5°C), 2°F (1°C), 3°F (1.5°C) and 4°F (2°C).

2. Automatically decreasing the zone operating heating set point by the following values: 1°F (0.5°C), 2°F (1°C), 3°F (1.5°C) and 4°F (2°C).

Thermostats controlling single-stage HVAC systems shall comply with Section R408.2.8.1. Thermostats controlling variable capacity systems shall comply with Section R408.2.8.2. Thermostats controlling multistage HVAC systems shall comply with either Section R408.2.8.1 or R408.2.8.2. Where a *demand response signal* is not available, the *thermostat* shall be capable of performing all other functions.

R408.2.8.1 Single-stage HVAC system controls. Thermostats controlling single-stage HVAC systems shall be provided with a *demand responsive control* that complies with one of the following:

1. Certified OpenADR 2.0a VEN, as specified under Clause 11, Conformance.
2. Certified OpenADR 2.0b VEN, as specified under Clause 11, Conformance.
3. Certified by the manufacturer as being capable of responding to a *demand response signal* from a certified OpenADR 2.0b VEN by automatically implementing the control functions requested by the VEN for the equipment it controls.
4. IEC 62746-10-1.
5. The communication protocol required by a controlling entity, such as a utility or service provider, to participate in an automated demand response program.
6. The physical configuration and communication protocol of CTA 2045-A or CTA-2045-B.

R408.2.8.2 Variable-capacity and two-stage HVAC system controls. Thermostats controlling variable-capacity and two-stage HVAC systems shall be provided with a *demand responsive control* that complies with the communication and performance requirements of AHRI 1380.

R408.2.9 Opaque walls. Reserved

R408.2.10 Whole-home lighting control. The *dwelling unit* shall have a *manual* control by the main entrance that turns off all the permanently installed interior lighting or a lighting control system that has the capability to turn off all permanently installed interior lighting from remote locations.

Exceptions:

1. Up to 5 percent of the total lighting power may remain uncontrolled.
2. Spaces where lighting is controlled by a count-down timer or *occupant sensor control*.

R408.2.11 Higher efficacy lighting. All spaces shall be provided with hardwired lighting with a lamp efficacy of 90 lumens per watt (lm/W) or a luminaire efficacy of 55 lm/W.

Exceptions:

1. Closets.
2. Other storage spaces.