CHAPTER C4
COMMERCIAL ENERGY EFFICIENCY

SECTION ECC C401
GENERAL

C401.1 Scope. The provisions in this chapter are applicable to commercial buildings and their building sites.

C401.2 Application. *Commercial buildings* shall comply with Section C401.2.1 or C401.2.2.

C401.2.1 New York City Energy Conservation Code. Commercial Provisions. Commercial buildings shall comply with Sections C402 through C406 and C408. Dwelling units and sleeping units in Group R-2 buildings without systems serving multiple units shall be deemed to be in compliance with this chapter, provided that they comply with Section R406.

Exception: *Additions*, *alterations*, *repairs* and changes of occupancy to existing buildings complying with Chapter C5.

C401.2.2 ASHRAE 90.1. *Commercial buildings shall comply with the requirements of 2025 NYC ASHRAE 90.1.*

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

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

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

SECTION ECC C402
BUILDING THERMAL ENVELOPE REQUIREMENTS

C402.1 General. *Building thermal envelope* assemblies for buildings that are intended to comply with the code on a prescriptive basis in accordance with the compliance path described in Item 1 of Section C401.2.1 shall comply with the following:

1. The opaque portions of the *building thermal envelope* shall comply with the specific insulation requirements of Section C402.2 and the thermal requirements of Section C402.1.2, C402.1.3 or C402.1.4. Where the total area of through penetrations of mechanical equipment is greater than 1 percent of the opaque *above-grade wall* area, the *building thermal envelope* shall comply with Section C402.1.2.1.8.
2. Roof solar reflectance and thermal *emittance* shall comply with Section C402.4.
3. *Fenestration* in the *building thermal envelope* shall comply with Section C402.5. Where *buildings* have a vertical *fenestration* area or skylight area greater than that allowed in Section C402.5, the *building* and *building thermal envelope* shall comply with Item 2 of Section C401.2.1, C401.2.2 or C402.1.4.
4. *Air leakage* of *building thermal envelope* shall comply with Section C402.6.
5. *Thermal bridges* in *above-grade walls* shall comply with Section C402.7.
6. *Walk-in coolers*, *walk-in freezers*, *refrigerated warehouse coolers* and *refrigerated warehouse freezers* shall comply with Section C403.12.

C402.1.1 Low-energy buildings. Low-energy *buildings*, or portions thereof, separated from the remainder of an otherwise conditioned *building* by *building thermal envelope* assemblies, shall be exempt from the *building thermal envelope* provisions of Section C402 where one of the following is met:

1. Those with a peak design rate of energy usage less than 3.4 Btu/h × ft^2 (10.7 W/m^2) or 1.0 watt per square foot (10.7 W/m^2) of floor area for space conditioning purposes.
2. Those that do not contain *conditioned space*.

C402.1.1.1 Greenhouses. *Greenhouses* that are mechanically heated or cooled and do not meet the provisions for low-energy buildings in Section C402.1.1 shall be exempt from the *building thermal envelope* provisions of Section C402 where all the following are met:

1. Exterior opaque envelope assemblies comply with Sections C402.2 and C402.5.5.
2. Interior partition *building thermal envelope* assemblies that separate the *greenhouse* from *conditioned space* comply with Sections C402.2, C402.5.3 and C402.5.5.
3. *Fenestration* assemblies that comply with the *building thermal envelope* requirements in Table C402.1.1.1. The *U-factor* for a roof shall be for the *roof assembly* or a roof that includes the assembly and an *internal curtain system*.

TABLE C402.1.1.1
FENESTRATION BUILDING THERMAL ENVELOPE MAXIMUM REQUIREMENTS

COMPONENT	*U*-FACTOR (Btu/h × ft^2 × °F)
Skylight	0.5
Vertical fenestration	0.7

C402.1.1.2 Equipment buildings. *Buildings* that comply with all the following shall be exempt from the *building thermal envelope* provisions of this code:

1. Are separate *buildings* with not more than 1,200 square feet (111 m^2) of floor area.
2. Are intended to house electric equipment with installed equipment power totaling not less than 7 watts per square foot (75 W/m^2) and not intended for human occupancy.
3. Have a heating system capacity not greater than 20,000 Btu/h (6 kW) and a heating *thermostat* setpoint that is restricted to not more than 50°F (10°C).
4. Have an average wall and roof *U-factor* less than 0.2 in *Climate Zones* 4 and 5 and less than 0.12 in *Climate Zones* 6.
5. Comply with the roof solar reflectance and thermal *emittance* provisions for *Climate Zone* 1.

C402.1.2 Assembly *U*-factor, *C*-factor or *F*-factor method. *Building thermal envelope* opaque assemblies shall have a *U*-, *C*- or *F-factor* not greater than that specified in Table C402.1.2. *Commercial buildings* or portions of *commercial buildings* enclosing *Group R* occupancies shall use the *U*-, *C*- or *F-factor* from the "*Group R*" column of Table C402.1.2. *Commercial buildings* or portions of *commercial buildings* enclosing occupancies other than *Group R* shall use the *U*-, *C*- or *F*-factor from the "All other" column of Table C402.1.2.

TABLE C402.1.2
OPAQUE BUILDING THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, U-FACTOR METHOD[a, b]

CLIMATE ZONE	4		5		6	
	All other	Group R	All other	Group R	All other	Group R
Roofs						
Insulation entirely above roof deck	U-0.030	U-0.030	U-0.030	U-0.030	U-0.028	U-0.028
Pre-engineered Metal buildings	U-0.035	U-0.035	U-0.035	U-0.035	U-0.028	U-0.028
Attic and other	U-0.020	U-0.020	U-0.020	U-0.020	U-0.017	U-0.017
Walls, above grade[e]						
Mass[f]	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.067
Pre-engineered Metal building	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.046
Metal framed[i]	U-0.061	U-0.061	U-0.052	U-0.052	U-0.47	U-0.043
Wood framed and other	U-0.061	U-0.061	U-0.048	U-0.048	U-0.048	U-0.048
Walls, below grade						
Below-grade wall[c]	C-0.119	C-0.092	C-0.119	C-0.092	C-0.092	C-0.063
Floors						
Mass[d]	U-0.057	U-0.051	U-0.053	U-0.051	U-0.051	U-0.051
Joist/framing	U-0.033	U-0.033	U-0.033	U-0.033	U-0.027	U-0.027
Slab-on-grade floors						
Unheated slabs	F-0.52	F-0.52	F-0.52	F-0.51	F-0.51	F-0.434
Heated slabs	F-0.62	F-0.62	F-0.62	F-0.62	F-0.62	F-0.602
Opaque doors						
Nonswinging door	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31
Swinging door[g]	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37
Garage door <14% glazing[h]	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31

For SI: 1 pound per square foot = 4.88 kg/m2, 1 pound per cubic foot = 16 kg/m3.

a. Where assembly U-factors, C-factors and F-factors are established in 2025 NYC ASHRAE 90.1, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table, provided that the construction, excluding the cladding system on walls, complies with the appropriate construction details from 2025 NYC ASHRAE 90.1.

b. Where U-factors have been established by testing in accordance with ASTM C1363, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table. The R-value of continuous insulation shall be permitted to be added to or subtracted from the original tested design.

c. Where heated slabs are below grade, below-grade walls shall comply with the U-factor requirements for above-grade mass walls.

d. “Mass floors” shall be in accordance with Section C402.1.3.4.

e. Reserved.

f. Mass walls” shall be in accordance with Section C402.1.3.4.

g. Swinging door U-factors shall be determined in accordance with NFRC-100.

h. Garage doors having a single row of fenestration shall have an assembly U-factor less than or equal to 0.44, provided that the fenestration area is not less than 14 percent and not more than 25 percent of the total door area.

i. This refers to cold-formed steel studs or joists at 16” or 24” on-center

C402.1.2.1 Methods of determining *U*-, *C*- and *F*-factors. Where assembly U-factors, C-factors and F-factors and calculation procedures are established in *2025 NYC ASHRAE 90.1* Appendix A for opaque assemblies, such opaque assemblies shall be a compliance alternative provided they meet the criteria of Table C402.1.2 and the construction, excluding cladding system on walls, complies with the applicable construction details from *2025 NYC ASHRAE 90.1* Appendix A. Where U-factors have been established by testing in accordance with ASTM C1363, such opaque assemblies shall be a compliance alternative provided they meet the criteria of Table C402.1.4. The R-value of continuous insulation shall be permitted to be added to or subtracted from the original tested design. Airspaces used for assembly evaluations shall comply with Section C402.2.7.

C402.1.2.1.1 Tapered, above-deck insulation based on thickness. For tapered, above-deck roof insulation, area-weighted *U-factors* of non-uniform insulation thickness shall be determined by an *approved* method.

Exception: The area-weighted *U*-factor shall be permitted to be determined by using the inverse of the average *R*-value determined in accordance with the exception to Section C402.1.3.2.

C402.1.2.1.2 Suspended ceilings. Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the assembly *U-factor* of the roof-ceiling construction.

C402.1.2.1.3 Concrete masonry units, integral insulation. In determining compliance with Table C402.1.2, the *U-factor* of concrete masonry units with integral insulation shall be permitted to be used.

C402.1.2.1.4 Mass walls and floors. Compliance with required maximum *U-factors* for mass walls and mass floors in accordance with Table C402.1.2 shall be permitted for assemblies complying with Section C402.1.3.4.

C402.1.2.1.5 Area-weighted averaging of above-grade wall *U*-factors. Where *above-grade walls* include more than one assembly type or a penetration of the opaque wall area, the *area-weighted average U-factor* of the *above-grade wall* is permitted to be determined by an *approved* method.

C402.1.2.1.6 Cold-formed steel assemblies. U-factors for building thermal envelopes containing cold-formed steel framed ceiling and walls shall be permitted to be determined in accordance with Table A3.3.3.1 in 2025 NYC ASHRAE 90.1. Where the steel-framed wall contains no cavity insulation and uses continuous insulation to satisfy the U-factor maximum, the steel-framed wall member spacing is permitted to be installed at any on-center spacing.

C402.1.2.1.7 Spandrel panels. U-factors of opaque assemblies within fenestration framing systems shall be determined in accordance with ASTM C1363, ANSI/NFRC 100, or the default values in Table C303.1.5.

C402.1.2.1.8 Mechanical equipment penetrations. Where the total area of through the wall penetrations from mechanical equipment or equipment that is listed in TableC403.3.2(4) is greater than 1 percent of the opaque above-grade wall area, such area shall be calculated as a separate wall assembly, in accordance with either Section C402.1.2.1.5 or Section C402.1.4 using a published and *approved U-factor* for that equipment or a default *U-factor* of 0.5.

C402.1.3 Insulation component *R*-value method. For opaque portions of the *building thermal envelope* the *R*-values for *cavity insulation* and *continuous insulation* shall be not less than that specified in Table C402.1.3. *Group R* occupancy buildings or portions of *commercial buildings* enclosing *Group R* occupancies shall use the *R*-values from the "*Group R*" column of Table C402.1.3. *Commercial buildings* or portions of *commercial buildings* enclosing occupancies other than *Group R* shall use the *R*-values from the "All other" column of Table C402.1.3.

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

CLIMATE ZONE	4		5		6	
	All other	Group R	All other	Group R	All other	Group R
Roofs						
Insulation entirely above roof deck	R-33ci	R-33ci	R-33ci	R-33ci	R-35ci	R-35ci
Pre-engineered Metal buildings[b]	R-19ca + R-11 LS	R-19ca + R-11 LS	R-19ca + R-11 LS	R-19ca + R-11 LS	R-30ca + R-11 LS	R-25ca + R-11 + R-11 LS
Attic and other	R-53ca	R-53ca	R-53ca	R-53ca	R-60ca	R-60ca
Walls, above grade						
Mass[f]	R-13.3ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-17.5ci
Pre-engineered Metal building	R-13ca+14.9ci	R-13ca+14.9ci	R-13ca + R-14.9ci	R-13ca + R-14.9ci	R-13ca + R-14.9ci	R-13ca + R-15.8ci
Metal framed[j]	R-13ca+8.5ci	R-13ca +8.5ci	R-13ca+7.5ci	R-13ca+7.5ci	R-13ca+7.5ci	R-13ca+7.5ci
Wood framed and other	R-13ca+4.5ci or R-19ca+1.5ci	R-13ca+4.5ci or R-19ca+1.5ci	R-11 + R-10ci or R-19 + R-5ci or R-21 + R-4ci	R-11 + R-10ci or R-19 + R-5ci or R-21 + R-4ci	R-11 + R-10ci or R-19 + R-5ci or R-21 + R-4ci	R-11 + R-12ci or R-19 + R-7ci or R-21 + R-5ci
Walls, below grade						
Below-grade wall[d]	R-7.5ci	R-10ci	R-7.5ci	R-10ci	R-10ci	R-15ci
Floors						
Mass[e]	R-14.6ci	R-16.7ci	R-16.7ci	R-16.7ci	R-16.7ci	R-16.7ci
Joist/framing	R-30ca	R-30ca	R-30ca	R-30ca	R-38ca	R-38ca
Slab-on-grade floors						
Unheated slabs	R-15 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-20 for 24″ below	R-20 for 24″ below	R-20 for 48″ below
Heated slabs[g]	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48″ below + R-5 full slab	R-20 for 48″ below + R-5 full slab	R-20 for 48″ below + R-5 full slab	R-15 full slab

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.
ci = Continuous Insulation, NR = No Requirement, LS = Liner System, ca = Cavity insulation.
a. Assembly descriptions can be found 2025 NYC ASHRAE 90.1 Appendix A.
b. Where using *R*-value compliance method, a thermal spacer block shall be provided, otherwise use the *U*-factor compliance method in Table C402.1.2.
c. Reserved.
d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.
e. "Mass floors" shall be in accordance with Section C402.1.3.4.
f. "Mass walls" shall be in accordance with Section C402.1.3.4.
g. The first value is for perimeter insulation and the second value is for full, under-slab insulation. Perimeter and full-slab insulation components shall be installed in accordance with Section C402.2.4.
h. The first value is cavity insulation; the second value is continuous insulation. Therefore; "R-13ca+R-8.5ci" means R-13 cavity insulation and R-8.5 continuous insulation; "R-53ca" means R-53 cavity insulation and no continuous insulation.
i. Where the required R-value in Table C402.1.3 is met by using continuous insulation such that cavity insulation is not required, the R-Value is applicable to any wall framing spacing.
j. This refers to cold-formed steel studs or joists at 16" or 24" on-center.

C402.1.3.1 *R*-value of multi-layered insulation components. Where *cavity insulation* is installed in multiple layers, the *cavity insulation R*-values shall be summed to determine compliance with the *cavity insulation R-value* requirements. Where *continuous insulation* is installed in multiple layers, the *continuous insulation R*-values shall be summed to determine compliance with the *continuous insulation R-value* requirements. *Cavity insulation R*-values shall not be used to determine compliance with the *continuous insulation R-value* requirements in Table C402.1.3.

C402.1.3.2 Area-weighted averaging of *R*-values. Area-weighted averaging shall not be permitted for *R-value* compliance.

Exception: For tapered above-deck roof insulation, compliance with the *R*-values required in Table C402.1.3 shall be permit-ted to be demonstrated by multiplying the rated *R-value* per inch of the insulation material by the average thickness of the roof insulation. The average thickness of the roof insulation shall equal the total volume of the roof insulation divided by the area of the roof.

C402.1.3.3 Suspended ceilings. Insulation installed on suspended ceilings having removable ceiling tiles shall not be considered part of the minimum thermal resistance (*R-value*) of roof insulation in roof-ceiling construction.

C402.1.3.4 Mass walls and mass floors. Compliance with required maximum *U-factors* for mass walls and mass floors in accordance with Table C402.1.2 and minimum *R*-values for insulation components applied to mass walls and mass floors in accordance with Table C402.1.3 shall be permitted for assemblies complying with the following:

1. Where used as a component of the *building thermal envelope*, mass walls shall comply with one of the following:
    1.1. Weigh not less than 35 pounds per square foot (171 kg/m^2) of wall surface area.
    1.2. Weigh not less than 25 pounds per square foot (122 kg/m^2) of wall surface area where the material weight is not more than 120 pounds per cubic foot (pcf) (1922 kg/m^3).
    1.3. Have a heat capacity exceeding 7 Btu/ft^2 × °F (144 kJ/m^2 × K).
    1.4. Have a heat capacity exceeding 5 Btu/ft^2 × °F (103 kJ/m^2 × K) where the material weight is not more than 120 pcf (1922 kg/m^3).
2. Where used as a component of the *building thermal envelope*, the minimum weight of mass floors shall comply with one of the following:
    2.1. Thirty-five pounds per square foot (171 kg/m^2) of floor surface area.
    2.2. Twenty-five pounds per square foot (122 kg/m^2) of floor surface area where the material weight is not more than 120 pcf (1922 kg/m^3).

C402.1.4 Component performance method. *Building thermal envelope* values and *fenestration* areas determined in accordance with Equation 4-1 shall be an alternative to compliance with the *U*-, *F*-, psi-, chi-, and *C*-factors in Tables C402.1.2, C402.1.2.1.7, C402.1.4 and C402.5 and the maximum allowable *fenestration* areas in Section C402.5.1. *Fenestration* shall meet the applicable SHGC requirements of Section C402.5.3.

Equation 4-1 $A_P + B_P + C_P + T_P \leq A_T + B_T + C_T + T_T - V_F - V_S$

where:

A_P = Sum of the (area × *U*-factor) for each proposed building thermal envelope assembly, other than slab-on-grade or below-grade wall assemblies.

B_P = Sum of the (length × *F*-factor) for each proposed slab-on-grade edge condition.

C_P = Sum of the (area × *C*-factor) for each proposed below-grade wall assembly.

T_P = Sum of the (ΨLP) and (χNP) values for each type of thermal bridge condition of the building thermal envelope as identified in Section C402.7 in the proposed building. For the purposes of this section, the (ΨLP) and (χNP) values for thermal bridges caused by materials with a thermal conductivity less than or equal to 3.0 Btu × in/h × ft^2 × °F shall be assigned as zero.

ΨLP = Psi-factor × length of the thermal bridge elements in the proposed building thermal envelope.

χNP = Chi-factor × number of the thermal bridge point elements other than fasteners, ties or brackets in the proposed building thermal envelope.

A_T = Sum of the (area × *U*-factor permitted by Tables C402.1.2 and C402.5) for each proposed building thermal envelope assembly, other than slab-on-grade or below-grade wall assemblies.

B_T = Sum of the (length × *F*-factor permitted by Table C402.1.2) for each proposed slab-on-grade edge condition.

C_T = Sum of the (area × *C*-factor permitted by Table C402.1.2) for each proposed below-grade wall assembly.

T_T = Sum of the (ΨLT) and (χNT) values for each type of thermal bridge condition in the proposed building thermal envelope as identified in Section C402.7 with values specified as “compliant” in Table C402.1.4. For the purposes of this section, the (ΨLT) and (χNT) values for thermal bridges caused by materials with a thermal conductivity less than or equal to 3.0 Btu × in/h × ft^2 × °F shall be assigned as zero.

ΨLT = (Psi-factor specified as “compliant” in Table C402.1.4) × length of the thermal bridge elements in the proposed building thermal envelope.

χNT = (Chi-factor specified as “compliant” in Table C402.1.4) × number of the thermal bridge point elements other than fasteners, ties or brackets in the proposed building thermal envelope.

P_F = Maximum vertical fenestration area allowable by Section C402.5.1, C402.5.1.1 or C402.5.1.2.

Q_F = Proposed vertical fenestration area.

$R_F = Q_F - P_F$, but not less than zero (excess vertical fenestration area).

S_F = Area-weighted average *U*-factor permitted by Table C402.5 of all vertical fenestration assemblies. T_F = Area-weighted average *U*-factor permitted by Table C402.1.2 of all exterior opaque wall assemblies. $U_F = S_F - T_F$ (excess *U*-factor for excess vertical fenestration area).

$V_F = R_F \times U_F$ (excess $U \times A$ due to excess vertical fenestration area).

P_S = Maximum skylight area allowable by Section C402.1.2.

Q_S = Actual skylight area.

$R_S = Q_S - P_S$, but not less than zero (excess skylight area).

S_S = Area-weighted average *U*-factor permitted by Table C402.5 of all *skylights*.

T_S = Area-weighted average *U*-factor permitted by Table C402.1.2 of all opaque roof assemblies.

$U_S = S_S - T_S$ (excess *U*-factor for excess skylight area).

$V_S = R_S \times U_S$ (excess $U \times A$ due to excess skylight area).

A proposed psi- or *chi-factor* for each thermal bridge shall comply with one of the following, as applicable:

1. Where the proposed mitigation of a thermal bridge is compliant with the requirements of Section C402.7, the "compliant" values in Table C402.1.4 shall be used for the proposed psi- or chi-factors.
2. Where a thermal bridge is not mitigated in a manner at least equivalent to Section C402.7, the "noncompliant" values in Table C402.1.4 shall be used for the proposed psi- or chi-factors.
3. Where the proposed mitigation of a thermal bridge provides a psi- or chi-factor less than the "compliant" values in Table C402.1.4, the proposed psi- or chi-factor shall be determined by thermal analysis, testing or other approved sources.

TABLE C402.1.4
PSI- and CHI-FACTORS TO DETERMINE THERMAL BRIDGES FOR THE COMPONENT PERFORMANCE METHOD

THERMAL BRIDGE PER SECTION C402.7	THERMAL BRIDGE COMPLIANT WITH SECTION C402.7		THERMAL BRIDGE NONCOMPLIANT WITH SECTION C402.7	
	Psi-Factor (Btu/h × ft × °F)	Chi-Factor (Btu/h × °F)	Psi-Factor (Btu/h × ft × °F)	Chi-Factor (Btu/h × °F)
C402.7.1 Balconies and floor decks	0.2	N/A	0.5	N/A
C402.7.2 Cladding supports	0.2	N/A	0.3	N/A
C402.7.3 Structural beams and columns	N/A	1.0 carbon steel 0.3 concrete	N/A	2.0 carbon steel 1.0 concrete
C402.7.4 Vertical fenestration	0.15	N/A	0.3	N/A
C402.7.5 Parapets	0.2	N/A	0.4	N/A

For SI: 1 W/m × K = 0.578 Btu/h × ft × °F, 1 W/K = 1.9 Btu/h × °F. N/A = Not Applicable.

C402.1.5 Rooms containing fuel-burning appliances. Where combustion air is supplied through openings in an *exterior wall* to a room or space containing a space-conditioning fuel-burning appliance, one of the following shall apply:

1. The room or space containing the appliance shall be located outside of the *building thermal envelope*.
2. The room or space containing the appliance shall be enclosed and isolated from *conditioned spaces* inside the *building thermal envelope*. Such rooms shall comply with all of the following:
   2.1. The walls, floors and ceilings that separate the enclosed room or space from *conditioned spaces* shall be insulated to be not less than equivalent to the insulation requirement of *below-grade walls* as specified in Table C402.1.3 or Table C402.1.2.
   2.2. The walls, floors and ceilings that separate the enclosed room or space from *conditioned spaces* shall be sealed in accordance with Section C402.6.1.2.
   2.3. The doors into the enclosed room or space shall be fully gasketed.
   2.4. Piping serving as part of a heating or cooling system and *ducts* in the enclosed room or space shall be insulated in accordance with Section C403. Service water piping shall be insulated in accordance with Section C404.
   2.5. Where an air *duct* supplying combustion air to the enclosed room or space passes through *conditioned space*, the *duct* shall be insulated to an *R-value* of not less than R-8.

Exception: Fireplaces and stoves that comply with the *New York City Mechanical Code*, and the fireplace blocking requirements of the *New York City Building Code*.

C402.2 Specific insulation and installation requirements. Insulation in *building thermal envelope* opaque assemblies shall be installed in accordance with Section C303.2 and Sections C402.2.1 through C402.2.7.

C402.2.1 Roof-ceiling construction. Insulation materials in the roof-ceiling construction shall be installed between the roof or ceiling framing, continuously below the ceiling framing, continuously above, below, or within the roof deck or in any *approved* combination thereof. Insulation installed above the roof deck shall comply with Sections C402.2.1.1 through C402.2.1.3.

C402.2.1.1 Joints staggered. Continuous, above-deck insulation board located above the roof deck shall be installed in not less than two layers and the edge joints between each layer of insulation shall be staggered, except where insulation tapers to the roof deck at a gutter edge, roof drain or scupper.

C402.2.1.2 Skylight curbs. Skylight curbs shall be insulated to the level of the above-deck roof insulation or R-5, whichever is less.

Exception: Unit skylight curbs included as a component of a skylight listed and labeled in accordance with NFRC 100 shall not be required to be insulated.

C402.2.1.3 Minimum thickness of tapered insulation. The thickness of tapered above-deck roof insulation at its lowest point, gutter edge, roof drain or scupper, shall be not less than 1 inch (25 mm).

C402.2.2 Above-grade walls. *Above-grade wall* insulation materials shall be installed between the wall framing, be integral to the wall assembly, be continuous on the wall assembly, or be any combination of these insulation methods. Where *continuous insulation* is layered on the exterior side of a wall assembly, the joints shall be staggered.

C402.2.3 Floors over outdoor air or unconditioned space. Floor insulation shall be installed between floor framing, be integral to the floor assembly, be continuous on the floor assembly, or be any combination of these insulation methods. Where *continuous insulation* is layered on the exterior side of a floor assembly, the joints shall be staggered. Floor framing *cavity insulation* or structural slab insulation shall be installed to maintain permanent contact with the underside of the subfloor decking or structural slabs.

Exceptions:

1. The floor framing *cavity insulation* or structural slab insulation shall be permitted to be installed in contact with the top side of sheathing or *continuous insulation* installed on the bottom side of floor assemblies. Floor framing or structural slab members at the perimeter of the floor assembly shall be insulated vertically for their full depth with insulation equivalent to that required for the *above-grade wall* construction.
2. Insulation applied to the underside of concrete floor slabs shall be permitted an airspace of not more than 1 inch (25 mm) where it turns up and is in contact with the underside of the floor under walls associated with the *building thermal envelope*.

C402.2.4 Slabs-on-grade. Where installed, the perimeter insulation for slab-on-grade shall be placed on the outside of the foundation or on the inside of the foundation wall. For installations complying with Table C402.1.3, the perimeter insulation shall extend downward from the top of the slab for the minimum distance shown in the table or to the top of the footing, whichever is less, or downward to not less than the bottom of the slab and then horizontally to the interior or exterior for the total distance shown in the table. Insulation extending away from the building shall be protected by pavement or by not less than of 10 inches (254 mm) of soil. Where installed, full slab insulation shall be continuous under the entire area of the slab-on-grade floor, except at structural column locations and service penetrations. 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.

Exception: Where the slab-on-grade floor is greater than 24 inches (610 mm) below the finished exterior grade, perimeter insulation is not required.

C402.2.5 Below-grade walls. *Below-grade wall* insulation shall be installed between framing members, be integral to the wall assembly, be continuous on the wall assembly, or be any combination of these insulation methods. For installations complying with Section C401.2.1, insulation shall extend to a depth of not less than 10 feet (3048 mm) below the outside finished ground level or to the level of the lowest floor of the *conditioned space* enclosed by the *below-grade wall*, whichever is less.

C402.2.6 Insulation of radiant heating system panels. *Radiant heating system* panels, and their associated components that are installed in interior or exterior assemblies, shall be insulated to an *R*-value of not less than R-3.5 on all surfaces not facing the space being heated. *Radiant heating system* panels that are installed in the *building thermal envelope* shall be separated from the exterior of the building or unconditioned or exempt spaces by not less than the *R*-value of insulation installed in the opaque assembly in which they are installed or the assembly shall comply with Section C402.1.2.

C402.2.7 Airspaces. Where the R-value of an airspace is used to for compliance in accordance with Section C402.1, the airspace shall be enclosed in a cavity bounded on all sides by building components and constructed to minimize airflow into and out of the enclosed airspace. Airflow shall be deemed minimized where one of the following conditions occur:

1. The enclosed airspace is unventilated.
2. The enclosed airspace is bounded on at least one side by an anchored masonry veneer, constructed in accordance with Chapter 14 of the New York City Building Code and vented by veneer weep holes located only at the bottom of the airspace and spaced not less than 15 inches (381 mm) on center with top of the cavity airspace closed.

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

C402.2.8 Fireplaces. New wood-burning fireplaces shall have tight-fitting flue dampers or doors, and outdoor combustion air as required by the fireplace construction provisions of the New York City Construction Codes, as applicable. 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.

C402.3 Reserved.

C402.4 Roof solar reflectance and thermal emittance. *Low slope* roofs directly above cooled *conditioned spaces* in *Climate Zones* 0 through 3 shall comply with one or more of the options in Table C402.4.

Exceptions: The following roofs and portions of roofs are exempt from the requirements of Table C402.4:

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

TABLE C402.4
MINIMUM ROOF REFLECTANCE AND EMITTANCE OPTIONS[a]

Three-year-aged solar reflectance[b] of 0.55 and 3-year aged thermal emittance[c] of 0.75
Three-year-aged solar reflectance index[d] of 64

a. The use of area-weighted averages to comply with these requirements shall be permitted. Materials lacking 3-year-aged tested values for either solar reflectance or thermal emittance shall be assigned both a 3-year-aged solar reflectance in accordance with Section C402.4.1 and a 3-year-aged thermal emittance of 0.90.
b. Aged solar reflectance tested in accordance with ASTM C1549, ASTM E903 or ASTM E1918 or CRRC-S100.
c. Aged thermal emittance tested in accordance with ASTM C1371 or ASTM E408 or CRRC-S100.
d. Solar reflectance index (SRI) shall be determined in accordance with ASTM E1980 using a convection coefficient of 2.1 Btu/h × ft^2 × °F (12 W/m^2 × K). Calculation of aged SRI shall be based on aged tested values of solar reflectance and thermal emittance.

C402.4.1 Aged roof solar reflectance. Where an aged solar reflectance required by Section C402.4 is not available, it shall be determined in accordance with Equation 4-2.

Equation 4-2 $R_{aged} = [0.2 + 0.7(R_{initial} - 0.2)]$
where:
R_{aged} = The aged solar reflectance.
$R_{initial}$ = The initial solar reflectance determined in accordance with CRRC-S100.

C402.5 Fenestration. *Fenestration* shall comply with Sections C402.5.1 through C402.5.5 and Table C402.5. *Daylight responsive controls* shall comply with this section and Section C405.2.4.

TABLE C402.5
BUILDING ENVELOPE FENESTRATION MAXIMUM *U*-FACTOR AND SHGC REQUIREMENTS[c]

CLIMATE ZONE	4		5	6
	Vertical fenestration			
	U-factor[a]			
	Below 95'[d]	Above 95'[d]		
Metal framing, Fixed fenestration	U-0.30	U-0.34	U-0.34	U-0.34
Metal framing, Operable fenestration	U-0.40	U-0.42	U-0.43	U-0.41
Nonmetal framing, all fenestration	U-0.28	U-0.28	U-0.27	U-0.27
Entrance doors	U-0.63		U-0.63	U-0.63
SHGC[b]				
PF < 0.2	0.33		0.33	0.34
0.2 ≤ PF < 0.5	0.40		0.40	0.41
PF ≥ 0.5	0.53		0.53	0.54
Skylights				
U-factor	U-0.48		U-0.48	U-0.48
SHGC[b]	0.38		0.38	0.38

a. U-factor shall be rated in accordance with NFRC 100. U-factor shall reflect project-specific sizes, and include framing components plus glazing. SHGC shall be rated in accordance with NRFC 200.
b. SHGC shall reflect project-specific sizes, and include framing components plus glazing. SHGC of the center-of-glass shall be an acceptable alternative for determining compliance with the SHGC requirements for the overall fenestration area.
c. Fixed fenestration shall include glazed curtain walls, pre-fabricated storefronts and factory assembled fixed window units.
d. Where a portion of the fenestration frame is installed at or above 95 feet above grade, the unit may meet the requirements for 95 feet and above.

C402.5.1 Maximum area. The vertical *fenestration* area, not including *opaque doors* and opaque spandrel panels, shall be not greater than 30 percent of the gross *above-grade wall* area. The skylight area shall be not greater than 3 percent of the gross roof area.

C402.5.1.1 Increased vertical fenestration area with daylight responsive controls. Not more than 40 percent of the gross *above-grade wall* area shall be vertical *fenestration*, provided that all of the following requirements are met:

1. In buildings not greater than two stories above grade, not less than 50 percent of the *net floor area* is within a primary sidelit *daylight zone* or a toplit *daylight zone*.
2. In buildings three or more stories above grade, not less than 25 percent of the *net floor area* is within a primary sidelit *daylight zone* or a toplit *daylight zone*.
3. *Daylight responsive controls* are installed in *daylight zones.*
4. *Visible transmittance* (VT) of vertical *fenestration* is not less than 1.1 times *solar heat gain coefficient* (SHGC).

Exception: *Fenestration* that is outside the scope of NFRC 200 is not required to comply with Item 4.

C402.5.1.2 Increased skylight area with daylight responsive controls. The skylight area shall be not more than 6 percent of the roof area provided that *daylight responsive controls* are installed in toplit *daylight zones*.

C402.5.2 Minimum skylight fenestration area. *Skylights* shall be provided in enclosed spaces greater than 2,500 square feet (232 m^2) in floor area, directly under a roof with not less than 75 percent of the ceiling area with a ceiling height greater than 15 feet (4572 mm), and used as an office, lobby, atrium, concourse, corridor, storage space, gymnasium/exercise center, convention center, automotive service area, space where manufacturing occurs, nonrefrigerated warehouse, retail store, distribution/sorting area, transportation depot, parking garage , or workshop. The total toplit daylight zone shall be not less than half the floor area and shall comply with one of the following:

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

$$Skylight\ Effective\ Aperture = \frac{0.85 \times Sklylight\ Area \times Sklylight\ VT \times WF}{Toplight\ Zone}$$ **Equation 4-3**

where:

Skylight area = Total *fenestration* area of *skylights*.

Skylight VT = Area-weighted average visible transmittance of *skylights*.

WF = Area-weighted average well factor, where well factor is 0.9 if light well depth is less than 2 feet (610 mm), or 0.7 if light well depth is 2 feet (610 mm) or greater, or 1.0 for Tubular Daylighting Devices with VT_{annual} ratings.

Light well depth = Measure vertically from the underside of the lowest point of the *skylight* glazing to the ceiling plane under the skylight.

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

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

C402.5.2.1 Lighting controls in toplit daylight zones. *Daylight responsive controls* shall be provided in toplit *daylight zones*.

C402.5.2.2 Haze factor. *Skylights* in office, storage, automotive service, manufacturing, nonrefrigerated warehouse, retail store and distribution/sorting area spaces shall have a glazing material or diffuser with a haze factor greater than 90 percent when tested in accordance with ASTM D1003.

Exception: *Skylights* and tubular daylighting devices designed and installed to exclude direct sunlight entering the occupied space by the use of fixed or automated baffles, the geometry of skylight and light well or the use of optical diffuser components.

C402.5.3 Maximum *U*-factor and SHGC. The maximum *U-factor* and *solar heat gain coefficient* (SHGC) for *fenestration* shall be as specified in Table C402.5. The window projection factor shall be determined in accordance with Equation 4-4.

$$PF = A/B \qquad \textbf{Equation 4-4}$$

where:

PF = Projection factor (decimal).

A = Distance measured horizontally from the farthest continuous extremity of any overhang, eave or permanently attached shading device to the vertical surface of the glazing.

B = Distance measured vertically from the bottom of the glazing to the underside of the overhang, eave or permanently attached shading device.

Where different windows or glass doors have different *PF* values, they shall each be evaluated separately.

C402.5.3.1 Increased skylight SHGC. *Skylights* shall be permitted a maximum SHGC of 0.60 where located above *daylight zones* provided with *daylight responsive controls*.

C402.5.3.2 Increased skylight *U*-factor. Where *skylights* are installed above *daylight zones* provided with *daylight responsive controls*, maximum *U-factor* of 0.75 shall be permitted.

C402.5.3.3 Dynamic glazing. Where *dynamic glazing* is intended to satisfy the SHGC and VT requirements of Table C402.5, the ratio of the higher to lower *labeled* SHGC shall be greater than or equal to 2.4, and the *dynamic glazing* shall be 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 not be permitted.

Exception: *Dynamic glazing* is not required to comply with this section where both the lower and higher *labeled* SHGC already comply with the requirements of Table C402.5.

C402.5.3.4 Area-weighted *U*-factor. An area-weighted average combining vertical fixed fenestration and vertical operable fenestration in accordance with Equation 4-4a shall be permitted to demonstrate compliance with the U-factor requirements for those categories in Table C402.5. Entrance door and skylight U-factors shall be permitted to be averaged separately by fenestration product category. All U-factors shall be rated in accordance with NFRC 100.

$$\sum[(U1 * A1) \ldots (Un * An)] \leq (U_{fixed} * A_{fixed} + U_{operable} * A_{operable}) \quad \text{(Equation 4-4a)}$$

where:

U1 = rated U-factor of the 1st vertical fenestration assembly

A1 = area of the 1st vertical fenestration assembly

Un = rated U-factor of the nth vertical fenestration assembly

An = area of the nth vertical fenestration assembly

U_{fixed} = U-factor for vertical fixed fenestration in Table C402.4

A_{fixed} = total area of the vertical fixed fenestration assemblies

$U_{operable}$ = U-factor for vertical operable fenestration in Table C402.4

$A_{operable}$ = total area of the vertical operable fenestration assemblies.

C402.5.4 Daylight zones. *Daylight zones* referenced in Sections C402.5.1.1 through C402.5.3.2 shall comply with Sections C405.2.4.2 and C405.2.4.3, as applicable. *Daylight zones* shall include toplit *daylight zones* and sidelit *daylight* zones.

C402.5.5 Doors. *Opaque doors* shall comply with Table C402.1.2. *Opaque doors* shall be considered as part of the gross area of *above-grade walls* that are part of the *building thermal envelope*. Nonswinging *opaque doors* shall comply with Section C402.5.5.1. Other doors shall comply with the provisions of Section C402.5.3 for *vertical fenestration*.

C402.5.5.1 Nonswinging doors. Nonswinging *opaque doors* that are horizontally hinged sectional doors with a single row of *fenestration* shall have an assembly *U-factor* less than or equal to 0.440, provided that the *fenestration* area is not less than 14 percent and not more than 25 percent of the total door area.

C402.6 Air leakage—building thermal envelope. The *building thermal envelope* shall comply with Sections C402.6.1 through C402.6.7.

C402.6.1 Air barriers. A continuous *air barrier* shall be provided throughout the *building thermal envelope*. The *air barrier* is permitted to be located at any combination of inside, outside or within the *building thermal envelope*. The *air barrier* shall comply with Sections C402.6.1.1 and C402.6.1.2. The *air leakage* performance of the *air barrier* shall be verified in accordance with Section C402.6.2.

C402.6.1.1 Air barrier design and documentation requirements. Design of the continuous *air barrier* shall be documented as follows:

1. Components comprising the continuous *air barrier* and their position within each *building thermal envelope* assembly shall be identified.
2. Joints, interconnections and penetrations of the continuous *air barrier* components shall be detailed.

3. The continuity of the *air barrier* building element assemblies that enclose *conditioned space* or provide a boundary between *conditioned space* and unconditioned space shall be identified.
4. Documentation of the continuous *air barrier* shall detail methods of sealing the *air barrier,* such as wrapping, caulking, gasketing, taping or other *approved* methods at the following locations:
    4.1. Joints around *fenestration* and door frames.
    4.2. Joints between walls and floors; between walls at building corners; between walls and roofs, including para-pets and copings; where *above-grade walls* meet foundations; and at similar intersections.
    4.3. Penetrations or attachments through the continuous *air barrier*.
    4.4. Building assemblies used as *ducts* or plenums.
    4.5. Changes in continuous *air barrier* materials and assemblies.
5. Identify where testing will or will not be performed in accordance with Section C402.6.2. Where testing will not be performed, a plan for field inspections required by Section C402.6.2.3 shall be provided that includes the following:
    5.1. A schedule for periodic inspection.
    5.2. The continuous *air barrier* scope of work.
    5.3. A list of critical inspection items.
    5.4. Inspection documentation requirements.
    5.5. Provisions for corrective actions where needed.

C402.6.1.2 Air barrier construction. The *continuous air barrier* shall be constructed to comply with the following:

1. The *air barrier* shall be continuous for all assemblies that compromise the *building thermal envelope* and across the joints and assemblies.
2. *Air barrier* joints and seams shall be sealed, including sealing transitions in places and changes in materials. The joints and seals shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair its ability to resist positive and negative pressure differentials such as those from wind, stack effect and mechanical ventilation.
3. Penetrations of the *air barrier* shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. Sealing shall allow for expansion, contraction and mechanical vibration. Sealing materials shall be securely installed around the penetration so as not to dislodge, loosen or otherwise impair the penetrations' ability to resist positive and negative pressure. Sealing of concealed fire sprinklers, where required, shall be in a manner that is recommended by the fire sprinkler manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.
4. Recessed lighting fixtures shall comply with Section C402.6.1.2.1. Where similar objects are installed that penetrate the *air barrier*, provisions shall be made to maintain the integrity of the *air barrier*.
5. Electrical and communication boxes shall comply with Section C402.6.1.2.2.

C402.6.1.2.1 Recessed lighting. Recessed luminaires installed in the *building thermal envelope* shall be all of the following:

1. IC-rated.
2. *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 1.57 psf (75 Pa) pressure differential.
3. Sealed with a gasket or caulk between the housing and interior wall or ceiling covering.

C402.6.1.2.2 Electrical and communication boxes. Electrical and communication boxes that penetrate the *air barrier* of the *building thermal envelope*, and that do not comply with Section C402.6.1.2.2.1, shall be caulked, taped, gasketed or otherwise sealed to the *air barrier* element being penetrated. All openings on the concealed portion of the box shall be sealed. Where present, insulation shall rest against all concealed portions of the box.

C402.6.1.2.2.1 Air-sealed boxes. Where air-sealed boxes are installed, they shall be marked in accordance with NEMA OS 4. Air-sealed boxes shall be installed in accordance with the manufacturer's instructions.

C402.6.2 Air leakage compliance. *Air leakage* of the building thermal envelope shall be tested by an approved third party in accordance with Section C402.6.2.1 and C402.6.2.2. The measured air leakage shall not be greater than 0.35 cubic feet per minute per square foot (1.0 L/s x m^2) of the building thermal envelope area at a pressure differential of 0.3 inch water gauge (75 Pa) with the calculated building thermal envelope surface area being the sum of the above- and below-grade building thermal envelope.

C402.6.2.1 Whole building test method and reporting. The whole building thermal envelope shall be tested by an approved third party in accordance with ASTM E779, ASTM E1827, ASTM E3158 or an equivalent approved method. Air leakage shall be measured following a multi-point regression method and then averaged from depressurization and pressurization tests. A report that includes the tested surface area, floor area, air by volume, stories above grade, and air leakage rates shall be submitted to the building official and the building owner.

Exceptions:

1. For buildings greater than 50,000 square feet (4,645 m^2), portions of the building shall be permitted to be tested following the procedures for a guarded test in ASTM E3158 and the measured air leakage shall be area-weighted by the surface areas of the building thermal envelope in each portion. The weighted average tested air leakage shall not be greater than the whole building leakage limit. The following portions of the building shall be tested:
   1.1 The entire building thermal envelope area of stories that have any conditioned spaces directly under a roof.
   1.2 The entire building thermal envelope area of stories that have a building entrance, a floor over unconditioned space, a loading dock, or that are below grade.
   1.3 Representative above-grade portions of the building totaling not less than 25 percent of the wall area enclosing the remaining conditioned space.
2. Hospital, Museums and other occupancies approved by the commissioner may be permitted to satisfy the requirements of this section by performing a pressurization test.

C402.6.2.2 Building thermal envelope design and construction verification criteria. The installation of the continuous air barrier shall be verified by the building official, a registered design professional or approved agency in accordance with the following:

1. A review of the construction documents and other supporting data shall be conducted to assess compliance with the requirements in Section C402.6.1.
2. Inspection of continuous air barrier components and assemblies shall be conducted during construction to verify compliance with the requirements of Section C402.6.2.2.1 and C402.6.2.2.2. The air barrier shall remain accessible for inspection and repair.
3. A final inspection report shall be provided for inspections completed by the registered design professional or approved agency. The inspection report shall be provided to the building owner or owner's authorized agent and the building official. The report shall identify deficiencies found during inspection and details of corrective measures taken.

C402.6.2.2.1 Materials. Materials with an air permeability not greater than 0.004 cfm/ft^2(0.02 L/s × m^2) under a pressure differential of 0.3 inch water gauge (75 Pa) when tested in accordance with ASTM E2178 shall comply with this section. Materials in Items 1 through 16 shall be deemed to comply with this section, provided that joints are sealed and materials are installed as *air barriers* in accordance with the manufacturer's instructions.

1. Plywood with a thickness of not less than 3/8 inch (10 mm).
2. Oriented strand board having a thickness of not less than 3/8 inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than ½ inch (12.7 mm).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than ½ inch (12.7 mm).
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m^3) and having a thickness of not less than 1 ½ inches (38 mm).
6. Open-cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m^3) and having a thickness of not less than 4.5 inches (113 mm).
7. Exterior or interior gypsum board having a thickness of not less than ½ inch (12.7 mm).
8. Cement board having a thickness of not less than ½ inch (12.7 mm).
9. Built-up roofing membrane.
10. Modified bituminous roof membrane.
11. Single-ply roof membrane.
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than 5/8 inch (15.9 mm).
13. Cast-in-place and precast concrete.
14. Fully grouted concrete block masonry.
15. Sheet steel or aluminum.
16. Solid or hollow masonry constructed of clay or shale masonry units.

C402.6.2.3.2 Assemblies. Assemblies of materials and components with an average *air leakage* not greater than 0.04 cfm/ft^2 (0.2 L/s × m^2) under a pressure differential of 0.3 inch of water gauge (75 Pa) where tested in accordance with ASTM E2357, ASTM E1677, ASTM D8052 or ASTM E283 shall comply with this section. Assemblies listed in Items 1 through 3 below shall be deemed to comply, provided that joints are sealed and the requirements of Section C402.6.1.2 are met.

1. Concrete masonry walls coated with either one application of block filler or two applications of a paint or sealer coating.
2. Masonry walls constructed of clay or shale masonry units with a nominal width greater than or equal to 4 inches (102 mm).
3. A Portland cement/sand parge, stucco or plaster not less than ½ inch (12.7 mm) in thickness.

C402.6.3 Air leakage of fenestration and opaque doors. The *air leakage* of *fenestration* and opaque door assemblies shall comply with Table C402.6.3. Testing shall be conducted by an accredited, independent testing laboratory in accordance with applicable reference test standards in Table C402.6.3 and *labeled* by the manufacturer.

Exceptions:

1. Field-fabricated *fenestration* assemblies that are sealed in accordance with Section C402.6.1.
2. *Fenestration* in *buildings* that is tested in accordance with Section C402.6.2 is not required to meet the *air leakage* requirements in Table C402.6.3.

TABLE C402.6.3
MAXIMUM AIR LEAKAGE RATE FOR FENESTRATION ASSEMBLIES

FENESTRATION ASSEMBLY	MAXIMUM RATE (cfm/ft^2)	TEST PROCEDURE
Windows	0.20[a]	AAMA/WDMA/CSA101/I.S.2/A440 or NFRC 400
Sliding doors	0.20[a]	
Swinging doors	0.20[a]	
Skylights—with condensation weepage openings	0.30	
Skylights—all other	0.20[a]	
Curtain walls	0.06	NFRC 400 or ASTM E283 at 1.57 psf (75 Pa)
Storefront glazing	0.06	
Commercial glazed swinging entrance doors	1.00	
Power-operated sliding doors and power operated folding doors	1.00	
Revolving doors	1.00	
Garage doors	0.40	ANSI/DASMA 105, NFRC 400, or ASTM E283 at 1.57 psf (75 Pa)
Rolling doors	1.00	
High-speed doors	1.30	

For SI: 1 cubic foot per minute = 0.47 L/s, 1 square foot = 0.093 m^2.

a. The maximum rate for windows, sliding and swinging doors, and *skylights* is permitted to be 0.3 cfm per square foot of fenestration or door area when tested in accordance with AAMA/WDMA/CSA101/I.S.2/A440 at 6.24 psf (300 Pa).

C402.6.4 Doors and access openings to shafts, chutes, stairways and elevator lobbies. Doors and *access* openings from *conditioned space* to shafts, chutes, stairways and elevator lobbies not within the scope of the *fenestration* assemblies covered by Section C402.6.3 shall be gasketed, weather-stripped or sealed.

Exceptions:

1. Door openings required to comply with the duct and air transfer opening requirements of the *New York City Building Code*.
2. Doors and door openings required to comply with UL 1784 by the *New York City Building Code*.

C402.6.5 Air intakes, exhaust openings, stairways and shafts. Stairway enclosures, elevator shaft vents and other outdoor air intakes and exhaust openings integral to the *building thermal envelope* shall be provided with dampers in accordance with Section C403.7.7.

C402.6.6 Vestibules. *Building entrances* shall be protected with an enclosed vestibule. Doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time. The installation of one or more revolving doors in the *building entrance* shall not eliminate the requirement that a vestibule be provided on any doors adjacent to revolving doors.

Exceptions: Vestibules are not required for the following:

1. Doors not intended to be used by the public, such as doors to mechanical or electrical equipment rooms, or intended solely for employee use.
2. Doors opening directly from a *sleeping unit* or dwelling unit.
3. Doors that open directly from a space less than 3,000 square feet (298 m^2) in area, in buildings less than 75 feet (23 m) in height.
4. Revolving doors.
5. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.
6. Doors that open directly from a space less than 1,000 square feet (92.9 m^2) in area, in buildings 75 feet (22.86 m) and greater in height.

C402.6.7 Loading dock weather seals. Cargo door openings and loading door openings shall be equipped with weather seals that restrict *air leakage* and provide direct contact along the top and sides of vehicles that are parked in the doorway.

C402.7 Thermal bridging documentation and mitigation. Where present, intersections listed in Section C402.7.1 that create thermal bridges shall be detailed in construction documents. Thermal bridges shall be mitigated in accordance with Section C402.7.2.

Exceptions:

1. Assemblies not enclosing conditioned space.
2. Clear field thermal bridges.
3. Thermal bridges in uninsulated assemblies.
4. Linear- and point thermal bridges having a material thermal conductivity less than 3.0 Btu·in/h·ft^2·°F (0.433 W/(m·K)).
5. Alterations except as required under section C503.

C402.7.1 Thermal bridge details. The following intersections shall be evaluated for thermal bridges and be detailed in construction documents:

1. Structural framing and members.
2. Cladding attachment systems
3. Assembly intersections:
    a. Roof edge, parapet
    b. Intermediate floor to wall intersection
    c. Intermediate floor balcony or overhang to opaque wall intersection
    d. Intermediate floor balcony in contact with vertical fenestration
    e. Cladding support
    f. Wall to vertical fenestration intersection

C402.7.2 Thermal bridges in above-grade walls. Thermal bridges in above-grade walls shall comply with this section or an approved design accordance with Section 102.

Exceptions: Blocking, coping, flashing, and other similar materials for attachment of roof coverings.

C402.7.2.1 Balconies and floor decks. Balconies and concrete floor decks shall not penetrate the building thermal envelope. Such assemblies shall be separately supported or shall be supported by structural attachments or elements that minimize thermal bridging through the building thermal envelope.

Exceptions: Balconies and concrete floor decks shall be permitted to penetrate the building thermal envelope where one of the following applies:

1. An area-weighted U-factor is used for above-grade wall compliance which includes a U-factor of 0.8 Btu/h·ft^2·°F (1.38W/m × K) for the area of the above-grade wall penetrated by the concrete floor deck in accordance with Section C402.1.2.1.5, or
2. An approved *thermal break device* with an *R-value* of not less than R-10 insulation material is installed in accordance with the manufacturer's instructions or.
3. An approved design in accordance with Section 102 where the above-grade wall U-factor used for compliance accounts for all balcony and concrete floor deck thermal bridges.

C402.7.2.2 Cladding supports. Linear elements supporting opaque cladding shall be offset from the structure with attachments that allow the continuous insulation, where present, to pass behind the cladding support element except at the point of attachment.

Exceptions:

1. An approved design in accordance with Section 102 where the above-grade wall U-factor used for compliance accounts for the cladding support element thermal bridge.
2. Anchoring for curtain wall and window wall systems where curtain wall and window wall systems comply with Section C402.7.2.4.

C402.7.2.3 Structural beams and columns. Structural steel and concrete beams and columns that project through the building thermal envelope shall be covered with not less than R-5 insulation for not less than 2 feet (610 mm) beyond the interior or exterior surface of an insulation component within the building thermal envelope.

Exception:

1. Where an approved thermal break device is installed in accordance with the manufacturer's instructions.
2. An approved design in accordance with Section102 where the above-grade wall U-factor used to demonstrate compliance accounts for the beam or column thermal bridge.

C402.7.2.4 Vertical fenestration. Vertical fenestration intersections with above-grade walls shall comply with one or more of the following:

1. Where above-grade walls include continuous insulation, the plane of the exterior glazing layer or, for metal frame fenestration, a non-metal thermal break in the frame shall be positioned within 2 inches (610 mm) of the interior or exterior surface of the continuous insulation.
2. Where above-grade walls do not include continuous insulation, the plane of the exterior glazing layer or, for metal frame fenestration, a non-metal thermal break in the frame shall be positioned within the thickness of the integral or cavity insulation.
3. The surface of the rough opening, not covered by the fenestration frame, shall be insulated with insulation of not less than R-3 material or covered with a wood buck that is not less than 1.5 inches (457 mm) thick.

Exceptions:

1. Where an *approved* design in accordance with Section 102 for the above-grade wall U-factor used for compliance accounts for *thermal bridges* at the intersection with the vertical fenestration.
2. Doors

C402.7.2.4.1 vertical fenestration with spandrels. Vertical fenestration with spandrels shall comply with one of the following:

1. For the intersection between vertical fenestration and opaque spandrel in a shared framing system, manufacturer's data for the spandrel U-factor shall account for thermal bridges.
2. Use Default values as listed in C303.1.5

C402.7.2.5 Parapets. Parapets shall comply with one or more of the following as applicable:

1. Where continuous insulation is installed on the exterior side of the above-grade wall and the roof is insulated with insulation entirely above deck, the continuous insulation shall extend up both sides of the parapet not less than 2 feet (610 mm) above the roof covering or to the top of the parapet, whichever is less. Parapets that are an integral part of a fire-resistance rated wall, and the exterior continuous insulation applied to the parapet, shall comply with the fire resistance ratings of the building code.

2. Where continuous insulation is installed on the exterior side of the above-grade wall and the roof insulation is below the roof deck, the continuous insulation shall extend up the exterior side of the parapet to not less than the height of the top surface of the roof assembly.
3. Where continuous insulation is not installed on the exterior side of the above-grade wall and the roof is insulated with insulation entirely above deck, the wall cavity or integral insulation shall extend into the parapet up to the exterior face of the roof insulation or equivalent R-value insulation shall be installed not less than 2 feet (610 mm) horizontally inward on the underside of the roof deck.
4. Where continuous insulation is not installed on the exterior side of the above-grade wall and the roof insulation is below the roof deck, the wall and roof insulation components shall be continuous and adjacent to each other at the roof-ceiling-wall intersection.
5. Where a thermal break device with not less than R-10 insulation material aligned with the above-grade wall and roof insulation is installed in accordance with the manufacturer's instructions.

Exception: An *approved* design in accordance with Section 102 where the *above-grade wall U*-factor used for compliance accounts for the parapet *thermal bridge*.

SECTION ECC C403
BUILDING MECHANICAL SYSTEMS

C403.1 General. Mechanical systems and equipment serving the building heating, cooling, ventilating or refrigerating needs shall comply with one of the following:

1. Section C403.1.1 and Sections C403.2 through C403.17.
2. *Data Centers* shall comply with Section C403.1.1, Section C403.1.2 and Sections C403.6 through C403.17.
3. Section C409.

C403.1.1 Calculation of heating and cooling loads. Design loads associated with heating, ventilating and air conditioning of the *building* shall be determined in accordance with ANSI/ASHRAE/ACCA Standard 183 or by an *approved* equivalent computational procedure using the design parameters specified in Chapter 3. Heating and cooling loads shall be adjusted to account for load reductions that are achieved where energy recovery systems are utilized in the HVAC system in accordance with the ASHRAE HVAC Systems and Equipment Handbook by an *approved* equivalent computational procedure.

C403.1.2 Data centers. *Data center systems* shall comply with Sections 6 and 8 of ASHRAE 90.4.

C403.1.3 Electric-resistance space heating. *Dwelling units* and *sleeping units* using electric-resistance space heating shall limit the total installed heating capacity of all electric-resistance space heating to no more than 2.0 kW per unit. All other *occupiable spaces* within the *building* using electric-resistance space heating shall limit the total installed heating capacity of all electric-resistance space heating to not more than either of the following:

1. 2.5 W per square foot.
2. 5 percent of the total building HVAC system heating capacity or serve less than 5 percent of the *conditioned floor area*, whichever is less.

Exceptions:

1. Portions of *buildings* that require greater electric resistance space heating capacity for health care, research, or commercial and industrial processes subject to approval of the *building* official.
2. Redundant or emergency systems required by regulation in Groups I-2 and I-3 facilities.
3. Temporary electric resistance heating systems with a maximum setpoint of 40°F (4°C) in unfinished and unoccupied tenant spaces.
4. Heat pump supplemental heating that complies with Section C403.4.1.1.
5. Makeup air for commercial kitchen exhaust systems required to be tempered by Section 508 of the *New York City Mechanical Code* is permitted to be heated by electric resistance.

C403.2 System design. Mechanical systems shall be designed to comply with Sections C403.2.1 through C403.2.3. Where elements of a building's mechanical systems are addressed in Sections C403.3 through C403.14, such elements shall comply with the applicable provisions of those sections.

C403.2.1 Zone isolation required. HVAC systems serving *zones* that are over 25,000 square feet (2323 m^2) in floor area or that span more than one floor and are designed to operate or be occupied nonsimultaneously shall be divided into isolation areas. Each isolation area shall be equipped with *isolation devices* and controls configured to automatically shut off the supply of conditioned air and outdoor air to and exhaust air from the isolation area. Each isolation area shall be controlled independently by a device meeting the requirements of Section C403.4.2.2. Central systems and plants shall be provided with controls and devices that will allow system and equipment operation for any length of time while serving only the smallest isolation area served by the system or plant.

Exceptions:

1. Exhaust air and outdoor air connections to isolation areas where the *fan system* to which they connect is not greater than 5,000 cfm (2360 L/s).
2. Exhaust airflow from a single isolation area of less than 10 percent of the design airflow of the exhaust system to which it connects.
3. Isolation areas intended to operate continuously or intended to be inoperative only when all other isolation areas in a *zone* are inoperative.

C403.2.2 Ventilation. *Ventilation*, either natural or mechanical, shall be provided in accordance with Chapter 4 of the *New York City Mechanical Code*. Where mechanical ventilation is provided, the system shall provide the capability to reduce the outdoor air supply to the minimum required by Chapter 4 of *the New York City Mechanical Code*.

C403.2.3 Fault detection and diagnostics. Buildings with a gross *conditioned floor area* of not less than 100,000 square feet (9290 m^2) served by one or more HVAC systems that are controlled by a *direct digital control* (DDC) system shall include a fault detection and diagnostics (FDD) system to monitor the HVAC system's performance and automatically identify faults. The *FDD system* shall:

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

Exception: R-1 and R-2 occupancies.

C403.3 Heating and cooling equipment efficiencies. Heating and cooling equipment installed in mechanical systems shall be sized in accordance with Section C403.3.1 and shall be not less efficient in the use of energy than as specified in Section C403.3.2.

C403.3.1 Equipment sizing. The output capacity of heating and cooling equipment shall be not greater than that of the smallest available equipment size that exceeds the loads calculated in accordance with Section C403.1.1. A single piece of equipment providing both heating and cooling shall satisfy this provision for one function with the capacity for the other function as small as possible, within available equipment options.

Exceptions:

1. Required standby equipment and systems provided with controls and devices that allow such systems or equipment to operate automatically only when the primary equipment is not operating.
2. Multiple units of the same equipment type with combined capacities exceeding the design load and provided with controls that are configured to sequence the operation of each unit based on load.

C403.3.2 HVAC equipment performance requirements. Equipment shall meet the minimum efficiency requirements of Tables C403.3.2(1) through C403.3.2(16) when tested and rated in accordance with the applicable test procedure. Plate-type liquid-to-liquid heat exchangers shall meet the minimum requirements of AHRI 400. The efficiency shall be verified through certification under an *approved* certification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements. Where components, such as indoor or outdoor coils, from different manufacturers are used, calculations and supporting data shall be furnished by the designer that demonstrates that the combined efficiency of the specified components meets the requirements herein.

TABLE C403.3.2(1)
ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS MINIMUM EFFICIENCY REQUIREMENTS[c,d]

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY	HEADING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[e]	TEST PROCEDURE[a, e]
Air conditioners, air cooled	< 65,000 Btu/h[b]	All	Split system, three phase[b]	13.0 SEER before 1/1/2025 13.4 SEER2 after 1/1/2025	AHRI 210/240—2017 before 1/1/2025 AHRI 210/240—2023 after 1/1/2025
			Single-package, three phase[b]	14.0 SEER before 1/1/2025 13.4 SEER2 after 1/1/2025	
Space constrained, air cooled[f]	≤ 30,000 Btu/h[b]	All	Split system, three phase[b]	12.0 SEER before 1/1/2025 12.7 SEER2 after 1/1/2025	AHRI 210/240—2017 before 1/1/2025 AHRI 210/240—2023 after 1/1/2025
			Single package, three phase[b]	12.0 SEER before 1/1/2025 13.9 SEER2 after 1/1/2025	
Small duct, high velocity, air cooled[f]	≤ 65,000 Btu/h[b]	All	Split system, three phase[b]	12.0 SEER before 1/1/2025 13.0 SEER2 after 1/1/2025	AHRI 210/240—2017 before 1/1/2025 AHRI 210/240—2023 after 1/1/2025
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	Split system and single package	14.8 IEER	AHRI 340/360
		All other		14.6 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)		14.2 IEER	
		All other		14.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric resistance (or none)	Split system and single package	13.2 IEER	AHRI 340/360
		All other		13.0 IEER	
	≥ 760,000 Btu/h	Electric resistance (or none)		12.5 IEER	
		All other		12.3 IEER	
Air conditioners, water cooled	< 65,000 Btu/h	All	Split system and single package	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)		12.1 EER 13.9 IEER	AHRI 340/360
		All other		11.9 EER 13.7 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)		12.5 EER 13.9 IEER	
		All other		12.3 EER 13.7 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric resistance (or none)		12.4 EER 13.6 IEER	
		All other		12.2 EER 13.4 IEER	
	≥ 760,000 Btu/h	Electric resistance (or none)		12.2 EER 13.5 IEER	
		All other		12.0 EER 13.3 IEER	

TABLE C403.3.2(1)
ELECTRICALLY OPERATED UNITARYAIR CONDITIONERS AND CONDENSING UNITS MINIMUM EFFICIENCY REQUIREMENTS[c,d]—continued

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY	HEADING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[e]	TEST PROCEDURE[a, e]
Air conditioners, evaporatively cooled	< 65,000 Btu/h[b]	All	Split system and single package	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)		12.1 EER 12.3 IEER	AHRI 340/360
		All other		11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)		12.0 EER 12.2 IEER	
		All other		11.8 EER 12.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric resistance (or none)		11.9 EER 12.1 IEER	
		All other		11.7 EER 11.9 IEER	
	≥ 760,000 Btu/h	Electric resistance (or none)		11.7 EER 11.9 IEER	
		All other		11.5 EER 11.7 IEER	
Condensing units, air cooled	≥ 135,000 Btu/h	—	—	10.5 EER 11.8 IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h	—	—	13.5 EER 14.0 IEER	AHRI 365
Condensing units, evaporatively cooled	≥ 135,000 Btu/h	—	—	13.5 EER 14.0 IEER	AHRI 365

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

a. Chapter 6 contains a list of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. Single-phase, US air-cooled air conditioners less than 65,000 Btu/h are regulated as consumer products by the US Department of Energy Code of Federal Regulations DOE 10 CFR 430. SEER and SEER2 values for single-phase products are set by the US Department of Energy.

c. DOE 10 CFR 430 Subpart B Appendix M1 includes the test procedure updates effective January 1, 2023, documented in AHRI 210/240—2023.

d. This table is a restatement of information found in 10 CFR 430, 10 CFR 431, and ASHRAE 90.1 Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements.

e. Where more than one efficiency requirement, test procedure and date are provided, it pertains to the date of equipment manufacture.

f. As defined in AHRI Standard 210/240

TABLE C403.3.2(2)
ELECTRICALLY OPERATED AIR-COOLED UNITARY HEAT PUMPS
MINIMUM EFFICIENCY REQUIREMENTS[c,d]

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY	HEADING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[e]	TEST PROCEDURE[a]
Air cooled (cooling mode)	< 65,000 Btu/h	All	Split system, three phase[b]	14.0 SEER before 1/1/2025 14.3 SEER2 after 1/1/2025	AHRI 210/240—2017 before 1/1/2025 AHRI 210/240—2023 after 1/1/2025
			Single package, three phase[b]	14.0 SEER before 1/1/2025 13.4 SEER2 after 1/1/2025	
Space constrained, air cooled[f] (cooling mode)	≤ 30,000 Btu/h	All	Split system, three phase[b]	12.0 SEER before 1/1/2025 13.9 SEER2 after 1/1/2025	AHRI 210/240—2017 before 1/1/2025 AHRI 210/240—2023 after 1/1/2025
			Single package, three phase[b]	12.0 SEER before 1/1/2025 13.9 SEER2 after 1/1/2025	
Small duct, high velocity, air cooled[f] (cooling mode)	≤ 65,000 Btu/h	All	Split system, three phase[b]	12.0 SEER before 1/1/2025 14.0 SEER2 after 1/1/2025	AHRI 210/240—2017 before 1/1/2025 AHRI 210/240—2023 after 1/1/2025
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	Split system and single package	14.1 IEER	AHRI 340/360
		All other		13.9 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)		13.5 IEER	
		All other		13.3 IEER	
	≥ 240,000 Btu/h	Electric resistance (or none)		12.5 IEER	
		All other		12.3 IEER	

TABLE C403.3.2(2)
ELECTRICALLY OPERATED AIR-COOLED UNITARY HEAT PUMPS
MINIMUM EFFICIENCY REQUIREMENTS[c,a]-continued

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY	HEADING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[e]	TEST PROCEDURE[a]
Air cooled (heating mode)	< 65,000 Btu/h (cooling capacity)	—	Split system, three phase[b]	8.2 HSPF before 1/1/2025 7.5 HSPF2 after 1/1/2025	AHRI 210/240—2017 before 1/1/2025 AHRI 210/240—2023 after 1/1/2025
			Single package, three phase[b]	8.0 HSPF before 1/1/2025 6.7 HSPF2 after 1/1/2025	
Space constrained, air cooled[f] (heating mode)	≤ 30,000 Btu/h (cooling capacity)	—	Split system, three phase[b]	7.4 HSPF before 1/1/2025 7.0 HSPF2 after 1/1/2025	AHRI 210/240—2017 before 1/1/2025 AHRI 210/240—2023 after 1/1/2025
			Single package, three phase[b]	7.4 HSPF before 1/1/2025 6.7 HSPF2 after 1/1/2025	
Small duct high velocity, air cooled[f] (heating mode)	≤ 65,000 Btu/h	—	Split system, three phase[b]	7.2 HSPF before 1/1/2025 6.9 HSPF2 after 1/1/2025	AHRI 210/240—2017 before 1/1/2025 AHRI 210/240—2023 after 1/1/2025
Air cooled (heating mode)	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb outdoor air	3.40 COP_H	AHRI 340/360
			17°F db/15°F wb outdoor air	2.25 COP_H	
	≥ 135,000 Btu/h and < 240,000 Btu/h (cooling capacity)		47°F db/43°F wb outdoor air	3.30 SOP_H	
			17°F db/15°F wb outdoor air	2.05 COP_H	
	≥ 240,000 Btu/h (cooling capacity)		47°F db/43°F wb outdoor air	3.20 COP_H	
			17°F db/15°F wb outdoor air	2.05 COP_H	

For SI: 1 British thermal unit per hour = 0.2931 W, °C = (°F – 32)/1.8, wb = wet bulb, db = dry bulb.

a. Chapter 6 contains a list of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. Single-phase, US air-cooled heat pumps less than 65,000 Btu/h are regulated as consumer products by the US Department of Energy Code of Federal Regulations DOE 10 CFR 430. SEER, SEER2 and HSPF values for single-phase products are set by the US Department of Energy.

c. DOE 10 CFR 430 Subpart B Appendix M1 includes the test procedure updates effective January 1, 2023, documented in AHRI 210/240—2023.

d. This table is a restatement of information found in 10 CFR 430, 10 CFR 431, and ASHRAE 90.1 Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements.

e. Where more than one efficiency requirement, test procedure and date are provided, it pertains to the date of equipment manufacture.

f. As defined in AHRI Standard 210/240

TABLE C403.3.2(3)
LIQUID-CHILLING PACKAGES
MINIMUM EFFICIENCY REQUIREMENTS[a, b, e]

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	PATH A	PATH B	TEST PROCEDURE[c]
Air cooled	< 150 tons	EER (Btu/Wh)	≥ 10.100 FL	≥ 9.700 FL	AHRI 550/590
			≥ 13.700 IPLV.IP	≥ 15.800 IPLV.IP	
	≥ 150 tons		≥ 10.100 FL	≥ 9.700FL	
			≥ 14.000 IPLV.IP	≥ 16.100 IPLV.IP	
Air cooled without condenser, electrically operated	All capacities	EER (Btu/Wh)	Air-cooled without condenser must be rated with matching condensers and comply with air-cooled chiller efficiency requirements		AHRI 550/590
Liquid-cooled, electrically operated positive displacement	< 75 tons	kW/ton	≤ 0.750 FL	≤ 0.780 FL	AHRI 550/590
			≤ 0.600 IPLV.IP	≤ 0.500 IPLV.IP	
	≥ 75 tons and < 150 tons		≤ 0.720 FL	≤ 0.750 FL	
			≤ 0.560 IPLV.IP	≤ 0.490 IPLV.IP	
	≥ 150 tons and < 300 tons		≤ 0.660 FL	≤ 0.680 FL	
			≤ 0.540 IPLV.IP	≤ 0.440 IPLV.IP	
	≥ 300 tons and < 600 tons		≤ 0.610 FL	≤ 0.625 FL	
			≤ 0.520 IPLV.IP	≤ 0.410 IPLV.IP	
	≥ 600 tons		≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.500 IPLV.IP	≤ 0.380 IPLV.IP	
Liquid-cooled, electrically operated centrifugal	< 150 tons	kW/ton	≤ 0.610 FL	≤ 0.695 FL	AHRI 550/590
			≤ 0.550 IPLV.IP	≤ 0.440 IPLV.IP	
	≥150 tons and <300 tons		≤ 0.610 FL	≤ 0.635 FL	
			≤ 0.550 IPLV.IP	≤ 0.400 IPLV.IP	
	≥ 300 tons and < 400 tons		≤ 0.560 FL	≤ 0.595 FL	
			≤ 0.520 IPLV.IP	≤ 0.390 IPLV.IP	
	≥ 400 tons and < 600 tons		≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.500 IPLV.IP	≤ 0.380 IPLV.IP	
	≥ 600 tons		≤ 0.560 FL	≤ 0.585 FL	
			≤ 0.500 IPLV.IP	≤ 0.380 IPLV.IP	
Air cooled absorption, single effect	All capacities	COP (W/W)	≥ 0.600 FL	NA[d]	AHRI 560
Liquid-cooled absorption, single effect	All capacities	COP (W/W)	≥ 0.700 FL	NA[d]	AHRI 560
Absorption double effect, indirect fired	All capacities	COP (W/W)	≥ 1.000 FL	NA[d]	AHRI 560
			≥ 0.150 IPLV.IP		
Absorption double effect, direct fired	All capacities	COP (W/W)	≥ 1.000 FL	NA[d]	AHRI 560
			≥ 1.000 IPLV		

a. Chapter 6 contains a list of the referenced standards, which include test procedures, including the reference year version of the test procedure.
b. The requirements for centrifugal chillers shall be adjusted for nonstandard rating conditions per Section C403.3.2.1 and are applicable only for the range of conditions listed there. The requirements for air-cooled, water-cooled positive displacement and absorption chillers are at standard rating conditions defined in the reference test procedure.
c. Both the full-load and IPLV.IP requirements must be met or exceeded to comply with this standard. When there is a Path B, compliance can be with either Path A or Path B for any application.
d. NA means the requirements are not applicable for Path B, and only Path A can be used for compliance.
e. FL is the full-load performance requirements, and IPLV.IP is for the part-load performance requirements.

TABLE C403.3.2(4)
ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS, SINGLE-PACKAGE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS—MINIMUM EFFICIENCY REQUIREMENTS[e,f]

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 430 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[d]	TEST PROCEDURE[a]
PTAC (cooling mode) standard size	< 7,000 Btu/h	95°F db/75°F wb outdoor air[c]	11.9 EER	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		14.0 – (0.300 × Cap/1,000) EER[d]	
	> 15,000 Btu/h		9.5 EER	
PTAC (cooling mode) nonstandard size[a]	< 7,000 Btu/h	95°F db/75°F wb outdoor air[c]	9.4 EER	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		10.9 – (0.213 × Cap/1,000) EER[d]	
	> 15,000 Btu/h		7.7 EER	
PTHP (cooling mode) standard size	< 7,000 Btu/h	95°F db/75°F wb outdoor air[c]	11.9 EER	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		14.0 – (0.300 × Cap/1,000) EER[d]	
	> 15,000 Btu/h		9.5 EER	
PTHP (cooling mode) nonstandard size[b]	< 7,000 Btu/h	95°F db/75°F wb outdoor air[c]	9.3 EER	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		10.8 – (0.213 × Cap/1,000) EER[d]	
	> 15,000 Btu/h		7.6 EER	
PTHP (heating mode) standard size	< 7,000 Btu/h	47°F db/43°F wb outdoor air	3.3 COP_H	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		3.7 – (0.052 × Cap/1,000) COP_H[d]	
	> 15,000 Btu/h		2.90 COP_H	
PTHP (heating mode) nonstandard size[b]	< 7,000 Btu/h	47°F db/43°F wb outdoor air	2.7 COP_H	AHRI 310/380
	≥ 7,000 Btu/h and ≤ 15,000 Btu/h		2.9 – (0.026 × Cap/1000) COP_H[d]	
	> 15,000 Btu/h		2.5 COP_H	
SPVAC (cooling mode) single and three phase	< 65,000 Btu/h	95°F db/75°F wb outdoor air[c]	11.0 EER	AHRI 390
	≥ 65,000 Btu/h and ≤ 135,000 Btu/h		10.0 EER	
	≥ 135,000 Btu/h and ≤ 240,000 Btu/h		10.0 EER	
SPVHP (cooling mode)	< 65,000 Btu/h	95°F db/75°F wb outdoor air[c]	11.0 EER	AHRI 390
	≥ 65,000 Btu/h and ≤ 135,000 Btu/h		10.0 EER	
	≥ 135,000 Btu/h and ≤ 240,000 Btu/h		10. 0 EER	
SPVHP (heating mode)	< 65,000 Btu/h	47°F db/43°F wb outdoor air	3.3 COP_H	AHRI 390
	≥ 65,000 Btu/h and ≤ 135,000 Btu/h		3.0 COP_H	
	≥ 135,000 Btu/h and ≤ 240,000 Btu/h		3.0 COP_H	

TABLE C403.3.2(4)
ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGE VERTICAL AIR CONDITIONERS, SINGLE-PACKAGE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONER HEAT PUMPS—MINIMUM EFFICIENCY REQUIREMENTS[e,f]-continued

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 430 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[d]	TEST PROCEDURE[a]
Room air conditioners without reverse cycle with louvered sides for applications outside US[d]	< 6,000 Btu/h	—	11.0 CEER	ANSI/AHAM RAC-1
	≥ 6,000 Btu/h and < 8,000 Btu/h	—	11.0 CEER	
	≥ 8,000 Btu/h and < 14,000 Btu/h	—	10.9 CEER	
	≥ 14,000 Btu/h and < 20,000 Btu/h	—	10.7 CEER	
	≥ 20,000 Btu/h and < 28,000 Btu/h	—	9.4 CEER	
	≥ 28,000 Btu/h	—	9.0 CEER	
Room air conditioners without louvered sides	< 6,000 Btu/h	—	10.0 CEER	ANSI/AHAM RAC-1
	≥ 6,000 Btu/h and < 8,000 Btu/h	—	10.0 CEER	
	≥ 8,000 Btu/h and < 11,000 Btu/h	—	9.6 CEER	
	≥ 11,000 Btu/h and < 14,000 Btu/h	—	9.5 CEER	
	≥ 14,000 Btu/h and < 20,000 Btu/h	—	9.3 CEER	
	≥ 20,000 Btu/h	—	9.4 CEER	
Room air conditioners with reverse cycle, with louvered sides for applications outside US[d]	< 20,000 Btu/h	—	9.8 CEER	ANSI/AHAM RAC-1
	≥ 20,000 Btu/h	—	9.3 CEER	
Room air conditioners with reverse cycle without louvered sides for applications outside US[d]	< 14,000 Btu/h	—	9.3 CEER	ANSI/AHAM RAC-1
	≥ 14,000 Btu/h	—	8.7 CEER	
Room air conditioners, casement only for applications outside US[d]	All	—	9.5 CEER	ANSI/AHAM RAC-1
Room air conditioners, casement slider for applications outside US[d]	All	—	10.4 CEER	ANSI/AHAM RAC-1

For SI: 1 British thermal unit per hour = 0.2931 W, °C = (°F – 32)/1.8, wb = wet bulb, db = dry bulb.

"Cap" = The rated cooling capacity of the project in Btu/h. Where the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. Where the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculations.

a. Chapter 6 contains a list of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. Nonstandard size units must be factory labeled as follows: "MANUFACTURED FOR NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW STANDARD PROJECTS." Nonstandard size efficiencies apply only to units being installed in existing sleeves having an external wall opening of less than 16 inches high or less than 42 inches wide and having a cross-sectional area less than 670 square inches.

c. The cooling-mode wet bulb temperature requirement only applies for units that reject condensate to the condenser coil.

d. Room air conditioners are regulated as consumer products by 10 CFR 430. For US applications of room air conditioners, refer to Informative Appendix F, Table F-3, for the US DOE minimum efficiency requirements for US applications.

e. "Cap" in EER and COPH equations for PTACs and PTHPs means cooling capacity in Btu/h at 95°F outdoor dry-bulb temperature.

f. This table is a restatement of information found in 10 CFR 430, 10 CFR 431, and ASHRAE 90.1 Table 6.8.1-4 Electrically Operated Packaged Terminal Air Conditioners, Pack-aged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single-Package Vertical Heat Pumps, Room Air Conditioners, and Room Air- Conditioner Heat Pumps—Minimum Efficiency Requirements.

TABLE C403.3.2(5)
WARM-AIR FURNACES AND COMBINATION WARM-AIR FURNACES/ AIR-CONDITIONING UNITS, WARM-AIR DUCT FURNACES AND UNIT HEATERS MINIMUM EFFICIENCY REQUIREMENTS[g,h]

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 430 & 431 included here as a convenience to the users of this code)

DESCRIPTION	FUEL	ELECTRIC POWER PHASE	HEATING CAPACITY (INPUT), Btu/h[b]	COMBO-UNIT COOLING CAPACITY, Btu/h	SUBTYPE	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Warm-air furnace	Gas	1	< 225,000	< 65,000	Nonweatherized	80% AFUE	Appendix N[g]
					Weatherized	81% AFUE	Appendix N[g]
Warm-air furnace	Gas	1	< 225,000	≥ 65,000	Nonweatherized	80% AFUE	Appendix N[g]
					Weatherized	81% AFUE or 80% E_t[c]	Appendix N[g]
Warm-air furnace	Gas	3	< 225,000	All	Nonweatherized	80% AFUE	Appendix N[g]
					Weatherized	81% AFUE	Appendix N[g]
Warm-air furnace	Gas	All	≥ 225,000 and ≤ 400,000	All	All	81% E_t[c]	ANSI Z21.47 before 5/8/2023 10 CFR 431.76 after 5/8/2023
Warm-air furnace	Gas	All	> 400,000	All	All	81% E_t[c]	ANSI Z21.47 before 5/8/2023 10 CFR 431.76 after 5/8/2023
Warm-air furnace	Oil	1	< 225,000	< 65,000	Nonweatherized	83% AFUE $P_{W.SB}$≤ 11 W $P_{W.OFF}$≤ 11 W	Appendix N[g]
					Weatherized	78% AFUE	Appendix N[g]
Warm-air furnace	Oil	1	< 225,000	≥ 65,000	Nonweatherized	83% AFUE	Appendix N[g]
					Weatherized	78% AFUE or 80% E_t[d]t	Appendix N[g]
							Section 42 UL 727
Warm-air furnace	Oil	3	<225,000	All	Nonweatherized	83% AFUE	Appendix N[g]
					Weatherized	78% AFUE	Appendix N[g]

TABLE C403.3.2(5)
WARM-AIR FURNACES AND COMBINATION WARM-AIR FURNACES/ AIR-CONDITIONING UNITS, WARM-AIR DUCT FURNACES AND UNIT HEATERS MINIMUM EFFICIENCY REQUIREMENTS[g,h]-continued

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 430 & 431 included here as a convenience to the users of this code)

DESCRIPTION	FUEL	ELECTRIC POWER PHASE	HEATING CAPACITY (INPUT), Btu/h[b]	COMBO-UNIT COOLING CAPACITY, Btu/h	SUBTYPE	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Warm-air furnace	Oil	All	≥ 225,000	All	All	82% E_t[d]	Section 42 UL 727 before 5/8/2023 10 CFR 431.76 after 5/8/2023
Warm-air furnace	Electric	1	< 225,000	< 65,000	All	78% AFUE $P_{W.SB}$≤ 10 W $P_{W.OFF}$≤ 10 W	Appendix N[g]
Warm-air furnace	Electric	1	< 225,000	≥ 65,000	All	96% AFUE	Appendix N[g]
Warm-air furnace	Electric	3	< 225,000	All	All	96% AFUE	Appendix N[g]
Warm-air duct furnaces	Gas	All	All	All	All	80% E_c[d]	ANSI Z83.8
Warm-air unit heaters	Gas	All	All	All	All	80% E_c[d, e]	ANSI Z83.8
Warm-air unit heaters	Oil	All	All	All	All	80% E_c[d, e]	Section 40 UL 731

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

a. Chapter 6 contains a list of the referenced standards, which include test procedures, including the reference year version of the test procedure. For this table, the following applies:
- Appendix N = 10 CFR 430 Appendix N
- ANSI Z21.47 = Section 2.39, Thermal Efficiency, ANSI Z21.47
- ANSI Z83.3 = Section 2.10, Efficiency, ANSI Z83.3
- UL 727 = Section 42, Combustion, UL 727
- UL 731 = Section 40, Combustion, UL 731

b. Compliance of multiple firing rate units shall be at the maximum firing rate.

c. Et = thermal efficiency. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

d. Ec = combustion efficiency (100 percent less flue losses). See test procedure for detailed discussion.

e. Units must also include an interrupted or intermittent ignition device (IID) and have either power venting or an automatic flue damper.

f. Reserved.

g. 10 CFR 430 is limited to-single phase equipment that is not contained within the same cabinet with a central air conditioner whose rated cooling capacity is above 65,000 Btu/h but for the test and rating procedures are not impacted for three-phase and can be used for AFUE ratings for ASHRAE/IES Standard 90.1 three-phase products and single-phase products with a cooling capacity greater than 65,000 Btu/h.

h. This table is a restatement of information found in 10 CFR 430,.10 CFR 431, and ASHRAE 90.1 Table 6.8.1-5 Warm-Air Furnace and Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces, and Unit Heaters--Minimum Efficiency Requirements.

TABLE C403.3.2(6)
GAS- AND OIL-FIRED BOILERS
MINIMUM EFFICIENCY REQUIREMENTS[i]

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 430 & 431 included here as a convenience to the users of this code)

EQUIPMENT TYPE[b]	SUBCATEGORY OR RATING CONDITION	SIZE CATEGORY (INPUT)	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Boilers, hot water	Gas fired	< 300,000 Btu/h[g, h]	84% AFUE	DOE 10 CFR 430 Appendix N
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e]	80% E_t[d]	DOE 10 CFR 431.86
		> 2,500,000 Btu/h[b] and ≤ 10,000,000 Btu/h[b]	82% E_c[c]	
		> 10,000,000 Btu/h[b]	82% E_c[c]	
	Oil fired[f]	< 300,000 Btu/h[g, h]	86% AFUE	DOE 10 CFR 430 Appendix N
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e]	82% E_t[d]	DOE 10 CFR 431.86
		> 2,500,000 Btu/h[b] and ≤ 10,000,000 Btu/h[b]	84% E_c[c]	
		> 10,000,000 Btu/h[b]	84% E_c[c]	
Boilers, steam	Gas fired	< 300,000 Btu/h[g]	82% AFUE	DOE 10 CFR 430 Appendix N
	Gas fired—all, except natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e]	79% E_t[d]	DOE 10 CFR 431.86
		> 2,500,000 Btu/h[b] and ≤ 10,000,000 Btu/h[b]	79% E_t[d]	
		> 10,000,000 Btu/h[b]	79% E_t[d]	
	Gas fired—natural draft	≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e]	79% E_t[d]	
		> 2,500,000 Btu/h[b]	79% E_t[d]	
	Oil fired[f]	< 300,000 Btu/h[g]	85% AFUE	DOE 10 CFR 430 Appendix N
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[e]	81% E_t[d]	DOE 10 CFR 431.86
		> 2,500,000 Btu/h[b] and ≤ 10,000,000 Btu/h[b]	81% E_t[d]	
		> 10,000,000 Btu/h[b]	81% E_t[d]	

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

a. Chapter 6 contains a list of the referenced standards, which include test procedures, including the reference year version of the test procedure.
b. These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.
c. Ec = Combustion efficiency (100 percent less flue losses).
d. Et = Thermal efficiency.
e. Maximum capacity—minimum and maximum ratings as provided for and allowed by the unit's controls.
f. Includes oil-fired (residual).
g. Boilers shall not be equipped with a constant burning pilot light.
h. A boiler not equipped with a tankless domestic water-heating coil shall be equipped with an automatic means for adjusting the temperature of the water such that an incremental change in inferred heat load produces a corresponding incremental change in the temperature of the water supplied.
i. High-capacity space-heating gas boiler systems with system input capacities of not less than 1,000,000 Btu/h (293 kW) and not greater than 10,000,000 Btu/h (2931 kW) in new buildings shall comply with Sections C403.10.1 and C403.10.2.

TABLE C403.3.2(7)
PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT
MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	TOTAL SYSTEM HEAT-REJECTION CAPACITY AT RATED CONDITIONS	SUBCATEGORY OR RATING CONDITION[h]	PERFORMANCE REQUIRED[a, b, c, f, g]	TEST PROCEDURE[d,e]
Propeller or axial fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥ 40.2 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Centrifugal fan open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering wb	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Propeller or axial fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥ 16.1 gpm/hp	CTI ATC-105S and CTI STD-201 RS
Centrifugal fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering wb	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201 RS
Propeller or axial fan dry coolers (air-cooled fluid coolers)	All	115°F entering water 105°F leaving water 95°F entering wb	≥ 4.5 gpm/hp	CTI ATC-105DS
Propeller or axial fan evaporative condensers	All	R-448A test fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb	≥ 160,000 Btu/h × hp	CTI ATC-106
Propeller or axial fan evaporative condensers	All	Ammonia test fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb	≥ 134,000 Btu/h × hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	R-448A test fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb	≥ 137,000 Btu/h × hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	Ammonia test fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb	≥ 110,000 Btu/h × hp	CTI ATC-106
Air-cooled condensers	All	125°F condensing temperature 190°F entering gas temperature 15°F subcooling 95°F entering db	≥ 176,000 Btu/h × hp	AHRI 460

For SI: °C = (°F – 32)/1.8, L/s × kW = (gpm/hp)/(11.83), COP = (Btu/h × hp)/(2550.7), db = dry bulb temperature, wb = wet bulb temperature.

a. For purposes of this table, open-circuit cooling tower performance is defined as the water-flow rating of the tower at the thermal rating condition listed in the table divided by the fan motor nameplate power.

b. For purposes of this table, closed-circuit cooling tower performance is defined as the process water-flow rating of the tower at the thermal rating condition listed in the table divided by the sum of the fan motor nameplate power and the integral spray pump motor nameplate power.

c. For purposes of this table, dry-cooler performance is defined as the process water-flow rating of the unit at the thermal rating condition listed in the table divided by the total fan motor nameplate power of the unit, and air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the total fan motor nameplate power of the unit.

d. ASHRAE 90.1 Section 13 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

e. The efficiencies and test procedures for both open- and closed-circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of separate wet and dry heat exchange sections. The certification requirements do not apply to field-erected cooling towers.

f. All cooling towers shall comply with the minimum efficiency listed in the table for that specific type of tower with the capacity effect of any project-specific accessories and/or options included in the capacity of the cooling tower.

g. For purposes of this table, evaporative condenser performance is defined as the heat rejected at the specified rating condition in the table, divided by the sum of the fan motor nameplate power and the integral spray pump nameplate power.

h. Requirements for evaporative condensers are listed with ammonia R-717 and R-448A as test fluids in the table. Evaporative condensers intended for use with halocarbon refrigerants other than R-448A must meet the minimum efficiency requirements listed with R-448A as the test fluid. For ammonia, the condensing temperature is defined as the saturation temperature corresponding to the refrigerant pressure at the condenser entrance. For R-448A, which is a zeotropic refrigerant, the condensing temperature is defined as the arithmetic average of the dew point and the bubble point temperatures corresponding to the refrigerant pressure at the condenser entrance.

TABLE C403.3.2(8)
ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR CONDITIONERS MINIMUM EFFICIENCY REQUIREMENTS

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
VRF air conditioners, air cooled	< 65,000 Btu/h three-phase	All	VRF multisplit system	13.0 SEER before 1/1/2025 13.4 SEER2 after 1/1/2025	AHRI 210/240-2023
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	VRF multisplit system	11.2 EER before 1/1/202415.5 IEER after 1/1/2024	AHRI 1230-2021
		All other		11.0 EER before 1/1/2024 15.5 IEER after 1/1/2024	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric resistance (or none)	VRF multisplit system	11.0 EER before 1/1/2024 14.9 IEER after 1/1/2024	
		All other		10.8 EER before 1/1/2024 14.9 IEER after 1/1/2024	
	≥ 240,000 Btu/h	Electric resistance (or none)	VRF multisplit system	10.0 EER before 1/1/2024 13.9 IEER after 1/1/2024	
		All other		9.8 EER before 1/1/2024 13.9 IEER after 1/1/2024	

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

a. Chapter 6 contains a list of the referenced standards, which include test procedures, including the reference year version of the test procedure.

TABLE C403.3.2(9)
ELECTRICALLY OPERATED
VARIABLE-REFRIGERANT-FLOW AND APPLIED HEAT PUMPS
MINIMUM EFFICIENCY REQUIREMENTS

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
VRF air cooled (cooling mode)	< 65,000 Btu/h three-phase	All	VRF multisplit system	SEER =13.0 Before 1/1/2025 SEER2 = 13.4 On or after 1/1/2025	AHRI 210/240-2023
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric resistance (or none)	VRF multisplit system	11.0 EER Before 1/1/2024 14.6 IEER On or after 1/1/2024	AHRI 1230-2021
			VRF multisplit system with heat recovery	10.8 EER Before 1/1/2024 14.4 IEER On or after 1/1/2024	
	≥ 135,000 Btu/h and < 240,000 Btu/h		VRF multisplit system	10.6 EER Before 1/1/2024 14.4 IEER On or after 1/1/2024	
			VRF multisplit system with heat recovery	10.4 EER Before 1/1/2024 13.7 IEER On or after 1/1/2024	
	≥ 240,000 Btu/h and ≤ 760,000 Btu/h after 1/1/2024 ≥ 240,000 Btu/h after 1/1/2024		VRF multisplit system	9.5 EER Before 1/1/2024 12.7 IEER On or after 1/1/2024	
			VRF multisplit system with heat recovery	9.3 EER Before 1/1/2024 12.5 IEER On or after 1/1/2024	

TABLE C403.3.2(9)
ELECTRICALLY OPERATED
VARIABLE-REFRIGERANT-FLOW AND APPLIED HEAT PUMPS
MINIMUM EFFICIENCY REQUIREMENTS-continued

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
VRF water source (cooling mode)	< 17,000 Btu/h	All	VRF multisplit systems 86°F entering water	12.0 EER before 1/1/2024	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h		VRF multisplit systems with heat recovery 86°F entering water	11.8 EER before 1/1/2024	
			VRF multisplit systems 86°F entering water	12.0 EER before 1/1/2024	
	< 65,000 Btu/h		VRF multisplit systems 86°F entering water	16.0 IEER after 1/1/2024	AHRI 1230-2021 before 11/29/2024 AHRI 600-2023 after 11/29/2024
			VRF multisplit systems with heat recovery 86°F entering water	15.8 IEER after 1/1/2024	
	≥ 65,000 Btu/h and < 135,000 Btu/h		VRF multisplit system 86°F entering water	12.0 EER before 1/1/2024 16.0 IEER after 1/1/2024	
			VRF multisplit system with heat recovery 86°F entering water	11.8 EER before 1/1/2024 15.8 IEER after 1/1/2024	
	≥ 135,000 Btu/h and < 240,000 Btu/h		VRF multisplit system 86°F entering water	10.0 EER before 1/1/2024 14.0 IEER after 1/1/2024	
			VRF multisplit system with heat recovery 86°F entering water	9.8 EER before 1/1/2024 13.8 IEER after 1/1/2024	
	≥ 240,000 Btu/h		VRF multisplit system 86°F entering water	10.0 EER before 1/1/2024 12.0 IEER after 1/1/2024	
			VRF multisplit system with heat recovery 86°F entering water	9.8 EER before 1/1/2024 11.8 IEER after 1/1/2024	
VRF groundwater source (cooling mode)	< 135,000 Btu/h	All	VRF multisplit system 59°F entering water	16.2 EER	AHRI 1230-2014 Addendum 1 before 1/1/2024 AHRI 1230-2021 on or after 1/1/2024
			VRF multisplit system with heat recovery 59°F entering water	16.0 EER	
	≥ 135,000 Btu/h		VRF multisplit system 59°F entering water	13.8 EER	
			VRF multisplit system with heat recovery 59°F entering water	13.6 EER	

TABLE C403.3.2(9)
ELECTRICALLY OPERATED
VARIABLE-REFRIGERANT-FLOW AND APPLIED HEAT PUMPS
MINIMUM EFFICIENCY REQUIREMENTS-continued

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
VRF ground source (cooling mode)	< 135,000 Btu/h	All	VRF multisplit system 77°F entering water	13.4 EER	AHRI 1230-2014 Addendum 1 before 1/1/2024 AHRI 1230-2021 on or after 1/1/2024
			VRF multisplit system with heat recovery 77°F entering water	13.2 EER	
	≥ 135,000 Btu/h		VRF multisplit system 77°F entering water	11.0 EER	
			VRF multisplit system with heat recovery 77°F entering water	10.8 EER	
VRF air cooled (heating mode)	< 65,000 Btu/h (cooling capacity) three-phase for applications in the US and single- and three-phase for applications outside the US		VRF multisplit system	HSPF2 = 7.5	AHRI 210/240-2023
	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)		VRF multisplit system 47°F db/43°F wb outdoor air	3.3 COP_H	AHRI 1230-2014 Addendum 1 before 1/1/2024 AHRI 1230-2021 on or after 1/1/2024
			17°F db/15°F wb outdoor air	2.25 COP_H	
	≥ 135,000 Btu/h (cooling capacity)		VRF multisplit system 47°F db/43°F wb outdoor air	3.2 COP_H	
			17°F db/15°F wb outdoor air	2.05 COP_H	
VRF water source (heating mode)	< 65,000 Btu/h (cooling capacity)		VRF multisplit system 68°F entering water	4.3 COP_H	
	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)		VRF multisplit system 68°F entering water	4.3 COP_H	
	≥ 135,000 Btu/h and < 240,000 Btu/h (cooling capacity)		VRF multisplit system 68°F entering water	4.0 COP_H	
	≥ 240,000 Btu/h (cooling capacity)		VRF multisplit system 68°F entering water	3.9 COP_H	
VRF groundwater source (heating mode)	< 135,000 Btu/h (cooling capacity)		VRF multisplit system 50°F entering water	3.6 COP_H	
	≥ 135,000 Btu/h (cooling capacity)		VRF multisplit system 50°F entering water	3.3 COP_H	
VRF ground source (heating mode)	< 135,000 Btu/h (cooling capacity)		VRF multisplit system 32°F entering water	3.1 COP_H	
	≥ 135,000 Btu/h (cooling capacity)		VRF multisplit system 32°F entering water	2.8 COP_H	

For SI: °C = (°F – 32)/1.8, 1 British thermal unit per hour = 0.2931 W, db = dry bulb temperature, wb = wet bulb temperature.

a. Chapter 6 contains a list of the referenced standards, which include test procedures, including the reference year version of the test procedure.

TABLE C403.3.2(10)
FLOOR-MOUNTED AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS
MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMUM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/dew point)	TEST PROCEDURE
Air cooled	Downflow	< 80,000 Btu/h	2.70	85°F/52°F (Class 2)	AHRI 1360
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.58		
		≥ 295,000 Btu/h	2.36		
	Upflow—ducted	< 80,000 Btu/h	2.67		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.55		
		≥ 295,000 Btu/h	2.33		
	Upflow—nonducted	< 65,000 Btu/h	2.16	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.04		
		≥ 240,000 Btu/h	1.89		
	Horizontal	< 65,000 Btu/h	2.65	95°F/52°F (Class 3)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.55		
		≥ 240,000 Btu/h	2.47		
Air cooled with fluid economizer	Downflow	< 80,000 Btu/h	2.70	85°F/52°F (Class 1)	AHRI 1360
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.58		
		≥ 295,000 Btu/h	2.36		
	Upflow—ducted	< 80,000 Btu/h	2.67		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.55		
		≥ 295,000 Btu/h	2.33		
	Upflow—nonducted	< 65,000 Btu/h	2.09	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	1.99		
		≥ 240,000 Btu/h	1.81		
	Horizontal	< 65,000 Btu/h	2.65	95°F/52°F (Class 3)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.55		
		≥ 240,000 Btu/h	2.47		
Water cooled	Downflow	< 80,000 Btu/h	2.82	85°F/52°F (Class 1)	AHRI 1360
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.73		
		≥ 295,000 Btu/h	2.67		
	Upflow—ducted	< 80,000 Btu/h	2.79		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.70		
		≥ 295,000 Btu/h	2.64		
	Upflow—nonducted	< 65,000 Btu/h	2.43	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.32		
		≥ 240,000 Btu/h	2.20		
	Horizontal	< 65,000 Btu/h	2.79	95°F/52°F (Class 3)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.68		
		≥ 240,000 Btu/h	2.60		

TABLE C403.3.2(10)
FLOOR-MOUNTED AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS
MINIMUM EFFICIENCY REQUIREMENTS-continued

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMUM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/dew point)	TEST PROCEDURE
Water cooled with fluid economizer	Downflow	< 80,000 Btu/h	2.77	85°F/52°F (Class 1)	AHRI 1360
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.68		
		≥ 295,000 Btu/h	2.61		
	Upflow—ducted	< 80,000 Btu/h	2.74		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.65		
		≥ 295,000 Btu/h	2.58		
	Upflow-nonducted	< 65,000 Btu/h	2.35	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.24		
		≥ 240,000 Btu/h	2.12		
	Horizontal	< 65,000 Btu/h	2.71	95°F/52°F (Class 3)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.60		
		≥ 240,000 Btu/h	2.54		
Glycol cooled	Downflow	< 80,000 Btu/h	2.56	85°F/52°F (Class 1)	AHRI 1360
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.24		
		≥ 295,000 Btu/h	2.21		
	Upflow—ducted	< 80,000 Btu/h	2.53		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.21		
		≥ 295,000 Btu/h	2.18		
	Upflow-nonducted	< 65,000 Btu/h	2.08	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	1.90		
		≥ 240,000 Btu/h	1.81		
	Horizontal	< 65,000 Btu/h	2.48	95°F/52°F (Class 3)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.18		
		≥ 240,000 Btu/h	2.18		
Glycol cooled with fluid economizer	Downflow	< 80,000 Btu/h	2.51	85°F/52°F (Class 1)	AHRI 1360
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.19		
		≥ 295,000 Btu/h	2.15		
	Upflow—ducted	< 80,000 Btu/h	2.48		
		≥ 80,000 Btu/h and < 295,000 Btu/h	2.16		
		≥ 295,000 Btu/h	2.12		
	Upflow-nonducted	< 65,000 Btu/h	2.00	75°F/52°F (Class 1)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	1.82		
		≥ 240,000 Btu/h	1.73		
	Horizontal	< 65,000 Btu/h	2.44	95°F/52°F (Class 3)	
		≥ 65,000 Btu/h and < 240,000 Btu/h	2.10		
		≥ 240,000 Btu/h	2.10		

For SI: 1 British thermal unit per hour = 0.2931 W, °C = (°F – 32)/1.8, COP = (Btu/h × hp)/(2,550.7).

TABLE C403.3.2(11)
VAPOR-COMPRESSION-BASED INDOOR POOL DEHUMIDIFIERS
MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE
Single package indoor (with or without economizer)	Rating conditions: A or C	3.5 MRE	AHRI 910
Single package indoor water-cooled (with or without economizer)	Rating conditions: A, B or C	3.5 MRE	
Single package indoor air-cooled (with or without economizer)	Rating conditions: A, B or C	3.5 MRE	
Split system indoor air-cooled (with or without economizer)	Rating conditions: A, B or C	3.5 MRE	

TABLE C403.3.2(12)
ELECTRICALLY OPERATED DX-DOAS UNITS, SINGLE-PACKAGE AND REMOTE CONDENSER, WITHOUT ENERGY RECOVERY
MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (dehumidification mode)	—	3.8 ISMRE2	AHRI 920
Air-source heat pumps (dehumidification mode)	—	3.8 ISMRE2	AHRI 920
Water cooled (dehumidification mode)	Cooling tower condenser water	4.7 ISMRE2	AHRI 920
Air-source heat pump (heating mode)	—	2.05 ISCOP2	AHRI 920
Water-source heat pump (dehumidification mode)	Ground source, closed and open loop[b]	4.6 ISMRE2	AHRI 920
	Water source	3.8 ISMRE2	
Water-source heat pump (heating mode)	Ground source, closed and open loop[b]	2.13 ISCOP2	AHRI 920
	Water source	2.13 ISCOP2	

a. Chapter 6 contains a list of the referenced standards, which include test procedures, including the reference year version of the test procedure.
b. Open-loop systems are rated using closed-loop test conditions.

TABLE C403.3.2(13)
ELECTRICALLY OPERATED DX-DOAS UNITS, SINGLE-PACKAGE AND REMOTE CONDENSER, WITH ENERGY RECOVERY
MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (dehumidification mode)	—	5.0 ISMRE2	AHRI 920
Air-source heat pumps (dehumidification mode)	—	5.0 ISMRE2	AHRI 920
Water cooled (dehumidification mode)	Cooling tower condenser water	5.1 ISMRE2	AHRI 920
Air-source heat pump (heating mode)	—	3.2 ISCOP2	AHRI 920
Water-source heat pump (dehumidification mode)	Ground source, closed and open loop[b]	5.0 ISMRE2	AHRI 920
	Water source	4.6 ISMRE2	
Water-source heat pump (heating mode)	Ground source, closed and open loop[b]	3.5 ISCOP2	AHRI 920
	Water source	4.04 ISCOP2	

a. Chapter 6 contains a list of the referenced standards, which include test procedures, including the reference year version of the test procedure.
b. Open-loop systems are rated using closed-loop test conditions.

TABLE C403.3.2(14)
ELECTRICALLY OPERATED WATER-SOURCE HEAT PUMPS
MINIMUM EFFICIENCY REQUIREMENTS[b]

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Water-to-air, water loop (cooling mode)	< 17,000 Btu/h	All	86°F entering water	12.2 EER	ISO 13256-1
	≥ 17,000 Btu/h and < 65,000 Btu/h			13.0 EER	
	≥ 65,000 Btu/h and < 135,000 Btu/h			13.0 EER	
Water-to-air, ground water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	18.0 EER	ISO 13256-1
Brine-to-air, ground loop (cooling mode)	< 135,000 Btu/h	All	77°F entering water	14.1 EER	ISO 13256-1
Water-to-water, water loop (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	ISO 13256-2
Water-to-water, ground water (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.3 EER	ISO 13256-2
Brine-to-water, ground loop (cooling mode)	< 135,000 Btu/h	All	77°F entering water	12.1 EER	ISO 13256-2
Water-to-water, water loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	4.3 COP_H	ISO 13256-1
Water-to-air, ground water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.7 COP_H	ISO 13256-1
Brine-to-air, ground loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering water	3.2 COP_H	ISO 13256-1
Water-to-water, water loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	3.7 COP_H	ISO 13256-1
Water-to-water, ground water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water	3.1 COP_H	ISO 13256-2
Brine-to-water, ground loop (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering water	2.5 COP_H	ISO 13256-2

For SI: 1 British thermal unit per hour = 0.2931 W, °C = (°F – 32)/1.8.

a. Chapter 6 contains a list of the referenced standards, which include test procedures, including the reference year version of the test procedure.

b. Single-phase, US air-cooled heat pumps < 65,000 Btu/h are regulated as consumer products by 10 CFR 430. SEER, SEER2, HPSF and HPSF2 values for single-phase products are set by the US DOE. Informative Note: See ASHRAE 90.1 Informative Appendix F for the US DOE minimum.

TABLE C403.3.2(15)
HEAT-PUMP AND HEAT RECOVERY CHILLER PACKAGES
MINIMUM EFFICIENCY REQUIREMENTS[g, o]

HEATING OPERATION EFFICIENCY[b, e, j]																	
EQUIPMENT TYPE	SIZE CATEGORY REFRIGERATING CAPACITY[n], ton_R	COOLING OPERATION EFFICIENCY[a, d, e, j] AIR-SOURCE EER (FL/IPLV), Btu/W × h LIQUID- SOURCE POWER INPUT PER CAPACITY (FL/IPLV), kW/ton_R		HEATING SOURCE CONDITIONS (leaving liquid) OR OUTDOOR AIR TEMPERATURE (db/wb), °F	HEAT-PUMP HEATING FULL-LOAD HEATING EFFICIENCY (COP_H)[f, h, k] W/W				SIMULTANEOUS COOLING AND HEATING FULL-LOAD EFFICIENCY (COP_{SHC})[b, i], W/W				HEAT RECOVERY HEATING FULL-LOAD EFFICIENCY (COP_{HR})[c, i] W/W				Test Procedure[a]
					Entering/Leaving Heating Liquid Temperature				Entering/Leaving Heating Liquid Temperature				Entering/Leaving Heating Liquid Temperature				
					Low	Medium	High	Boost	Low	Medium	High	Boost	Low	Medium	Hot-Water 1	Hot-Water 2	
		Path A	Path B		95°F/ 105°F	105°F/ 120°F	120°F/ 140°F	120°F/ 140°F	95°F/ 105°F	105°F/ 120°F	120°F/ 140°F	120°F/ 140°F	95°F/ 105°F	105°F/ 120°F	90°F/ 140°F	120°F/ 140°F	
Air source	< 150.0	≥ 9.595 FL ≥ 13.02 IPLV.IP	≥ 9.215 FL ≥ 15.01 IPLV.IP	47 db 43 wb[l]	≥ 3.290	≥ 2.770	≥ 2.310	NA	NA	NA	NA	NA	NA	NA	NA	NA	AHRI 550/590
				17 db 15 wb[l]	≥ 2.029	≥ 1.775	≥ 1.483	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	≥ 150.0	≥ 9.595 FL ≥ 13.30 IPLV.IP	≥ 9.215 FL ≥ 15.30 IPLV.IP	47 db 43 wb[l]	≥ 3.290	≥ 2.770	≥ 2.310	NA	NA	NA	NA	NA	NA	NA	NA	NA	
				17 db 15 wb[l]	≥ 2.029	≥ 1.775	≥ 1.483	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Liquid-source electrically operated positive displacement	≥ 11.25[p] and < 150	≤ 0.7895 FL ≤ 0.6316 IPLV.IP	≤ 0.8211 FL ≤ 0.5263 IPLV.IP	44[m]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	≥ 8.330	≥ 6.410	≥ 4.862	≥ 4.420	AHRI 550/590
				65[m]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	NA	NA	NA	NA	
	≥ 150 and < 300	≤ 0.7579 FL ≤ 0.5895 IPLV.IP	≤ 0.7895 FL ≤ 0.5158 IPLV.IP	44[m]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	≥ 8.330	≥ 6.410	≥ 4.862	≥ 4.420	
				65[m]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	NA	NA	NA	NA	
	≥ 300 and < 400	≤ 0.6947 FL ≤ 0.5684 IPLV.IP	≤ 0.7158 FL ≤ 0.4632 IPLV.IP	44[m]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	≥ 8.330	≥ 6.410	≥ 4.862	≥ 4.420	
				65[m]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	NA	NA	NA	NA	
	≥ 400 and < 600	≤ 0.6421 FL ≤ 0.5474 IPLV.IP	≤ 0.6579 FL ≤ 0.4316 IPLV.IP	44[m]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	≥ 8.900	≥ 6.980	≥ 5.500	≥ 5.000	
				65[m]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	NA	NA	NA	NA	
	≥ 600	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6158 FL ≤ 0.4000 IPLV.IP	44[m]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	≥ 8.900	≥ 6.980	≥ 5.500	≥ 5.000	
				65[m]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	NA	NA	NA	NA	
Liquid-source electrically operated centrifugal	≥11.25[p] and <150	≤ 0.6421 FL ≤ 0.5789 IPLV.IP	≤ 0.7316 FL ≤ 0.4632 IPLV.IP	44[m]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	≥ 8.330	≥ 6.410	≥ 4.862	≥ 4.420	AHRI 550/590
				65[m]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	NA	NA	NA	NA	
	≥ 150 and < 300	≤ 0.6190 FL ≤ 0.5748 IPLV.IP	≤ 0.6684 FL ≤ 0.4211 IPLV.IP	44[m]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	≥ 8.330	≥ 6.410	≥ 4.862	≥ 4.420	
				65[m]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	NA	NA	NA	NA	
	≥ 300 and < 400	≤ 0.5895 FL ≤ 0.5526 IPLV.IP	≤ 0.6263 FL ≤ 0.4105 IPLV.IP	44[m]	≥ 4.640	≥ 3.680	≥ 2.680	NA	≥ 8.330	≥ 6.410	≥ 4.420	NA	≥ 8.330	≥ 6.410	≥ 4.862	≥ 4.420	
				65[m]	NA	NA	NA	≥ 3.550	NA	NA	NA	≥ 6.150	NA	NA	NA	NA	
	≥ 400 and < 600	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6158 FL ≤ 0.4000 IPLV.IP	44[m]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	≥ 8.900	≥ 6.980	≥ 5.500	≥ 5.000	
				65[m]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	NA	NA	NA	NA	
	≥ 60	≤ 0.5895 FL ≤ 0.5263 IPLV.IP	≤ 0.6158 FL ≤ 0.4000 IPLV.IP	44[m]	≥ 4.930	≥ 3.960	≥ 2.970	NA	≥ 8.900	≥ 6.980	≥ 5.000	NA	≥ 8.900	≥ 6.980	≥ 5.500	≥ 5.000	
				65[m]	NA	NA	NA	≥ 3.900	NA	NA	NA	≥ 6.850	NA	NA	NA	NA	

TABLE C403.3.2(15)
HEAT-PUMP AND HEAT RECOVERY CHILLER PACKAGES
MINIMUM EFFICIENCY REQUIREMENTS[g, o] (Continued)

For SI: °C = (°F – 32)/1.8.
NA = Not Applicable.

a. Cooling rating conditions are standard rating conditions defined in AHRI 550/590 (I-P), Table 4, except for liquid-cooled centrifugal chilling packages which can adjust cooling efficiency for nonstandard rating conditions using Kadj procedure in accordance with ASHRAE 90.1 Section 6.4.1.2.1.
b. Heating full-load rating conditions are at standard rating conditions defined in AHRI 550/590 (I-P), Table 4; includes the impact of defrost for air source heating ratings.
c. For liquid-source heat recovery chilling packages that have capabilities for heat rejection to a heat recovery condenser and a tower condenser the COPHR applies to operation at full load with 100 percent heat recovery (no tower rejection). Units that only have capabilities for partial heat recovery shall meet the requirements of ASHRAE 90.1 Table 6.8.1-3.
d. For cooling operation, compliance with both the FL and IPLV is required, but only compliance with Path A or Path B cooling efficiency is required.
e. For units that operate in both cooling and heating, compliance with both the cooling and heating efficiency is required.
f. For applications where the chilling package is installed to operate only in heating, compliance only with the heating performance COPH is required at only one of the heating AHRI 550/590 (I-P) standard rating conditions of Low, Medium, High, or Boost. Compliance with cooling performance is not required.
g. For air source heat pumps, compliance with both the 47°F and 17°F heating source outdoor air temperature (OAT) rating efficiency is required for heating.
h. For heat-pump chilling package applications where the cooling capacity is not being used for conditioning, compliance with the heating performance COPH is only required at one of the four heating AHRI 550/590 standard ratings condi- tions of Low, Medium, High, or Boost. Compliance with the cooling performance is required as defined in notes a and d, except as noted in note f.
i. For simultaneous cooling and heating chillers applications where there is simultaneous cooling and heating, compliance with the simultaneous cooling performance heat recovery COPSHC is only required at one of the four simultaneous cooling and heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, High, or Boost. Compliance with the cooling only performance is required as defined in notes a and d.
j. For heat recovery heating chilling package applications where there is simultaneous cooling and heating, compliance with the heating performance heat recovery COPHR is only required at one of the four heating AHRI 550/590 (I-P) stan- dard ratings conditions of Low, Medium, Hot-Water 1, or Hot-Water 2. Compliance with the cooling only performance is required as defined in notes a and d.
k. Chilling packages employing a freeze-protection liquid in accordance with ASHRAE 90.1 Section 6.4.1.2.2 shall be tested or rated with water for the purpose of compliance with the requirements of this table.
l. Outdoor air entering dry-bulb (db) temperature and wet-bulb (wb) temperature.
m. Source-leaving liquid temperature.
   - The cooling evaporator liquid flow rate used for the heating rating for a reverse cycle air-to-water heat pump shall be the flow rate determined during the full-load cooling rating.
   - The cooling evaporator liquid flow rate for the simultaneous cooling and heating and heat recovery liquid cooled chilling packages rating shall be the liquid flow rates from the cooling operation full load rating.
   - For heating-only fluid-to-fluid chiller packages, the evaporator flow rate obtained with an entering liquid temperature of 54°F and a leaving liquid temperature of 44°F shall be used.
n. The size category is the full-load net refrigerating cooling mode capacity, which is the capacity of the evaporator available for cooling of the thermal load external to the chilling package.
o. A heat recovery condenser at its maximum load point must remove enough heat from the refrigerant to cool the refrigerant to remove all superheat energy and begin condensation of the refrigerant. A heat recovery system where only the superheat is reduced is not covered by ASHRAE 90.1 Table 6.8.1-16 and is considered a desuperheater, and the chiller package must comply with ASHRAE 90.1 Table 6.8.1-3.
p. Water-to-water heat pumps with a capacity less than 135,000 Btu/h are covered by ASHRAE 90.1 Table 6.8.1-15.

TABLE C403.3.2(16)
CEILING-MOUNTED COMPUTER ROOM AIR CONDITIONERS
MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMUM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/dew point)	TEST PROCEDURE[a]
Air cooled with free air discharge condenser	Ducted	< 29,000 Btu/h	2.05	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.02		
		≥ 65,000 Btu/h	1.92		
	Nonducted	< 29,000 Btu/h	2.08		
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.05		
		≥ 65,000 Btu/h	1.94		
Air cooled with free air discharge condenser with fluid economizer	Ducted	< 29,000 Btu/h	2.01	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.97		
		≥ 65,000 Btu/h	1.87		
	Nonducted	< 29,000 Btu/h	2.04		
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.00		
		≥ 65,000 Btu/h	1.89		
Air cooled with ducted condenser	Ducted	< 29,000 Btu/h	1.86	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.83		
		≥ 65,000 Btu/h	1.73		
	Nonducted	< 29,000 Btu/h	1.89		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.86		
		≥ 65,000 Btu/h	1.75		
Air cooled with fluid economizer and ducted condenser	Ducted	< 29,000 Btu/h	1.82	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.78		
		≥ 65,000 Btu/h	1.68		
	Nonducted	< 29,000 Btu/h	1.85		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.81		
		≥ 65,000 Btu/h	1.70		
Water cooled	Ducted	< 29,000 Btu/h	2.38	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.28		
		≥ 65,000 Btu/h	2.18		
	Nonducted	< 29,000 Btu/h	2.41		
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.31		
		≥ 65,000 Btu/h	2.20		

TABLE C403.3.2(16)
CEILING-MOUNTED COMPUTER ROOM AIR CONDITIONERS
MINIMUM EFFICIENCY REQUIREMENTS—continued

EQUIPMENT TYPE	STANDARD MODEL	NET SENSIBLE COOLING CAPACITY	MINIMUM NET SENSIBLE COP	RATING CONDITIONS RETURN AIR (dry bulb/dew point)	TEST PROCEDURE[a]
Water cooled with fluid economizer	Ducted	< 29,000 Btu/h	2.33	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.23		
		≥ 65,000 Btu/h	2.13		
	Nonducted	< 29,000 Btu/h	2.36		
		≥ 29,000 Btu/h and < 65,000 Btu/h	2.26		
		≥ 65,000 Btu/h	2.16		
Glycol cooled	Ducted	< 29,000 Btu/h	1.97	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.93		
		≥ 65,000 Btu/h	1.78		
	Nonducted	< 29,000 Btu/h	2.00		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.98		
		≥ 65,000 Btu/h	1.81		
Glycol cooled with fluid economizer	Ducted	< 29,000 Btu/h	1.92	75°F/52°F (Class 1)	AHRI 1360
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.88		
		≥ 65,000 Btu/h	1.73		
	Nonducted	< 29,000 Btu/h	1.95		
		≥ 29,000 Btu/h and < 65,000 Btu/h	1.93		
		≥ 65,000 Btu/h	1.76		

For SI: 1 British thermal unit per hour = 0.2931 W, °C = (°F – 32)/1.8, COP = (Btu/h × hp)/(2,550.7).

a. Chapter 6 contains a list of the referenced standards, which include test procedures, including the reference year version of the test procedure.

C403.3.2.1 Water-cooled centrifugal chilling packages. Equipment not designed for operation at AHRI Standard 550/590 test conditions of 44.00°F leaving and 54.00°F entering chilled-fluid temperatures, and with 85.00°F entering and 94.30°F leav- ing condenser-fluid temperatures, shall have maximum full-load kW/ton (FL) and part-load rating requirements adjusted using the following equations:

Equation 4-5 $FL_{adj} = FL/K_{adj}$

Equation 4-6 $PLV_{adj} = IPLV.IP/K_{adj}$

where:

K_{adj} = $A \times B$

FL = Full-load kW/ton value from Table C403.3.2(3).

FL_{adj} = Maximum full-load kW/ton rating, adjusted for nonstandard conditions.

$IPLV.IP$ = $IPLV.IP$ value from Table C403.3.2(3).

PLV_{adj} = Maximum $NPLV$ rating, adjusted for nonstandard conditions.

A = $0.00000014592\times(LIFT)^4-0.0000346496\times(LIFT)^3+0.00314196\times(LIFT)^2-0.147199\times(LIFT)+3.93073$

B = $0.0015 \times L_{vg}E_{vap} + 0.934$

$LIFT$ = $L_{vg}Cond - L_{vg}E_{vap}$

$L_{vg}Cond$ = Full-load condenser leaving fluid temperature (°F).

$L_{vg}E_{vap}$ = Full-load evaporator leaving temperature (°F).

The FL_{adj} and PLV_{adj} values are applicable only for centrifugal chillers meeting all of the following full-load design ranges:

- $36.00°F \le L_{vg}E_{vap} \le 60.00°F$
- $L_{vg}Cond \le 115.00°F$
- $20.00°F \le LIFT \le 80.00°F$

Manufacturers shall calculate the FL_{adj} and PLV_{adj} before determining whether to label the chiller. Centrifugal chillers designed to operate outside of these ranges are not covered by this code.

C403.3.2.2 Positive displacement (air- and water-cooled) chilling packages. Equipment with a leaving fluid temperature higher than 32°F (0°C) and water-cooled positive displacement chilling packages with a condenser leaving fluid temperature below 115°F (46°C) shall meet the requirements of the tables in Section C403.3.2 when tested or certified with water at standard rating conditions, in accordance with the referenced test procedure.

C403.3.3 Hot gas bypass limitation. Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited as indicated in Table C403.3.3, as limited by Section C403.5.1.

TABLE C403.3.3
MAXIMUM HOT GAS BYPASS CAPACITY

RATED CAPACITY	MAXIMUM HOT GAS BYPASS CAPACITY (% of total capacity)
≤ 240,000 Btu/h	50
> 240,000 Btu/h	25

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

C403.3.4 Boilers. Boiler systems shall comply with the following:

1. Combustion air positive shutoff shall be provided on all newly installed boiler systems that meet one or more of the following conditions:
   1.1. The total input capacity is not less than 2,500,000 Btu/h (733 kW) and one or more of the boilers are designed to operate with a nonpositive vent static pressure.
   1.2. Any stack serving the *boiler system* is connected to two or more boilers with a total combined input capacity of not less than 2,500,000 Btu/h (733 kW).
2. Newly installed boilers or boiler systems with a combustion air fan motor *nameplate horsepower* rating of 10 horsepower (7.46 kW) or more shall comply with one of the following:
   2.1. The fan motor shall be variable speed.
   2.2. The fan motor shall include controls that modulate fan airflow as a function of the load to a speed 50 percent or less of design air volume.

C403.3.4.1 Boiler oxygen concentration controls. Newly installed boilers with an input capacity of 5,000,000 Btu/h (1465 kW) and steady state full-load less than 90 percent shall maintain stack-gas oxygen concentrations not greater than the values specified in Table C403.3.4.1. Combustion air volume shall be controlled with respect to measured flue gas oxygen concentration. The use of a common gas and combustion air control linkage or jack shaft is not permitted.

TABLE C403.3.4.1
BOILER OXYGEN CONCENTRATIONS

BOILER APPLICATION	MAXIMUM STACK-GAS OXYGEN CONCENTRATION[a]
Commercial boilers or where ≤ 10% of the boiler system capacity is used for process applications at design conditions	5%
Process boilers	3%

a. Concentration levels measured by volume on a dry basis over firing rates of 20 to 100 percent.
Exception: These concentration limits do not apply where 50 percent or more of the boiler system capacity serves Group R-2 occupancies.

C403.3.4.2 Boiler turndown. *Boiler systems* with design input of greater than 1,000,000 Btu/h (293 kW) shall comply with the turndown ratio specified in Table C403.3.4.2.

The system turndown requirement shall be met through the use of multiple single-input boilers, one or more *modulating boilers* or a combination of single-input and *modulating boilers*.

TABLE C403.3.4.2
BOILER TURNDOWN

BOILER SYSTEM DESIGN INPUT (Btu/h)	MINIMUM TURNDOWN RATIO
≥ 1,000,000 and ≤ 5,000,000	3 to 1
> 5,000,000 and ≤ 10,000,000	4 to 1
> 10,000,000	5 to 1

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

C403.3.5 Buildings with high efficiency space heating gas boiler systems. New buildings where space heating is served by one or more gas hot water boilers with a minimum thermal efficiency (Et) of 90 percent when rated in accordance with the test procedures in Table C403.3.2(6) shall comply with this section, unless otherwise approved by the authority having jurisdiction. The hot water distribution system shall be designed so that the coils and other heat exchangers are selected such that at outdoor design conditions, the hot water return temperature entering the boilers is 120°F (49°C) or less when the boiler is firing.

C403.4 Heating and cooling system controls. Heating and cooling system shall be provided with controls in accordance with Sections C403.4.1 through C403.4.8.

C403.4.1 Thermostatic controls. The supply of heating and cooling energy to each *zone* shall be controlled by individual thermostatic controls capable of responding to temperature within the *zone*. Where humidification or dehumidification or both is provided, not fewer than one humidity control device shall be provided for each humidity control system.

Exception: Independent perimeter systems that are designed to offset only *building thermal envelope* heat losses, gains or both serving one or more perimeter *zones* also served by an interior system provided that both of the following conditions are met:

1. The perimeter system includes not fewer than one thermostatic control *zone* for each *building* exposure having *exterior walls* facing only one orientation (within ±45 degrees) (0.8 rad) for more than 50 contiguous feet (15240 mm).
2. The perimeter system heating and cooling supply is controlled by *thermostats* located within the *zones* served by the system.

C403.4.1.1 Heat pump supplementary heat. Heat pumps having supplementary electric resistance, fuel gas, or liquid fuel heating systems shall have controls that limit supplemental heat operation to only those times when one of the following applies:

1. The vapor compression cycle cannot provide necessary heating energy to satisfy the thermostat setting where controls are installed such that supplementary heat shall operate only when the outdoor air temperature is less than 17°F and supplemental heat capacity does not exceed 25 percent of total the design load.
2. The heat pump is operating in defrost mode.
3. The vapor compression cycle malfunctions.
4. The thermostat malfunctions.

C403.4.1.2 Deadband. Where used to control both heating and cooling, *zone* thermostatic controls shall:

1. Have separate setpoints for heating and cooling, each individually adjustable.
2. Be capable of and initially configured to provide a temperature range or deadband between the two setpoints of not less than 5°F (3°C) within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.
3. Have a minimum deadband of not less than 1°F (0.56°C) when setpoints are adjusted.

Exceptions:

1. *Thermostats* requiring *manual* changeover between heating and cooling modes.
2. Occupancies or applications where applicable codes or accreditation standards requiring precision in indoor temperature control shall be permitted to be initially configured to not less than 1°F (0.56°C) deadband.

C403.4.1.3 Setpoint adjustment and display. Where thermostatic control setpoints are capable of being adjusted by occupants or HVAC system operators, the adjustment shall be independent for the heating setpoint and the cooling setpoint; when one setpoint is changed, the other shall not change except as needed to maintain the minimum deadband required by Section C403.4.1.2. For thermostatic controls that display setpoints, both the heating and cooling setpoints shall be displayed simultaneously, or the setpoint of the currently active mode (heating or cooling) shall be displayed along with an indication of that mode.

C403.4.1.4 Setpoint overlap restriction. Where heating and cooling to a *zone* are controlled by separate *zone* thermostatic controls located within the *zone*, mechanical or software means shall be provided to prevent the heating setpoint from exceeding the cooling setpoint, minus the deadband required by Section C403.4.1.2.

C403.4.1.5 Heated or cooled vestibules. The heating system for heated vestibules and air curtains with integral heating shall be provided with controls configured to shut off the source of heating when the outdoor air temperature is greater than 45°F (7°C). Vestibule heating and cooling systems shall be controlled by a *thermostat* located in the vestibule configured to limit heating to a temperature not greater than 60°F (16°C) and cooling to a temperature not less than 85°F (29°C).

Exception: Control of heating or cooling provided by *site-recovered energy* or transfer air that would otherwise be exhausted.

C403.4.1.6 Hot water boiler outdoor temperature setback control. Hot water boilers that supply heat to the *building* through one- or two-pipe heating systems shall have an outdoor setback control that lowers the boiler water temperature based on the outdoor temperature.

C403.4.2 Off-hour controls. Each *zone* shall be provided with thermostatic setback controls that are controlled by either an *automatic* time clock or programmable control system.

Exceptions:

1. *Zones* that will be operated continuously.
2. *Zones* with a full HVAC load demand not exceeding 6,800 Btu/h (2 kW) and having a *manual* shutoff switch located with *ready access*.

C403.4.2.1 Thermostatic setback. Thermostatic setback controls shall be configured to set back or temporarily operate the system to maintain *zone* temperatures down to 55°F (13°C) or up to 85°F (29°C).

C403.4.2.2 Automatic setback and shutdown. *Automatic* time clock or programmable controls shall be capable of starting and stopping the system for seven different daily schedules per week and retaining their programming and time setting during a loss of power for not fewer than 10 hours. Additionally, the controls shall have a *manual* override that allows temporary operation of the system for up to 2 hours; a manually operated timer configured to operate the system for up to 2 hours; or an occupancy sensor.

C403.4.2.3 Optimum start and stop. Optimum start and stop controls shall be provided for each heating and cooling system with direct control of individual *zones*. The optimum start controls shall be configured to automatically adjust the daily start time of the heating and cooling system in order to bring each space to the desired occupied temperature immediately prior to scheduled occupancy. The optimum stop controls shall be configured to reduce the heating and cooling system's heating temperature setpoint and increase the cooling temperature setpoint by not less than 2°F (1.11°C) before scheduled unoccupied periods based on the thermal lag and acceptable drift in space temperature that is within comfort limits.

Exception: *Dwelling units* and *sleeping units* are not required to have optimum start controls.

C403.4.3 Hydronic systems controls. The heating of fluids that have been previously mechanically cooled and the cooling of fluids that have been previously mechanically heated shall be limited in accordance with Sections C403.4.3.1 through C403.4.3.3. Hydronic heating systems comprised of multiple-packaged boilers and designed to deliver conditioned water or steam into a common distribution system shall include *automatic* controls configured to sequence operation of the boilers. Hydronic heating systems composed of a single boiler and greater than 500,000 Btu/h (146.5 kW) input design capacity shall include either a multi- staged or modulating burner.

C403.4.3.1 Three-pipe system. Hydronic systems that use a common return system for both hot water and chilled water are prohibited.

C403.4.3.2 Two-pipe changeover system. Systems that use a common distribution system to supply both heated and chilled water shall be designed to allow a deadband between changeover from one mode to the other of not less than 15°F (8.3°C) outside air temperatures; be designed to and provided with controls that will allow operation in one mode for not less than 4 hours before changing over to the other mode; and be provided with controls that allow heating and cooling supply tempera- tures at the changeover point to be not more than 30°F (16.7°C) apart.

C403.4.3.3 Hydronic (water loop) heat pump systems. Hydronic heat pump systems shall comply with Sections C403.4.3.3.1 through C403.4.3.3.3.

C403.4.3.3.1 Temperature deadband. Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are configured to provide a heat pump water supply temperature deadband of not less than 20°F (11°C) between initiation of heat rejection and heat addition by the central devices.

Exception: Where a system loop temperature optimization controller is installed and can determine the most efficient operating temperature based on real-time conditions of demand and capacity, deadbands of less than 20°F (11°C) shall be permitted.

C403.4.3.3.2 Heat rejection. The following shall apply to hydronic water loop heat pump systems:

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

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

C403.4.3.3.3 Two-position valve. Each hydronic heat pump on the hydronic system having a total pump system power exceeding 10 hp (7.5 kW) shall have a two-position *automatic* valve interlocked to shut off the water flow when the compressor is off.

C403.4.4 Part-load controls. Hydronic systems greater than or equal to 300,000 Btu/h (87.9 kW) in design output capacity supplying heated or chilled water to comfort conditioning systems shall include controls that are configured to do all of the following:

1. Automatically reset the supply-water temperatures in response to varying building heating and cooling demand using coil valve position, zone-return water temperature, building-return water temperature or outside air temperature. The temperature shall be reset by not less than 25 percent of the design supply-to-return water temperature difference.
2. Automatically vary fluid flow for hydronic systems with a combined pump motor capacity of 2 hp (1.5 kW) or larger with three or more control valves or other devices by reducing the system design flow rate by not less than 50 percent or the maximum reduction allowed by the equipment manufacturer for proper operation of equipment by valves that modu- late or step open and close, or pumps that modulate or turn on and off as a function of load.
3. Automatically vary pump flow on heating-water systems, chilled-water systems and heat rejection loops serving water- cooled unitary air conditioners as follows:
    3.1. Where pumps operate continuously or operate based on a time schedule, pumps with nominal output motor power of 2 hp or more shall have a variable speed drive.
    3.2. Where pumps have *automatic direct digital control* configured to operate pumps only when zone heating or cooling is required, a variable speed drive shall be provided for pumps with motors having the same or greater nominal output power indicated in Table C403.4.4 based on the *climate zone* and system served.
4. Where a variable speed drive is required by Item 3 of this section, pump motor power input shall be not more than 30 percent of design wattage at 50 percent of the design water flow. Pump flow shall be controlled to maintain one control valve nearly wide open or to satisfy the minimum differential pressure.

Exceptions:

1. Supply-water temperature reset is not required for chilled-water systems supplied by off-site district chilled water or chilled water from ice storage systems.
2. Variable pump flow is not required on dedicated coil circulation pumps where needed for freeze protection.
3. Variable pump flow is not required on dedicated equipment circulation pumps where configured in primary/secondary design to provide the minimum flow requirements of the equipment manufacturer for proper operation of equipment.
4. Variable speed drives are not required on heating water pumps where more than 50 percent of annual heat is generated by an electric boiler.

TABLE C403.4.4
VARIABLE SPEED DRIVE (VSD) REQUIREMENTS FOR DEMAND-CONTROLLED PUMPS

CHILLED WATER AND HEAT REJECTION LOOP PUMPS IN THESE CLIMATE ZONES	HEATING WATER PUMPS IN THESE CLIMATE ZONES	VSD REQUIRED FOR MOTORS WITH RATED OUTPUT OF:
4,	—	≥ 5 hp
5, 6	5, 6	≥ 7.5 hp
—	4	≥ 10 hp

For SI: 1 hp = 0.746 kW.

C403.4.5 Pump isolation. Chilled water plants including more than one chiller shall be capable of and configured to reduce flow automatically through the chiller plant when a chiller is shut down. Chillers piped in series for the purpose of increased temperature differential shall be considered as one chiller.

Boiler systems including more than one boiler shall be capable of and configured to reduce flow automatically through the *boiler system* when a boiler is shut down.

C403.4.6 Demand responsive controls. Electric heating and cooling systems shall be provided with demand responsive controls capable of executing the following actions in response to a demand response signal:

1. Automatically increase 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) while maintaining the minimum room temperature requirements of the New York City Building Code.

Where a *demand response signal* is not present, the heating and cooling system controls shall be capable of performing all other functions. Where thermostats are controlled by direct digital control including, but not limited to, an energy management system, the system shall be capable of *demand responsive control* and capable of adjusting all thermal set-points to comply. The *demand responsive controls* shall comply with either Section C403.4.6.1 or Section C403.4.6.2.

Exceptions:

1. Group I occupancies in accordance with the *New York City Building Code.*
2. Group H occupancies in accordance with the *New York City Building Code*.
3. Controls serving *data center* systems.
4. Occupancies or uses requiring precision in indoor temperature control as *approved* by the *building official.*
5. Buildings that comply with load management measure G02 in Section C406.3.3.

C403.4.6.1 Air conditioners and heat pumps with two or more stages of control and cooling capacity of less than 65,000 Btu/h. Thermostats for Air conditioners and heat pumps with two or more stages of control and a cooling capacity less than 65,000 Btu/h (19 kW) shall be provided with a demand responsive control that complies with the communication and performance requirements of AHRI 1380.

C403.4.6.2 All other heating and cooling systems. Thermostats for heating and cooling 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.

C403.4.7 Heating and cooling system controls for operable openings to the outdoors. All doors from a conditioned space to the outdoors and all other individual operable openings from a conditioned space to the outdoors that are larger than 40 square feet (3.7 m2) when fully open shall have automatic controls interlocked with the heating and cooling system. The controls shall be configured to do the following within 5 minutes of opening:

1. Disable mechanical heating to the zone or reset the space heating temperature setpoint to 55°F (12.5°C) or less.
2. Disable mechanical cooling to the zone or reset the space cooling temperature setpoint to 90°F (32°C) or more. Mechanical cooling can remain enabled if the outdoor air temperature is below the space temperature.

Exceptions:

1. Building entrances with automatic closing devices.
2. Emergency exits with an automatic alarm that sounds when open.
3. Operable openings and doors serving enclosed spaces without a thermostat or heating or cooling temperature sensor.
4. Separately zoned areas associated with the preparation of food that contain appliances that contribute to the heat- ing or cooling loads of a restaurant or similar type of occupancy.
5. Warehouses that utilize operable openings for the function of the occupancy, where approved by the building official.
6. The first entrance doors where located in the exterior wall and are part of a vestibule system.
7. Operable openings into spaces served by radiant heating and cooling systems.
8. Alterations where walls would have to be opened solely for the purpose of meeting this requirement and where approved.
9. Doors served by air curtains meeting the requirements of Section C402.6.6.

C403.4.8 Humidification and dehumidification controls. Humidification and dehumidification controls shall be in accordance with this section.

C403.4.8.1 Dehumidification. Humidistatic controls shall not use mechanical cooling to reduce the humidity below the lower of a dew point of 55°F (13°C) or relative humidity of 60 percent in the coldest zone served by the system. Lower humidity shall be permitted where mechanical cooling is being used for temperature control.

Exceptions:

1. Where approved, systems serving zones where specific humidity levels are required, such as museums and hospitals, and where humidistatic controls are capable of and configured to maintain a dead band of at least 10 percent relative humidity where no active humidification or dehumidification takes place.
2. Systems serving zones where humidity levels are required to be maintained with precision of not more than ±5 percent relative humidity to comply with applicable codes or accreditation standards or as approved by the authority having jurisdiction.

C403.4.8.2 Humidification. Humidistatic controls shall not use fossil fuels or electricity to produce relative humidity above 30 percent in the warmest zone served by the system.

Exceptions:

1. Where approved, systems serving zones where specific humidity levels are required, such as museums and hospitals, and where humidistatic controls are capable of and configured to maintain a deadband of at least 10 percent relative humidity where no active humidification or dehumidification takes place.

2. Systems serving zones where humidity levels are required to be maintained with precision of not more than ±5 percent relative humidity to comply with applicable codes or accreditation standards or as approved by the authority having jurisdiction.

C403.4.8.3 Control interlock. Where a zone is served by a system or systems with both humidification and dehumidification capability, means such as limit switches, mechanical stops, or for DDC systems, software programming, shall be provided capable of and configured to prevent simultaneous operation of humidification and dehumidification equipment.

Exception: Systems serving zones where humidity levels are required to be maintained with precision of not more than ±5 percent relative humidity to comply with applicable codes or accreditation standards or as approved by the authority having jurisdiction.

C403.5 Economizers. Economizers shall comply with Sections C403.5.1 through C403.5.5.

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

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

The total supply capacity of all fan cooling units not provided with economizers shall not exceed 20 percent of the total supply capacity of all fan cooling units in the building or 300,000 Btu/h (88 kW), whichever is greater.

3. Individual fan systems with cooling capacity greater than or equal to 270,000 Btu/h (79.1 kW) in buildings having a Group R occupancy.

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

Exceptions: Economizers are not required for the following systems:

1. Where more than 25 percent of the air designed to be supplied by the system is to spaces that are designed to be humidified above 35°F (1.7°C) dew-point temperature to satisfy process needs.
2. Systems expected to operate less than 20 hours per week.
3. Systems serving supermarket areas with open refrigerated casework.

4. Where the cooling efficiency is greater than or equal to the efficiency requirements in Table C403.5(2).
5. Systems that include a heat recovery system in accordance with Section C403.11.5.
6. Direct-expansion fan coils or unitary equipment with a capacity less than 54,000 Btu/h (15.8 kW) and multiple stages of compressor capacity installed with a dedicated outdoor air system.

TABLE C403.5(1)
MINIMUM CHILLED-WATER SYSTEM COOLING CAPACITY FOR DETERMINING ECONOMIZER COOLING REQUIREMENTS

CLIMATE ZONES (COOLING)	TOTAL CHILLED-WATER SYSTEM CAPACITY LESS CAPACITY OF COOLING UNITS WITH AIR ECONOMIZERS	
	Local Water-Cooled Chilled-Water Systems	Air-Cooled Chilled-Water Systems or District Chilled-Water Systems
4	720,000 Btu/h	940,000 Btu/h
5, 6	1,320,000 Btu/h	1,720,000 Btu/h

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

TABLE C403.5(2)
EQUIPMENT EFFICIENCY PERFORMANCE EXCEPTION FOR ECONOMIZERS

CLIMATE ZONES	COOLING EQUIPMENT PERFORMANCE IMPROVEMENT (EER OR IPLV)
4	20% efficiency improvement

C403.5.1 Integrated economizer control. Economizer systems shall be integrated with the mechanical cooling system and be configured to provide partial cooling even where additional mechanical cooling is required to provide the remainder of the cooling load. Controls shall not be capable of creating a false load in the mechanical cooling systems by limiting or disabling the economizer or any other means, such as hot gas bypass, except at the lowest stage of mechanical cooling.

Units that include an air economizer shall comply with the following:

1. Unit controls shall have the mechanical cooling capacity control interlocked with the air economizer controls such that the outdoor air damper is at the 100 percent open position when mechanical cooling is on and the outdoor air damper does not begin to close to prevent coil freezing due to minimum compressor run time until the leaving air temperature is less than 45°F (7°C).
2. Direct expansion (DX) units that control 75,000 Btu/h (22 kW) or greater of rated capacity of the capacity of the mechanical cooling directly based on occupied space temperature shall have not fewer than two stages of mechanical cooling capacity.
3. Other DX units, including those that control space temperature by modulating the airflow to the space, shall be in accordance with Table C403.5.1.

TABLE C403.5.1
DX COOLING STAGE REQUIREMENTS FOR MODULATING AIRFLOW UNITS

RATING CAPACITY	MINIMUM NUMBER OF MECHANICAL COOLING STAGES	MINIMUM COMPRESSOR DISPLACEMENT[a]
≥ 65,000 Btu/h and < 240,000 Btu/h	3 stages	≤ 35% of full load
≥ 240,000 Btu/h	4 stages	≤ 25% full load

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

a. For mechanical cooling stage control that does not use variable compressor displacement, the percent displacement shall be equivalent to the mechanical cooling capacity reduction evaluated at the full load rating conditions for the compressor.

C403.5.2 Economizer heating system impact. HVAC system design and economizer controls shall be such that economizer operation does not increase building heating energy use during normal operation.

Exception: Economizers on variable air volume (VAV) systems that cause zone level heating to increase because of a reduction in supply air temperature.

C403.5.3 Air economizers. Where economizers are required by Section C403.5, air economizers shall comply with Sections C403.5.3.1 through C403.5.3.5.

C403.5.3.1 Design capacity. Air economizer systems shall be configured to modulate outdoor air and return air dampers to provide up to 100 percent of the design supply air quantity as outdoor air for cooling.

C403.5.3.2 Control signal. Economizer controls and dampers shall be configured to sequence the dampers with the mechanical cooling equipment and shall not be controlled by only mixed-air temperature.

Exception: The use of mixed-air temperature limit control shall be permitted for systems controlled from space temperature (such as single-zone systems).

C403.5.3.3 High-limit shutoff. Air economizers shall be configured to automatically reduce outdoor air intake to the design minimum outdoor air quantity when outdoor air intake will not reduce cooling energy usage. High-limit shutoff control types for specific climates shall be chosen from Table C403.5.3.3. High-limit shutoff control settings for these control types shall be those specified in Table C403.5.3.3.

TABLE C403.5.3.3
HIGH-LIMIT SHUTOFF CONTROL SETTING FOR AIR ECONOMIZERS[b]

DEVICE TYPE	CLIMATE ZONE	REQUIRED HIGH LIMIT (ECONOMIZER OFF WHEN):	
		Equation	Description
Fixed dry bulb	5, 6	T_{OA} > 70°F	Outdoor air temperature exceeds 70°F
	4	T_{OA} > 65°F	Outdoor air temperature exceeds 65°F
Differential dry bulb	5, 6	$T_{OA} > T_{RA}$	Outdoor air temperature exceeds return air temperature
Fixed enthalpy with fixed dry-bulb temperatures	All	h_{OA} > 28 Btu/lb[a] or T_{OA} > 75°F	Outdoor air enthalpy exceeds 28 Btu/lb of dry air[a] or
			Outdoor air temperature exceeds 75°F
Differential enthalpy with fixed dry-bulb temperature	All	$h_{OA} > h_{RA}$ or T_{OA} > 75°F	Outdoor air enthalpy exceeds return air enthalpy or
			Outdoor air temperature exceeds 75°F

For SI: °C = (°F – 32)/1.8, 1 Btu/lb = 2.33 kJ/kg.

a. At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at 75°F and 50 percent relative humidity. As an example, at approximately 6,000 feet elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.

b. Devices with selectable setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.

C403.5.3.4 Relief of excess outdoor air. Systems shall provide one of the following means to relieve excess outdoor air during air economizer operation to prevent overpressurizing the building.

1. Return or relief fan(s) meeting the requirements of Section C403.11.1.
2. A barometric or motorized damper relief path with a total pressure drop at a design relief airflow rate less than 0.10 inches water column (25 Pa) from the occupied space to the outdoors. Design relief airflow rate shall be the design supply airflow rate minus any continuous exhaust flows, such as toilet exhaust fans, whose makeup is provided by the economizer system.

The relief air outlet shall be located to avoid recirculation into the building.

C403.5.3.5 Economizer dampers. Return, exhaust/relief and outdoor air dampers used in economizers shall comply with Section C403.7.7.

C403.5.4 Water-side economizers. Where economizers are required by Section C403.5, water-side economizers shall comply with Sections C403.5.4.1 and C403.5.4.2.

C403.5.4.1 Design capacity. Water economizer systems shall be configured to cool supply air by indirect evaporation and providing up to 100 percent of the expected system cooling load at outdoor air temperatures of not greater than 50°F (10°C) dry bulb/45°F (7°C) wet bulb.

Exceptions:

1. Systems primarily serving computer rooms in which 100 percent of the expected system cooling load at 40°F (4°C) dry bulb/35°F (1.7°C) wet bulb is met with evaporative water economizers.
2. Systems primarily serving computer rooms with dry cooler water economizers that satisfy 100 percent of the expected system cooling load at 35°F (1.7°C) dry bulb.
3. Systems where dehumidification requirements cannot be met using outdoor air temperatures of 50°F (10°C) dry bulb/45°F (7°C) wet bulb and where 100 percent of the expected system cooling load at 45°F (7°C) dry bulb/40°F (4°C) wet bulb is met with evaporative water economizers.

C403.5.4.2 Maximum pressure drop. Precooling coils and water-to-water heat exchangers used as part of a water economizer system shall either have a water-side pressure drop of less than 15 feet (45 kPa) of water or a secondary loop shall be created so that the coil or heat exchanger pressure drop is not seen by the circulating pumps when the system is in the normal cooling (noneconomizer) mode.

C403.5.5 Economizer fault detection and diagnostics. Air-cooled unitary direct-expansion units listed in the tables in Section C403.3.2 and variable refrigerant flow (VRF) units that are equipped with an economizer in accordance with Sections C403.5 through C403.5.4 shall include a fault detection and diagnostics system complying with the following:

1. The following temperature sensors shall be permanently installed to monitor system operation:
   - 1.1. Outside air.
   - 1.2. Supply air.
   - 1.3. Return air.

2. Temperature sensors shall have an accuracy of ±2°F (1.1°C) over the range of 40°F to 80°F (4°C to 26.7°C).
3. Refrigerant pressure sensors, where used, shall have an accuracy of ±3 percent of full scale.
4. The unit controller shall be configured to provide system status by indicating the following:
    4.1. Free cooling available.
    4.2. Economizer enabled.
    4.3. Compressor enabled.
    4.4. Heating enabled.
    4.5. Mixed air low limit cycle active.
    4.6. The current value of each sensor.
5. The unit controller shall be capable of manually initiating each operating mode so that the operation of compressors, economizers, fans and the heating system can be independently tested and verified.
6. The unit shall be configured to report faults to a fault management application available for access by day-to-day operating or service personnel, or annunciated locally on zone thermostats.
7. The fault detection and diagnostics system shall be configured to detect the following faults:
    7.1. Air temperature sensor failure/fault.
    7.2. Not economizing when the unit should be economizing.
    7.3. Economizing when the unit should not be economizing.
    7.4. Damper not modulating.
    7.5. Excess outdoor air.

C403.6 Requirements for mechanical systems serving multiple zones. Sections C403.6.1 through C403.6.9 shall apply to mechanical systems serving multiple zones.

C403.6.1 Variable air volume and multiple-zone systems. Supply air systems serving multiple zones shall be variable air volume (VAV) systems that have zone controls configured to reduce the volume of air that is reheated, recooled or mixed in each zone to one of the following:

1. Thirty percent of the zone design peak supply for systems with direct digital control (DDC).
2. Systems with DDC where all of the following apply:
    2.1. The airflow rate in the deadband between heating and cooling does not exceed the highest of the allowed rates under Items 3, 4, 5 or 6 of this section.
    2.2. The first stage of heating modulates the zone supply air temperature setpoint up to a maximum setpoint while the airflow is maintained at the deadband flow rate.
    2.3. The second stage of heating modulates the airflow rate from the deadband flow rate up to the heating maxi- mum flow rate that is less than 50 percent of the zone design peak supply rate.

3. The outdoor airflow rate required to meet the minimum ventilation requirements of Chapter 4 of the *New York City Mechanical Code*.
4. The minimum primary airflow rate required to meet the Simplified Procedure ventilation requirements of ASHRAE 62.1 for the zone and is permitted to be the average airflow rate as allowed by ASHRAE 62.1.
5. Any higher rate that can be demonstrated to reduce overall system annual energy use by offsetting reheat/recool energy losses through a reduction in outdoor air intake for the system as approved by the building official.
6. The airflow rate required to comply with applicable codes or accreditation standards such as pressure relationships or minimum air change rates.

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

1. Zones or supply air systems where not less than 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered, including condenser heat, or site-solar energy source.
2. Systems that prevent reheating, recooling, mixing or simultaneous supply of air that has been previously cooled, either mechanically or through the use of economizer systems, and air that has been previously mechanically heated.

C403.6.2 Single-duct VAV systems, terminal devices. Single-duct VAV systems shall use terminal devices capable of and configured to reduce the supply of primary supply air before reheating or recooling takes place.

C403.6.3 Dual-duct and mixing VAV systems, terminal devices. Systems that have one warm air duct and one cool air duct shall use terminal devices that are configured to reduce the flow from one duct to a minimum before mixing of air from the other duct takes place.

C403.6.4 Single-fan dual-duct and mixing VAV systems, economizers. Individual dual-duct or mixing heating and cooling systems with a single fan and with total capacities greater than 90,000 Btu/h [(26.4 kW) 7.5 tons] shall not be equipped with air economizers.

C403.6.5 Supply-air temperature reset controls. Multiple-zone HVAC systems shall include controls that are capable of and configured to automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls shall be configured to reset the supply air temperature not less than 25 percent of the difference between the design supply-air temperature and the design room air temperature. Controls that adjust the reset based on zone humidity are allowed. HVAC zones that are expected to experience relatively constant loads shall have maximum airflow designed to accommodate the fully reset supply-air temperature.

Exceptions:

1. Systems that prevent reheating, recooling or mixing of heated and cooled supply air.
2. Seventy-five percent of the energy for reheating is from site-recovered or site-solar energy sources.

C403.6.6 Multiple-zone VAV system ventilation optimization control. Multiple-zone VAV systems with direct digital control of individual zone boxes reporting to a central control panel shall have automatic controls configured to reduce outdoor air intake flow below design rates in response to changes in system ventilation efficiency (Ev) as defined by the New York City Mechanical Code.

Exceptions:

1. VAV systems with zonal transfer fans that recirculate air from other zones without directly mixing it with outdoor air, dual-duct dual-fan VAV systems, and VAV systems with fan-powered terminal units.
2. Systems where total design exhaust airflow is more than 70 percent of total design outdoor air intake flow requirements.

C403.6.7 Parallel-flow fan-powered VAV air terminal control. Parallel-flow fan-powered VAV air terminals shall have automatic controls configured to:

1. Turn off the terminal fan except when space heating is required or where required for ventilation.
2. Turn on the terminal fan as the first stage of heating before the heating coil is activated.
3. During heating for warmup or setback temperature control, either:
   3.1. Operate the terminal fan and heating coil without primary air.
   3.2. Reverse the terminal damper logic and provide heating from the central air handler by primary air.

C403.6.8 Setpoints for direct digital control. For systems with direct digital control of individual zones reporting to the central control panel, the static pressure setpoint shall be reset based on the zone requiring the most pressure. In such case, the setpoint is reset lower until one zone damper is nearly wide open. The direct digital controls shall be capable of monitoring zone damper positions or shall have an alternative method of indicating the need for static pressure that is configured to provide all of the following:

1. Automatic detection of any zone that excessively drives the reset logic.
2. Generation of an alarm to the system operational location.
3. Allowance for an operator to readily remove one or more zones from the reset algorithm.

C403.6.9 Static pressure sensor location. Static pressure sensors used to control VAV fans shall be located such that the controller setpoint is not greater than 1.2 inches w.c. (299 Pa). Where this results in one or more sensors being located down- stream of major duct splits, not less than one sensor shall be located on each major branch to ensure that static pressure can be maintained in each branch.

C403.7 Ventilation and exhaust systems. In addition to other requirements of Section C403 applicable to the provision of ventilation air or the exhaust of air, ventilation and exhaust systems shall be in accordance with Sections C403.7.1 through C403.7.9.

C403.7.1 Demand control ventilation. Demand control ventilation (DCV) shall be provided for the following:

1. Spaces with ventilation provided by single-zone systems where an air-side economizer is provided in accordance with Section C403.5.
2. Spaces larger than 250 square feet (23 m^2) in Climate Zones 5 and 6 and spaces larger than 500 square feet (46.5 m^2) in climate zone 4 that have a design occupant load of 15 people or greater per 1,000 square feet (93 m^2) of floor area, as established in the *New York City Mechanical Code*, and are served by systems with one or more of the following:

   2.1 An air-side economizer

   2.2 Automatic modulating control of the outdoor air damper.

   2.3. A design outdoor airflow greater than 3,000 cfm (1416 L/s).

Exceptions:

1. Spaces served by systems with energy recovery in accordance with Section C403.7.4.2 and that have a floor area less than 1,000 square feet (93 m^2).
2. Multiple-zone systems without *direct digital control* of individual zones communicating with a central control panel.
3. Spaces served by multiple-zone systems with a design outdoor airflow less than 750 cfm (354 L/s).
4. Spaces where more than 75 percent of the space design outdoor airflow is required for makeup air that is exhausted from the space or transfer air that is required for makeup air that is exhausted from other spaces.
5. Spaces with one of the following occupancy classifications as defined in the *New York City Mechanical Code*: correctional cells, education laboratories, barber, beauty and nail salons, and bowling alley seating areas.
6. Spaces where the *registered design professional* demonstrates an engineered ventilation system design that:
   - 6.1. Prevents the maximum concentration of contaminants from being more than that obtainable by the required rate of outdoor air *ventilation*.
   - 6.2. Allows the required minimum design rate of outdoor air to be reduced by not less than 15 percent.

C403.7.2 Parking garage ventilation controls. Ventilation systems employed in enclosed parking garages shall comply with *New York City Mechanical Code* and the following:

1. Separate ventilation systems and control systems shall be provided for each parking garage section.
2. Control systems for each parking garage section shall be capable of and configured to reduce fan airflow to not less than 0.05 cfm per square foot [0.00025 m^3 /(s × m^2)] of the floor area served and not more than 20 percent of the design capacity.
3. The ventilation system for each parking garage section shall have controls and devices that result in fan motor demand of not more than 30 percent of design wattage at 50 percent of the design airflow.

Exception: Garage ventilation systems serving a single parking garage section having a total ventilation system motor nameplate horsepower (ventilation system motor nameplate kilowatt) not exceeding 5 hp (3.7 kW) at fan system design conditions and where the parking garage section has no mechanical cooling or mechanical heating.

Nothing in this section shall be construed to require more than one parking garage section in any parking structure.

C403.7.3 Ventilation air heating control. Units that provide ventilation air to multiple zones and operate in conjunction with zone heating and cooling systems shall not use heating or heat recovery to warm supply air to a temperature greater than 60°F (16°C) when representative building loads or outdoor air temperatures indicate that the majority of zones require cooling.

Exception: Units that heat the airstream using only series energy recovery when representative building loads or outdoor air temperature indicates that the majority of zones require cooling in Climate Zone 4.

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

C403.7.4.1 Nontransient dwelling units. Nontransient dwelling units shall be provided with outdoor air energy recovery ventilation systems complying with not less than one of the following:

1. The system shall have an enthalpy recovery ratio of not less than 50 percent at cooling design condition and not less than 60 percent at heating design condition.
2. The system shall have a sensible recovery efficiency (SRE) that is not less than 65 percent at 32°F (0°C). SRE and NMT shall be determined from a listed value or from interpolation of listed values at an airflow not less than the design airflow, based on testing in accordance with CAN/CSA C439.

Exception: Enthalpy recovery ratio requirements at cooling design condition.

C403.7.4.2 Spaces other than nontransient dwelling units. Where the supply airflow rate of a fan system serving a space other than a nontransient dwelling unit exceeds the values specified in Tables C403.7.4.2(1) and C403.7.4.2(2), the system shall include an energy recovery system *enthalpy recovery ratio* of not less than 50 percent, at design conditions. Where an air economizer is required, the energy recovery system shall include a bypass or controls that permit operation of the economizer as required by Section C403.5.

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

1. Where energy recovery systems are prohibited by the Section 514.2 of the *New York City Mechanical Code*.
2. Laboratory fume hood systems that include at least of the following features:

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

2.2. Direct makeup (auxiliary) air supply equal to or greater than 75 percent of the exhaust rate, heated not warmer than 2°F (1.1°C) above room setpoint, cooled to not cooler than 3°F (1.7°C) below room setpoint, with no humidification added, and no simultaneous heating and cooling used for dehumidification control.

3. Systems serving spaces that are heated to less than 60°F (15.5°C) and that are not cooled.

4. Heating and energy recovery where more than 60 percent of the outdoor heating energy is provided from site-recovered or site-solar energy in climate zones 5.

5. Systems in climate zone 4 requiring dehumidification that employ series energy recovery and have a minimum SERR of 0.40.

6. Where the sum of the airflow rates exhausted and relieved within 30 feet of each other is less than 75 percent of the design ventilation outdoor air flow rate, excluding exhaust air that is any of the following:

   a. used for another energy recovery system,

   b. not allowed by ASHRAE Standard 170 for use in energy recovery systems with leakage potential,

   c. prohibited by the *New York City Mechanical Code*, or

   d. part of Class 4 as defined in ASHRAE 62.1.

7. Systems expected to operate less than 20 hours per week at the *outdoor air* percentage covered by Table C403.7.4.2(1).

8. Systems exhausting toxic, flammable, paint or corrosive fumes or dust.

9. Commercial kitchen hoods used for collecting and removing grease vapors and smoke.

TABLE C403.7.4.2(1)
ENERGY RECOVERY REQUIREMENT (Ventilation systems operating less than 8,000 hours per year)

	PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE							
	≥ 10% and < 20%	≥ 20% and < 30%	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥ 70% and < 80%	≥ 80%
CLIMATE ZONE	Design Supply Fan Airflow Rate (cfm)							
4, 5, 6	≥ 26,000	≥ 16,000	≥ 5,500	≥ 4,500	≥ 3,500	≥ 2,000	≥ 1,000	> 120

For SI: 1 cfm = 0.4719 L/s.
NR = Not Required.

TABLE C403.7.4.2(2)
ENERGY RECOVERY REQUIREMENT (Ventilation systems operating not less than 8,000 hours per year)

	PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE							
	≥ 10% and < 20%	≥ 20% and < 30%	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥ 70% and < 80%	≥ 80%
CLIMATE ZONE	Design Supply Fan Airflow Rate (cfm)							
4, 5, 6	≥ 200	≥ 130	≥ 100	≥ 80	≥ 70	≥ 60	≥ 50	≥ 40

For SI: 1 cfm = 0.4719 L/s. NR = Not Required.

C403.7.5 Kitchen exhaust systems. Replacement air introduced directly into the exhaust hood cavity shall not be greater than 10 percent of the hood exhaust airflow rate. Conditioned supply air delivered to any space shall not exceed the greater of the following:

1. The ventilation rate required to meet the space heating or cooling load.
2. The hood exhaust flow minus the available transfer air from adjacent space where available transfer air is considered to be that portion of outdoor ventilation air not required to satisfy other exhaust needs, such as restrooms, and not required to maintain pressurization of adjacent spaces.

Kitchen exhaust hood systems serving Type I exhaust hoods shall be provided with demand control kitchen ventilation (DCKV) controls where a kitchen or kitchen/dining facility has a total Type I kitchen hood exhaust airflow rate greater than 5,000 cubic feet per minute (2360 L/s). DCKV systems shall be configured to provide a minimum of 50 percent reduction in exhaust and replacement air system airflow rates. Systems shall include controls necessary to modulate exhaust and replacement air system airflows in response to appliance operation and to maintain full capture and containment of smoke, effluent and combustion products during cooking and idle operation. Each hood shall be a factory-built commercial exhaust hood listed by a nationally recognized testing laboratory and shall have a maximum exhaust rate as specified in Table C403.7.5.

Where a single hood, or hood section, is installed over appliances with different duty ratings, the maximum allowable flow rate for the hood or hood section shall be based on the requirements for the highest appliance duty rating under the hood or hood section.

Exceptions:

1. UL 710 listed exhaust hoods that have a design maximum exhaust flow rate not greater than 250 cubic feet per minute (118 L/s) per linear foot (305 mm) of hood that serve kitchen or kitchen/dining facilities with a total kitchen hood exhaust airflow rate less than 5,000 cfm (2360 L/s).
2. Where allowed by the *New York City Mechanical Code*, an energy recovery ventilation system is installed on the kitchen exhaust with a sensible heat recovery effectiveness of not less than 40 percent on not less than 50 percent of the total exhaust hood airflow.

TABLE C403.7.5
MAXIMUM NET EXHAUST FLOW RATE, CFM PER LINEAR FOOT OF HOOD LENGTH

TYPE OF HOOD	LIGHT-DUTY EQUIPMENT	MEDIUM-DUTY EQUIPMENT	HEAVY-DUTY EQUIPMENT	EXTRA-HEAVY-DUTY EQUIPMENT
Wall-mounted canopy	140	210	280	385
Single island	280	350	420	490
Double island (per side)	175	210	280	385
Eyebrow	175	175	NA	NA
Backshelf/Pass-over	210	210	280	NA

For SI: 1 cfm = 0.4719 L/s; 1 foot = 304.8 mm.
NA = Not Allowed.

C403.7.6 Automatic control of HVAC systems serving guestrooms. In Group R-1 buildings containing more than 50 guestrooms, each guestroom shall be provided with controls complying with the provisions of Sections C403.7.6.1 and C403.7.6.2.

C403.7.6.1 Temperature setpoint controls. Controls shall be provided on each HVAC system that are capable of and configured with three modes of temperature control.

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

C403.7.6.2 Ventilation controls. Controls shall be provided on each HVAC system that are capable of and configured to automatically turn off the ventilation and exhaust fans within 20 minutes of the occupants leaving the guestroom, or isolation devices shall be provided to each guestroom that are capable of automatically shutting off the supply of outdoor air to and exhaust air from the guestroom.

Exception: Guestroom ventilation systems are not precluded from having an automatic daily pre-occupancy purge cycle that provides daily outdoor air ventilation during unrented periods at the design ventilation rate for 60 minutes, or at a rate and duration equivalent to one air change.

C403.7.7 Shutoff dampers. Outdoor air intake and exhaust openings and stairway and shaft vents shall be provided with Class I motorized dampers. The dampers shall have an air leakage rate not greater than 4 cfm/ft^2 (20.3 L/s × m^2) of damper surface area at 1.0 inch water gauge (249 Pa) and shall be labeled by an approved agency when tested in accordance with AMCA 500D for such purpose.

Outdoor air intake and exhaust dampers shall be installed with automatic controls configured to close when the systems or spaces served are not in use or during unoccupied period warm-up and setback operation, unless the systems served require outdoor or exhaust air in accordance with the *New York City Mechanical Code* or the dampers are opened to provide intentional economizer cooling.

Stairway and elevator shaft vent dampers shall be installed with automatic controls configured to open upon the activation of any fire alarm initiating device of the building's fire alarm system or the interruption of power to the damper, or by thermostatic control systems.

Exception: Nonmotorized gravity dampers shall be an alternative to motorized dampers for exhaust and relief openings as follows:

1. In buildings less than three stories in height above grade plane.
2. In buildings of any height located in Climate Zones 0, 1, 2 or 3.
3. Where the design exhaust capacity is not greater than 300 cfm (142 L/s).

Nonmotorized gravity dampers shall have an air leakage rate not greater than 20 cfm/ft^2 (101.6 L/s × m^2) where not less than 24 inches (610 mm) in either dimension and 40 cfm/ft2 (203.2 L/s × m^2) where less than 24 inches (610 mm) in either dimension. The rate of air leakage shall be determined at 1.0 inch water gauge (249 Pa) when tested in accordance with AMCA 500D for such purpose. The dampers shall be labeled by an approved agency.

C403.7.8 Occupied standby controls. The following spaces shall be equipped with occupied standby controls in accordance with Section C403.7.8.1 for each ventilation zone:

1. Postsecondary classrooms, lecture rooms and training rooms.
2. Conference/meeting/multipurpose rooms.
3. Lounges/breakrooms.
4. Enclosed offices.
5. Open-plan office areas.
6. Corridors.

Exception: Zones that are part of a multiple-zone system without automatic zone flow control dampers.

C403.7.8.1 Occupied-standby zone controls. Within 5 minutes of all spaces in that zone entering occupied-standby mode, the zone control shall operate as follows:

1. The active heating setpoint shall be set back by not less than 1°F (0.55°C).
2. The active cooling setpoint shall be set up by not less than 1°F (0.55°C).
3. All airflow supplied to the zone shall be shut off whenever the space temperature is between the active heating and cooling setpoints.
4. Multiple-zone systems shall comply with Section C403.7.8.1.1.

C403.7.8.1.1 Multiple-zone system controls. Multiple-zone systems required to automatically reset the effective minimum outdoor air setpoint, per Section C403.6.6, shall reset the effective minimum outdoor air setpoint based on a zone outdoor air requirement of zero for all zones in occupied-standby mode. Sequences of operation for system outside air reset shall comply with an approved method.

C403.7.9 Dwelling unit ventilation system. A fan that is the air mover for a heating or cooling system that serves an individual dwelling unit shall not be used to provide outdoor air.

Exception: Where the fan efficacy is not less than 1.2 cubic feet per minute (0.56 L/s) of outdoor airflow per watt when there is no demand for heating or cooling.

C403.8 Fans and fan controls. Fans in HVAC systems shall comply with Sections C403.8.1 through C403.8.6.1.

C403.8.1 Allowable fan horsepower. Where the summed fan system motor nameplate horsepower on an HVAC fan system is greater than 5 hp (3.7 kW) at fan system design conditions, it shall not be greater than the allowable total fan system motor name- plate hp (Option 1) or fan system bhp (Option 2), as specified in Table C403.8.1(1). Such summed HVAC fan system motor nameplate horsepower shall include supply fans, exhaust fans, return or relief fans, and fan-powered terminal units associated with systems providing heating or cooling capability. Single-zone variable air volume systems shall comply with the constant volume fan power limitation.

Exceptions:

1. Hospital, vivarium and laboratory systems that utilize flow control devices on exhaust or return to maintain space pressure relationships necessary for occupant health and safety or environmental control shall be permitted to use variable volume fan power limitation.
2. Individual exhaust fans with motor nameplate horsepower of 1 hp (0.746 kW) or less are exempt from the allowable fan horsepower requirement.

TABLE C403.8.1(1)
FAN POWER LIMITATION

	LIMIT	CONSTANT VOLUME	VARIABLE VOLUME
Option 1: Fan system motor nameplate hp	Allowable nameplate motor hp	$hp \le CFM_S \times 0.0011$	$hp \le CFM_S \times 0.0015$
Option 2: Fan system bhp	Allowable fan system bhp	$bhp \le CFM_S \times 0.00094 + A$	$bhp \le CFM_S \times 0.0013 + A$

For SI: 1 bhp = 735.5 W, 1 hp = 745.5 W, 1 cfm = 0.4719 L/s.
where:
CFM_S = The maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute. hp = The maximum combined motor nameplate horsepower.
bhp = The maximum combined fan brake horsepower.
A = Sum of $[PD \times CFM_D / 4131]$.
where:
PD = Each applicable pressure drop adjustment from Table C403.8.1(2) in. w.c.
CFM_D = The design airflow through each applicable device from Table C403.8.1(2) in cubic feet per minute.

TABLE C403.8.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT

DEVICE	ADJUSTMENT
Credits	
Return air or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms	0.5 inch w.c. (2.15 inches w.c. for laboratory and vivarium systems)
Return and exhaust airflow control devices	0.5 inch w.c.
Exhaust filters, scrubbers or other exhaust treatment	The pressure drop of device calculated at fan system design condition
Particulate filtration credit: MERV 9 thru 12	0.5 inch w.c.
Particulate filtration credit: MERV 13 thru 15	0.9 inch w.c.
Particulate filtration credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2 times the clean filter pressure drop at fan system design condition.
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition.
Biosafety cabinet	Pressure drop of device at fan system design condition.
Energy recovery device, other than coil runaround loop	For each airstream, (2.2 × energy recovery effectiveness - 0.5) inch w.c.
Coil runaround loop	0.6 inch w.c. for each airstream.

TABLE C403.8.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT (Continued)

DEVICE	ADJUSTMENT
Credits	
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design conditions.
Sound attenuation section (fans serving spaces with design back- ground noise goals below NC35)	0.15 inch w.c.
Exhaust system serving fume hoods	0.35 inch w.c.
Laboratory and vivarium exhaust systems in high-rise buildings	0.25 inch w.c./100 feet of vertical duct exceeding 75 feet.
Deductions	
Systems without central cooling device	- 0.6 inch w.c.
Systems without central heating device	- 0.3 inch w.c.
Systems with central electric resistance heat	- 0.2 inch w.c.

For SI: 1 inch w.c. = 249 Pa, 1 inch = 25.4 mm, 1 foot = 304.8 mm.
w.c. = Water Column, NC = Noise Criterion.

C403.8.2 Motor nameplate horsepower. For each fan, the fan brake horsepower (bhp) shall be indicated on the construction documents and the selected motor shall be not larger than the first available motor size greater than the following:

1. For fans less than 6 bhp (4476 W), 1.5 times the fan brake horsepower.
2. For fans 6 bhp (4476 W) and larger, 1.3 times the fan brake horsepower.

Exceptions:

1. Fans equipped with electronic speed control devices to vary the fan airflow as a function of load.
2. Fans with a fan nameplate electrical input power of less than 0.89 kW.
3. Systems complying with Section C403.8.1 fan system motor nameplate hp (Option 1).
4. Fans with motor nameplate horsepower less than 1 hp (746 W).

C403.8.3 Fan efficiency. Each fan and fan array shall have a fan energy index (FEI) of not less than 1.00 at the design point of operation, as determined in accordance with AMCA 208 by an approved independent testing laboratory and labeled by the manufacturer. Each fan and fan array used for a variable-air-volume system shall have an FEI of not less than 0.95 at the design point of operation, as determined in accordance with AMCA 208 by an approved independent testing laboratory and labeled by the manufacturer. The FEI for fan arrays shall be calculated in accordance with AMCA 208 Annex C.

Exceptions: The following fans are not required to have a fan energy index:

1. Fans that are not embedded fans with motor nameplate horsepower of less than 1.0 hp (0.75 kW) or with a nameplate electrical input power of less than 0.89 kW.
2. Embedded fans that have a motor nameplate horsepower of 5 hp (3.7 kW) or less, or with a fan system electrical input power of 4.1 kW or less.
3. Multiple fans operated in series or parallel as the functional equivalent of a single fan that have a combined motor nameplate horsepower of 5 hp (3.7 kW) or less or with a fan system electrical input power of 4.1 kW or less.

4. Fans that are part of equipment covered in Section C403.3.2.
5. Fans included in an equipment package certified by an approved agency for air or energy performance.
6. Ceiling fans, which are defined as nonportable devices suspended from a ceiling or overhead structure for circulating air via the rotation of the blades.
7. Fans used for moving gases at temperatures above 482°F (250°C).
8. Fans used for operation in explosive atmospheres.
9. Reversible fans used for tunnel ventilation.
10. Fans that are intended to operate only during emergency conditions.
11. Fans outside the scope of AMCA 208.

C403.8.4 Fractional hp fan motors. Motors for fans that are not less than 1/12 hp (0.062 kW) and are less than 1 hp (0.746 kW) shall be electronically commutated motors or shall have a minimum motor efficiency of 70 percent, rated in accordance with DOE 10 CFR 431. These motors shall have the means to adjust motor speed for either balancing or remote control. The use of belt-driven fans to sheave adjustments for airflow balancing instead of a varying motor speed shall be permitted.

Exceptions: The following motors are not required to comply with this section

1. Motors in the airstream within fan coils and terminal units that only provide heating to the space served.
2. Motors in space-conditioning equipment that comply with Section C403.3.2 or Sections C403.8.1. through C403.8.3.
3. Motors that comply with Section C405.8.

C403.8.5 Low-capacity ventilation fans. Mechanical ventilation system fans with motors less than 1/12 hp (0.062 kW) in capacity shall meet the efficacy requirements of Table C403.8.5 at one or more rating points. Airflow shall be tested in accordance with the test procedure referenced in Table C403.8.5 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 and in-line fans shall be determined at a static pressure not less than 0.2 inch w.c. (49.8 Pa). Fan efficacy for ducted range hoods, bathroom and utility room fans shall be determined at a static pressure not less than 0.1 inch w.c. (24.9 Pa).

Exceptions:

1. Where ventilation fans are a component of a listed heating or cooling appliance.
2. Dryer exhaust duct power ventilators, domestic range hoods and domestic range booster fans that operate intermittently.
3. Fans in radon mitigation systems.
4. Fans not covered within the scope of the test methods referenced in Table C403.8.5.
5. Ceiling fans regulated under 10 CFR 430, Appendix U.

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

SYSTEM TYPE	AIRFLOW RATE (CFM)	MINIMUM EFFICACY (CFM/WATT)	TEST PROCEDURE
Balanced ventilation system without heat or energy recovery	Any	1.2[a]	ASHRAE Standard 51 (ANSI/AMCA Standard 210)
HRV, ERV	Any	1.2	CAN/CSA 439
Range hood	Any	2.8	ASHRAE 51 (ANSI/AMCA Standard 210)
In-line supply or exhaust fan	Any	3.8	
Other exhaust fan	≤ 90	2.8	
	≥ 90 and < 200	3.5	
	≥ 200	4.0	

For SI: 1 cfm/ft = 0.47 L/s.
a. For balanced systems, HRVs and ERVs, determine the efficacy as the outdoor airflow divided by the total fan power.

C403.8.6 Fan control. Controls shall be provided for fans in accordance with Section C403.8.6.1 and as required for specific systems provided in Section C403.

C403.8.6.1 Fan airflow control. Each cooling system listed in Table C403.8.6.1 shall be designed to vary the indoor fan airflow as a function of load and shall comply with the following requirements:

1. Direct expansion (DX) and chilled water cooling units that control the capacity of the mechanical cooling directly based on space temperature shall have not fewer than two stages of fan control. Low or minimum speed shall not be greater than 66 percent of full speed. At low or minimum speed, the fan system shall draw not more than 40 percent of the fan power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and ventilation-only operation.
2. Other units including DX cooling units and chilled water units that control the space temperature by modulating the airflow to the space shall have modulating fan control. Minimum speed shall be not greater than 50 percent of full speed. At minimum speed the fan system shall draw not more than 30 percent of the power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and ventilation-only operation.
3. Units that include an air-side economizer in accordance with Section C403.5 shall have not fewer than two speeds of fan control during economizer operation.

Exceptions:

1. Modulating fan control is not required for chilled water and evaporative cooling units with fan motors of less than 1 hp (0.746 kW) where the units are not used to provide ventilation air and the indoor fan cycles with the load.
2. Where the volume of outdoor air required to comply with the ventilation requirements of the Mechanical Code of New York State at low speed exceeds the air that would be delivered at the speed defined in Section C403.8.6, the minimum speed shall be selected to provide the required ventilation air.

TABLE C403.8.6.1
COOLING SYSTEMS

COOLING SYSTEM TYPE	FAN MOTOR SIZE	MECHANICAL COOLING CAPACITY
DX cooling	Any	≥ 65,000 Btu/h
Chilled water and evaporative cooling	≥ ¼ hp	Any

For SI: 1 British thermal unit per hour = 0.2931 W; 1 hp = 0.746 kW.

C403.8.6.2 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 shall be provided with manual on capability and one or more of the following controls:

1. A timer control that has a minimum setpoint not greater than 30 minutes.
2. An occupant sensor control that automatically turns off exhaust fans within 30 minutes after all occupants have left the space.
3. A humidity control capable of manual or automatic adjustment from a minimum setpoint not greater than 50 percent to a maximum setpoint not greater than 80 percent relative humidity.
4. A contaminant control that responds to a particle or gaseous concentration.

Exception: Bathroom and toilet room exhaust systems serving as an integral component of an outdoor air ventilation system in Group R-2, R-3 and R-4 occupancies shall not be required to provide controls other than manual on capability.

An off setpoint shall not be used to comply with a minimum setpoint requirement.

C403.9 Large-diameter ceiling fans. Where provided, large-diameter ceiling fans shall be tested and labeled in accordance with AMCA 230 and shall meet the efficiency requirements of Table C403.9 and Section C403.9.1.

TABLE C403.9
CEILING FAN EFFICIENCY REQUIREMENTS[a]

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 430 included here as a convenience to the users of this code)

EQUIPMENT TYPE	MINIMUM EFFICIENCY[b,c]	TEST PROCEDURE
Large-diameter ceiling fan	CFEI ≥ 1.00 at high (maximum) speed; and CFEI ≥ 1.31 at 40% of high speed or the near- est speed that is not less than 40% of high speed	10 CFR 430, Appendix U

a. The minimum efficiency requirements at both high speed and 40% of maximum speed shall be met or exceeded to comply with this code.
b. Ceiling fans are regulated as consumer products by 10 CFR 430.
c. Chapter 6 contains a list of the referenced standards, which include test procedures, including the referenced year version of the test procedure.

C403.9.1 Ceiling Fan Energy Index (CFEI). The Ceiling Fan Energy Index shall be calculated as the ratio of the electric input power of a reference large-diameter ceiling fan to the electric input power of the actual large-diameter ceiling fan as calculated in accordance with AMCA 208 with the following modifications to the calculations for the reference fan: using an airflow constant (Q) of 26,500 cfm (12.5 m3/s), a pressure constant (P) of 0.0027 inch of water (0.6719 Pa), and fan efficiency constant (η) of 42 percent.

C403.10 Buildings with high-capacity space-heating gas boiler systems. Gas hot water boiler systems for space heating with system input capacities of not less than 1,000,000 Btu/h (293 kW) and not greater than 10,000,000 Btu/h (2931 kW) in new buildings shall comply with Sections C403.10.1 and C403.10.2.

Exceptions:

1. Where 25 percent of the annual space heating requirement is provided by on-site renewable energy, site-recovered energy or heat recovery chillers.
2. Space heating boilers installed in individual dwelling units.
3. Where 50 percent or more of the design heating load is served using perimeter convective heating, radiant ceiling panels or both.
4. Individual gas boilers with input capacity less than 300,000 Btu/h (88 kW) shall not be included in the calculations of the total system input or total system efficiency.

C403.10.1 Boiler efficiency. Gas hot water boilers shall have a thermal efficiency (E_t) of not less than 90 percent where rated in accordance with the test procedures in Table C403.3.2(6). Systems with multiple boilers are allowed to meet this requirement where the space heating input provided by equipment with E_t above or below 90 percent provides an input capacity-weighted average E_t of not less than 90 percent. For boilers rated only for combustion efficiency, the calculation for the input capacity- weighted average E_t shall use the combustion efficiency value.

C403.10.2 Hot water distribution system design. The hot water distribution system shall be designed to meet the following:

1. Coils and other heat exchangers shall be selected so that at design conditions the hot water return temperature entering the boilers is 120°F (49°C) or less.
2. Under all operating conditions, the water temperature entering the boiler is not greater than 120°F (49°C) or the flow rate of supply hot water that recirculates directly into the return system, such as by three-way valves or minimum flow bypass controls, shall be not greater than 20 percent of the design flow of the boilers.

C403.11 Heat rejection equipment. Heat rejection equipment, including air-cooled condensers, dry coolers, open-circuit cooling towers, closed-circuit cooling towers and evaporative condensers, shall comply with this section.

Exception: Heat rejection devices where energy usage is included in the equipment efficiency ratings listed in Tables C403.3.2(6) and C403.3.2(7).

C403.11.1 Fan speed control. Each fan system powered by an individual motor or array of motors with connected power, including the motor service factor, totaling 5 hp (3.7 kW) or more shall have controls and devices configured to automatically modulate the fan speed to control the leaving fluid temperature or condensing temperature and pressure of the heat rejection device. Fan motor power input shall be not more than 30 percent of design wattage at 50 percent of the design airflow.

Exceptions:

1. Fans serving multiple refrigerant or fluid cooling circuits.
2. Condenser fans serving flooded condensers.

C403.11.2 Multiple-cell heat rejection equipment. Multiple-cell heat rejection equipment with variable speed fan drives shall be controlled to operate the maximum number of fans allowed that comply with the manufacturer's requirements for all system components and so that all fans operate at the same fan speed required for the instantaneous cooling duty, as opposed to staged on and off operation. The minimum fan speed shall be the minimum allowable speed of the fan drive system in accordance with the manufacturer's recommendations.

C403.11.3 Limitation on centrifugal fan open-circuit cooling towers. Centrifugal fan open-circuit cooling towers with a combined rated capacity of 1,100 gpm (4164 L/m) or greater at 95°F (35°C) condenser water return, 85°F (29°C) condenser water supply, and 75°F (24°C) outdoor air wet-bulb temperature shall meet the energy efficiency requirement for axial fan open-circuit cooling towers listed in Table C403.3.2(7) .

Exception: Centrifugal open-circuit cooling towers that are designed with inlet or discharge ducts or require external sound attenuation.

C403.11.4 Tower flow turndown. Open-circuit cooling towers used on water-cooled chiller systems that are configured with multiple- or variable-speed condenser water pumps shall be designed so that all open-circuit cooling tower cells can be run in parallel with the larger of the flow that is produced by the smallest pump at its minimum expected flow rate or at 50 percent of the design flow for the cell.

C403.11.5 Heat recovery for service water heating. Condenser heat recovery shall be installed for heating or reheating of service hot water provided that the facility operates 24 hours a day, the total installed heat capacity of water-cooled systems exceeds 6,000,000 Btu/hr (1758 kW) of heat rejection, and the design service water heating load exceeds 1,000,000 Btu/h (293 kW).

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

1. Sixty percent of the peak heat rejection load at design conditions.
2. The preheating required to raise the peak service hot water draw to 85°F (29°C).

Exceptions:

1. Facilities that employ condenser heat recovery for space heating or reheat purposes with a heat recovery design exceeding 30 percent of the peak water-cooled condenser load at design conditions.
2. Facilities that provide 60 percent of their service water heating from site solar or site recovered energy or from other sources.

C403.11.6 Heat recovery for space conditioning in health care facilities. Where heated water is used for space heating, a heat pump chiller meeting the requirements of Table C403.3.2(15) for heat recovery and that uses the cooling system return water as the heat source shall be installed where the following are true:

1. The building is a Group I-2, Condition 2 occupancy.
2. The total design chilled water capacity for the Group I-2, Condition 2 occupancy, either air cooled or water cooled, required at cooling design conditions exceeds 3,600,000 Btu/h (1100 kw) of cooling.
3. Simultaneous heating, including reheat, and cooling occurs above 60°F (16°C) outdoor air temperature.

The heat recovery system shall have a cooling capacity of not less than 7 percent of the total design chilled water capacity of the Group I-2, Condition 2 occupancy at peak design conditions.

Exception: Buildings that provide 60 percent or more of their annual reheat energy from on-site renewable energy or other site-recovered energy. On-site renewable energy used to meet Section C405.15.1 or C406.3.1 shall not be used to meet this exception.

C403.12 Refrigeration equipment performance. Refrigeration equipment performance shall be determined in accordance with Sections C403.12.1 and C403.12.2 for commercial refrigerators, freezers, refrigerator-freezers, walk-in coolers, walk-in freezers and refrigeration equipment. The energy use shall be verified through certification under an approved certification program or, where a certification program does not exist, the energy use shall be supported by data furnished by the equipment manufacturer.

Exception: Walk-in coolers and walk-in freezers regulated under federal law in accordance with Subpart R of DOE 10 CFR 431.

C403.12.1 Commercial refrigerators, refrigerator-freezers and refrigeration. Refrigeration equipment, defined in DOE 10 CFR Part 431.62, shall have an energy use in kWh/day not greater than the values established in the same regulation when tested and rated in accordance with AHRI 1200. The applicable table is reproduced for convenience in Table C403.12.1.

TABLE C403.12.1
MINIMUM EFFICIENCY REQUIREMENTS:
COMMERCIAL REFRIGERATORS AND FREEZERS AND REFRIGERATION

(This table is intended to be a restatement of the legally binding provisions found in DOE 10 CFR Part 431 included as a convenience to the users of this code)

EQUIPMENT CATEGORY	CONDENSING UNIT CONFIGURATION	EQUIPMENT FAMILY	RATING TEMP., °F	OPERATING TEMP., °F	EQUIPMENT CLASSIFICATION[a,c]	MAXIMUM DAILY ENERGY CONSUMPTION, kWh/day[d, e]	TEST STANDARD
Remote condensing commercial refrigerators and commercial freezers	Remote (RC)	Vertical open (VOP)	38 (M)	≥ 32	VOP.RC.M	0.64 × TDA + 4.07	AHRI 1200
			0 (L)	< 32	VOP.RC.L	2.20 × TDA + 6.85	
		Semivertical open (SVO)	38 (M)	≥ 32	SVO.RC.M	0.66 × TDA + 3.18	
			0 (L)	< 32	SVO.RC.L	2.20 × TDA + 6.85	
		Horizontal open (HZO)	38 (M)	≥ 32	HZO.RC.M	0.35 × TDA + 2.88	
			0 (L)	< 32	HZO.RC.L	0.55 × TDA + 6.88	
		Vertical closed transparent (VCT)	38 (M)	≥ 32	VCT.RC.M	0.15 × TDA + 1.95	
			0 (L)	< 32	VCT.RC.L	0.49 × TDA + 2.61	
		Horizontal closed transparent (HCT)	38 (M)	≥ 32	HCT.RC.M	0.16 × TDA + 0.13	
			0 (L)	< 32	HCT.RC.L	0.34 × TDA + 0.26	
		Vertical closed solid (VCS)	38 (M)	≥ 32	VCS.RC.M	0.10 × V + 0.26	
			0 (L)	< 32	VCS.RC.L	0.21 × V + 0.54	
		Horizontal closed solid (HCS)	38 (M)	≥ 32	HCS.RC.M	0.10 × V + 0.26	
			0 (L)	< 32	HCS.RC.L	0.21 × V + 0.54	
		Service over counter (SOC)	38 (M)	≥ 32	SOC.RC.M	0.44 × TDA + 0.11	
			0 (L)	< 32	SOC.RC.L	0.93 × TDA + 0.22	
Self-contained commercial refrigerators and commercial freezers with and without doors	Self-contained (SC)	Vertical open (VOP)	38 (M)	≥ 32	VOP.SC.M	1.69 × TDA + 4.71	AHRI 1200
			0 (L)	< 32	VOP.SC.L	4.25 × TDA + 11.82	
		Semivertical open (SVO)	38 (M)	≥ 32	SVO.SC.M	1.70 × TDA + 4.59	
			0 (L)	< 32	SVO.SC.L	4.26 × TDA + 11.51	
		Horizontal open (HZO)	38 (M)	≥ 32	HZO.SC.M	0.72 × TDA + 5.55	
			0 (L)	< 32	HZO.RC.L	1.90 × TDA + 7.08	
		Vertical closed transparent (VCT)	38 (M)	≥ 32	VCT.SC.M	0.10 × V + 0.86	
			0 (L)	< 32	VCT.SC.L	0.29 × V + 2.95	
		Vertical closed solid (VCS)	38 (M)	≥ 32	VCS.SC.M	0.05 × V + 1.36	
			0 (L)	< 32	VCS.SC.L	0.22 × V + 1.38	
		Horizontal closed transparent (HCT)	38 (M)	≥ 32	HCT.SC.M	0.06 × V + 0.37	
			0 (L)	< 32	HCT.SC.L	0.08 × V + 1.23	
		Horizontal closed solid (HCS)	38 (M)	≥ 32	HCS.SC.M	0.05 × V + 0.91	
			0 (L)	< 32	HCS.SC.L	0.06 × V + 1.12	
		Service over counter (SOC)	38 (M)	≥ 32	SOC.SC.M	0.52 × TDA + 1.00	
			0 (L)	< 32	SOC.SC.L	1.10 × TDA + 2.10	

TABLE C403.12.1
MINIMUM EFFICIENCY REQUIREMENTS:
COMMERCIAL REFRIGERATORS AND FREEZERS AND REFRIGERATION—continued

(This table is intended to be a restatement of the legally binding provisions found in DOE 10 CFR Part 431 included as a convenience to the users of this code)

EQUIPMENT CATEGORY	CONDENSING UNIT CONFIGURATION	EQUIPMENT FAMILY	RATING TEMP., °F	OPERATING TEMP., °F	EQUIPMENT CLASSIFICATION[a,c]	MAXIMUM DAILY ENERGY CONSUMPTION, kWh/day[d, e]	TEST STANDARD
Self-contained commercial refrigerators with transparent doors for pull- down temperature applications	Self-contained (SC)	Pull-down (PD)	38 (M)	≥ 32	PD.SC.M	0.11 × V + 0.81	AHRI 1200
Commercial ice cream freezers	Remote (RC)	Vertical open (VOP)	-15 (I)	≤ -5[b]	VOP.RC.I	2.79 × TDA + 8.70	AHRI 1200
		Semivertical open (SVO)			SVO.RC.I	2.79 × TDA + 8.70	
		Horizontal open (HZO)			HZO.RC.I	0.70 × TDA + 8.74	
		Vertical closed transparent (VCT)			VCT.RC.I	0.58 × TDA + 3.05	
		Horizontal closed trans-parent (HCT)			HCT.RC.I	0.40 × TDA + 0.31	
		Vertical closed solid (VCS)			VCS.RC.I	0.25 × V + 0.63	
		Horizontal closed solid (HCS)			HCS.RC.I	0.25 × V + 0.63	
		Service over counter (SOC)			SOC.RC.I	1.09 × TDA + 0.26	
	Self-contained (SC)	Vertical open (VOP)			VOP.SC.I	5.40 × TDA + 15.02	AHRI 1200
		Semivertical open (SVO)			SVO.SC.I	5.41 × TDA + 14.63	
		Horizontal open (HZO)			HZO.SC.I	2.42 × TDA + 9.00	
		Vertical closed transparent (VCT)			VCT.SC.I	0.62 × TDA + 3.29	
		Horizontal closed trans-parent (HCT)			HCT.SC.I	0.56 × TDA + 0.43	
		Vertical closed solid (VCS)			VCS.SC.I	0.34 × V + 0.88	
		Horizontal closed solid (HCS)			HCS.SC.I	0.34 × V + 0.88	
		Service over counter (SOC)			SOC.SC.I	1.53 × TDA + 0.36	

For SI: 1 square foot = 0.0929 m2, 1 cubic foot = 0.02832 m3, °C = (°F – 32)/1.8.

a. The meaning of the letters in this column is indicated in the columns to the left.

b. Ice cream freezer is defined in DOE 10 CFR 431.62 as a commercial freezer that is designed to operate at or below -5 °F and that the manufacturer designs, markets or intends for the storing, displaying or dispensing of ice cream.

c. Equipment class designations consist of a combination [in sequential order separated by periods (AAA).(BB).(C)] of the following:
   - (AAA)—An equipment family code (VOP = vertical open, SVO = semivertical open, HZO = horizontal open, VCT = vertical closed transparent doors, VCS = vertical closed solid doors, HCT = horizontal closed transparent doors, HCS = horizontal closed solid doors, and SOC = service over counter);
   - (BB)—An operating mode code (RC = remote condensing and SC = self-contained); and
   - (C)—A rating temperature code [M = medium temperature (38°F), L = low temperature (0°F), or I = ice cream temperature (-15°F)].
   - For example, “VOP.RC.M” refers to the “vertical open, remote condensing, medium temperature” equipment class.

d. V is the volume of the case (ft3) as measured in AHRI 1200, Appendix C.TDA is the total display area of the case (ft2) as measured in AHRI 1200, Appendix D.

C403.12.2 Walk-in coolers and walk-in freezers. Walk-in cooler and walk-in freezer refrigeration systems, except for walk-in process cooling refrigeration systems as defined in DOE 10 CFR 431.302, shall meet the requirements of Tables C403.12.2.1(1), C403.12.2.1(2) and C403.12.2.1(3).

C403.12.2.1 Performance standards. Walk-in coolers and walk-in freezers shall meet the requirements of Tables C403.12.2.1(1), C403.12.2.1(2) and C403.12.2.1(3).

TABLE C403.12.2.1(1)
WALK-IN COOLER AND FREEZER DISPLAY DOOR EFFICIENCY REQUIREMENTS[a]
(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

CLASS DESCRIPTOR	CLASS	MAXIMUM ENERGY CONSUMPTION (kWh/day)[a]	TEST PROCEDURE
Display door, medium temperature	DD, M	$0.04 \times A_{dd} + 0.41$	10 CFR 431
Display door, low temperature	DD, L	$0.15 \times A_{dd} + 0.29$	10 CFR 431

a. Add is the surface area of the display door.

TABLE C403.12.2.1(2)
WALK-IN COOLER AND FREEZER NONDISPLAY DOOR EFFICIENCY REQUIREMENTS[a]
(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

CLASS DESCRIPTOR	CLASS	MAXIMUM ENERGY CONSUMPTION (kWh/day)[a]	TEST PROCEDURE
Passage door, medium temperature	PD, M	$0.05 \times A_{nd} + 1.7$	10 CFR 431
Passage door, low temperature	PD, L	$0.14 \times A_{nd} + 4.8$	10 CFR 431
Freight door, medium temperature	FD, M	$0.04 \times A_{nd} + 1.9$	10 CFR 431
Freight door, low temperature	FD, L	$0.12 \times A_{nd} + 5.6$	10 CFR 431

a. A_{nd} is the surface area of the nondisplay door.

TABLE C403.12.2.1(3)
WALK-IN COOLER AND FREEZER REFRIGERATION SYSTEM EFFICIENCY REQUIREMENTS
(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

CLASS DESCRIPTOR	CLASS	MINIMUM ANNUAL WALK-IN ENERGY FACTOR (AWEF) (Btu/W-h)[a]	TEST PROCEDURE
Dedicated condensing, medium temperature, indoor system	DC.M.I	5.61	AHRI 1250
Dedicated condensing, medium temperature, outdoor system	DC.M.O	7.60	
Dedicated condensing, low temperature, indoor system, net capacity (q_{net}) < 6,500 Btu/h	DC.L.I < 6,500	$9.091 \times 10^{-5} \times q_{net} + 1.81$	
Dedicated condensing, low temperature, indoor system, net capacity (q_{net}) ≥ 6,500 Btu/h	DC.L.I ≥ 6,500	2.40	
Dedicated condensing, low temperature, outdoor system, net capacity (q_{net}) < 6,500 Btu/h	DC.L.O < 6,500	$6.522 \times 10^{-5} \times q_{net} + 2.73$	
Dedicated condensing, low temperature, outdoor system, net capacity (q_{net}) ≥ 6,500 Btu/h	DC.L.O ≥ 6,500	3.15	
Unit cooler, medium	UC.M	9.00	
Unit cooler, low temperature, net capacity (q_{net}) < 15,500 Btu/h	UC.L < 15,500	$1.575 \times 10^{-5} \times q_{net} + 3.91$	
Unit cooler, low temperature, net capacity (q_{net}) ≥ 15,500 Btu/h	UC.L ≥ 15,500	4.15	

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

a. q_{net} is net capacity (Btu/h) as determined in accordance with AHRI 1250.

C403.12.3 Refrigeration systems. Refrigerated display cases, walk-in coolers or walk-in freezers that are served by remote compressors and remote condensers not located in a condensing unit, shall comply with Sections C403.12.3.1 and C403.12.3.2.

Exception: Systems where the working fluid in the refrigeration cycle goes through both subcritical and super-critical states (transcritical) or that use ammonia refrigerant are exempt.

C403.12.3.1 Condensers serving refrigeration systems. Fan-powered condensers shall comply with the following:

1. The design saturated condensing temperatures for air-cooled condensers shall not exceed the design dry-bulb temperature plus 10°F (5.6°C) for low-temperature refrigeration systems, and the design dry-bulb temperature plus 15°F (8°C) for medium temperature refrigeration systems where the saturated condensing temperature for blend refrigerants shall be determined using the average of liquid and vapor temperatures as converted from the condenser drain pressure.
2. Condenser fan motors that are less than 1 hp (0.75 kW) shall use electronically commutated motors, permanent split- capacitor-type motors or 3-phase motors.
3. Condenser fans for air-cooled condensers, evaporatively cooled condensers, air- or water-cooled fluid coolers or cooling towers shall reduce fan motor demand to not more than 30 percent of design wattage at 50 percent of design air volume, and incorporate one of the following continuous variable speed fan control approaches:
    3.1. Refrigeration system condenser control for air-cooled condensers shall use variable setpoint control logic to reset the condensing temperature setpoint in response to ambient dry-bulb temperature.
    3.2. Refrigeration system condenser control for evaporatively cooled condensers shall use variable setpoint control logic to reset the condensing temperature setpoint in response to ambient wet-bulb temperature.
4. Multiple fan condensers shall be controlled in unison.
5. The minimum condensing temperature setpoint shall be not greater than 70°F (21°C).

C403.12.3.2 Compressor systems. Refrigeration compressor systems shall comply with the following:

1. Compressors and multiple-compressor system suction groups shall include control systems that use floating suction pressure control logic to reset the target suction pressure temperature based on the temperature requirements of the attached refrigeration display cases or walk-ins.

Exception: Controls are not required for the following:

1. Single-compressor systems that do not have variable capacity capability.
2. Suction groups that have a design saturated suction temperature of 30°F (-1.1°C) or higher, suction groups that comprise the high stage of a two-stage or cascade system, or suction groups that primarily serve chillers for secondary cooling fluids.

2. Liquid subcooling shall be provided for all low-temperature compressor systems with a design cooling capacity equal to or greater than 100,000 Btu (29.3 kW) with a design-saturated suction temperature of -10°F (-23°C) or lower. The subcooled liquid temperature shall be controlled at a maximum temperature setpoint of 50°F (10°C) at the exit of the subcooler using either compressor economizer (interstage) ports or a separate compressor suction group operating at a saturated suction temperature of 18°F (-7.8°C) or higher.

    2.1. Insulation for liquid lines with a fluid operating temperature less than 60°F (15.6°C) shall comply with Table C403.13.3(1) or C403.13.3(2).

3. Compressors that incorporate internal or external crankcase heaters shall provide a means to cycle the heaters off during compressor operation.

C403.13 Construction of HVAC system elements. Ducts, plenums, piping and other elements that are part of an HVAC system shall be constructed and insulated in accordance with Sections C403.13.1 through C403.13.3.1.

C403.13.1 Duct and plenum insulation and sealing. Supply and return air ducts and plenums shall be insulated with not less than R-6 insulation where located in unconditioned spaces and where located outside the building with not less than R-8 insulation in Climate Zone 4 and not less than R-12 insulation in Climate Zones 5 and 6. Ducts located underground beneath buildings shall be insulated as required in this section or have an equivalent thermal distribution efficiency. Underground ducts utilizing the thermal distribution efficiency method shall be listed and labeled to indicate the R-value equivalency. Where located within a building thermal envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by not less than R-8 insulation in Climate Zone 4 and not less than R-12 insulation in Climate Zones 5 and 6.

Exceptions:

1. Where located within equipment.
2. Where the design temperature difference between the interior and exterior of the duct or plenum is not greater than 15°F (8°C).

Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with the New York City Mechanical Code.

C403.13.2 Duct construction. Ductwork shall be constructed and erected in accordance with the New York City Mechanical Code.

C403.13.2.1 Low-pressure duct systems. Longitudinal and transverse joints, seams and connections of supply and return ducts operating at a static pressure less than or equal to 2 inches water gauge (w.g.) (498 Pa) shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems or tapes installed in accordance with the manufacturer's instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the New York City Mechanical Code.

Exception: Locking-type longitudinal joints and seams, other than the snap-lock and button-lock types, need not be sealed as specified in this section.

C403.13.2.2 Medium-pressure duct systems. Ducts and plenums designed to operate at a static pressure greater than 2 inches water gauge (w.g.) (498 Pa) but less than 3 inches w.g. (747 Pa) shall be insulated and sealed in accordance with Section C403.12.1. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the New York City Mechanical Code.

C403.13.3 Piping insulation. Piping serving as part of a heating or cooling system shall be thermally insulated in accordance with Table C403.13.3(1) or C403.13.3(2).

Exceptions:

1. Factory-installed piping within HVAC equipment tested and rated in accordance with a test procedure referenced by this code.
2. Factory-installed piping within room fan-coils and unit ventilators tested and rated according to AHRI 440 (except that the sampling and variation provisions of Section 6.5 shall not apply) and AHRI 840, respectively.
3. Piping that conveys fluids that have a design operating temperature range between 60°F (15°C) and 105°F (41°C).
4. Strainers, control valves, and balancing valves associated with piping 1 inch (25 mm) or less in diameter.
5. Direct buried piping that conveys fluids at or below 60°F (15°C).
6. In radiant heating systems, sections of piping intended by design to radiate heat.

C403.13.3.1 Protection of piping insulation. Piping insulation exposed to the weather shall be protected from physical damage, including that caused by sunlight, moisture, equipment maintenance and wind. The protection shall provide shielding from solar radiation that can cause degradation of the material. The protection shall be removable and reuseable for not less than 6 inches (152 mm) from the connection to the equipment piping for maintenance. Adhesive tape shall not be permit- ted as a means of insulation protection.

TABLE C403.13.3(1)
MINIMUM PIPE INSULATION THICKNESS (in inches or *R*-value)[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 × ft² × °F)[b]	Mean Rating Temperature (°F)		< 1	1 to < 1 ½	1 ½ to < 4	4 to < 8	> 8
				Minimum insulation thickness (inches)				
> 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 1 ½ inches and located in partitions within conditioned spaces, reduction of these thicknesses by 1 inch shall be permitted (before thickness adjust- ment 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:

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

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 1 ½ inches shall be permitted (before thickness adjustment required in Note b but not to thicknesses less than 1 inch).

TABLE C403.13.3(2)
MINIMUM PIPE INSULATION *R*-VALUE[a]

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	NOMINAL PIPE OR TUBE SIZE (inches)				
	< 1	1 to < 1 ½	1 ½ to < 4	4 to < 8	≥ 8
	Minimum Insulation *R*-Value				
> 350	R-32	R-36	R-34	R-26	R-21
251–350	R-20	R-29	R-32	R-24	R-20
201–250	R-17	R-17	R-17	R-15	R-13
141–200	R-9	R-9	R-11	R-10	R-9
105–140	R-5	R-9	R-8	R-8	R-7
40–60	R-2	R-2	R-5	R-5	R-4
≤ 40	R-6	R-9	R-9	R-8	R-7

For SI: 1 inch = 25.4 mm, 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 × ft² × °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 × in/h × ft² × °F.

C403.14 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 C403.14.1 through C403.14.4.

C403.14.1 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.

C403.14.2 Snow- and ice-melt system controls. Snow- and ice-melting systems shall include automatic controls configured to shut off the system when the pavement temperature is above 50°F (10°C) and precipitation is not falling, and an automatic or manual control that is configured to shut off when the outdoor temperature is above 40°F (4°C).

C403.14.3 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°C) and that 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.

C403.14.4 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°C) or when the conditions of the protected fluid will prevent freezing.

C403.15 Dehumidification in spaces for plant growth and maintenance. Equipment that dehumidifies indoor grow and green- house spaces shall be one or more of the following:

1. Dehumidifiers tested in accordance with the test procedure listed in DOE 10 CFR 430 and DOE 10 CFR 430, Subpart B, Appendix X or X1.
2. An integrated HVAC system with on-site heat recovery designed to fulfill not less than 75 percent of the annual energy for dehumidification reheat.
3. A chilled water system with on-site heat recovery designed to fulfill not less than 75 percent of the annual energy for dehumidification reheat.
4. A solid or liquid desiccant dehumidification system for system designs that require a dewpoint of not more than 50°F (10°C).

C403.16 Service water pressure-booster systems. Service water pressure-booster systems shall be designed such that the following apply:

1. One or more pressure sensors shall be used to vary pump speed and/or start and stop pumps. The sensors shall either be located near the critical fixtures that determine the pressure required or logic shall be employed that adjusts the setpoint to simulate the operation of remote sensors.
2. No devices shall be installed for the purpose of reducing the pressure of all of the water supplied by any booster system pump or booster system, except for safety devices.
3. No booster system pumps shall operate when there is no service water flow.

C403.17 Clean water pumps. Clean water pumps meeting all the following criteria shall achieve a PEI rating not greater than 1.0:

1. Shaft input power is greater than or equal to 1.0 hp (0.75 kW) and less than or equal to 200 hp (149.1 kW) at its best efficiency point (BEP).
2. Designated as either an end-suction close-coupled, end-suction frame-mounted, in-line, radially split vertical or submersible turbine pump.
3. A flow rate of 25 gallons per minute (1.58 L/s) or greater at its BEP at full impeller diameter.
4. Maximum head of 459 feet (139.9 m) at its BEP at full impeller diameter and the number of stages required for testing.
5. Design temperature range from 14°F (-10°C) to 248°F (120°C).
6. Designed to operate with one of the following. Note that for either Item 6.1 or 6.2, the driver and impeller must rotate at the same speed.

   6.1. A 2- or 4-pole induction motor.

   6.2. A noninduction motor with a speed of rotation operating range that includes speeds of rotation between 2,880 and 4,320 rpm and/or 1,440 and 2,160 rpm.
7. For submersible turbine pumps, a 6-inch (152 mm) or smaller bowl diameter.
8. For end-suction close-coupled pumps and end-suction frame-mounted/own bearings pumps, specific speeds less than or equal to 5,000 rpm when calculated using US customary units.

Exceptions: The following pumps are exempt from these requirements:

1. Fire pumps.
2. Self-priming pumps.
3. Prime-assisted pumps.
4. Magnet-driven pumps.
5. Pumps designed to be used in a nuclear facility subject to 10 CFR 50.
6. Pumps meeting the design and construction requirements set forth in US Military Specification MIL-P-17639F (1996), “Pumps, Centrifugal, Miscellaneous Service Naval Shipboard Use” (as amended); MIL-P-17840C (1986), “Pump, Centrifugal, Close Coupled, Navy Standard for Use on Naval Ships” (as amended); MIL-P-17881D (1972), “Pump, Centrifugal, Boiler Feed, (Multi Stage)” (as amended); MIL-P-18472G (1989), “Pumps, Centrifugal, Condensate, Feed Booster, Waste Heat Boiler, and Distilling Plant” (as amended); MIL-P-18682D (1984), “Pump, Centrifugal, Main Condenser Circulating, Naval Shipboard” (as amended).

SECTION ECC C404
SERVICE WATER HEATING

C404.1 General. This section covers the minimum efficiency of, and controls for, service water-heating equipment and insulation of service hot water piping.

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

TABLE C404.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Parts 430 & 431 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	DRAW PATTERN	PERFORMANCE REQUIRED[a]	TEST PROCEDURE[b]
Electric table-top water heaters[c]	≤ 12 kW	≥ 20 gal ≤ 120 gal[d]	Very small Low Medium High	UEF ≥ 0.6323 – (0.0058 × V_r) UEF ≥ 0.9188 – (0.0031 × V_r) UEF ≥ 0.9577 – (0.0023 × V_r) UEF ≥ 0.9884 – (0.0016 × V_r)	DOE 10 CFR Part 430 App. E
Electric storage water heaters [e, f]: resistance and heat pump	≤ 12 kW	≥ 20 gal ≤ 55 gal[f]	Very small Low Medium High	UEF ≥ 0.8808 – (0.0008 × V_r) UEF ≥ 0.9254 – (0.0003 × V_r) UEF ≥ 0.9307 – (0.0002 × V_r) UEF ≥ 0.9349 – (0.0001 × V_r)	DOE 10 CFR Part 430 App. E
	≤ 12 kW	> 55 gal ≤120 gal[f]	Very small Low Medium High	UEF ≥ 1.9236 – (0.0011 × V_r) UEF ≥ 2.0440 – (0.0011 × V_r) UEF ≥ 2.1171 – (0.0011 × V_r) UEF ≥ 2.2418 – (0.0011 × V_r)	DOE 10 CFR Part 430 App. E
Electric storage water heaters[e, f, m]	> 12 kW	—	—	(0.3 + 27/V_m), %/h	DOE 10 CFR 431.106 App. B
Grid-enabled water heaters[g]	—	> 75 gal[d]	Very small Low Medium High	UEF ≥ 1.0136 – (0.0028 × V_r) UEF ≥ 0.9984 – (0.0014 × V_r) UEF ≥ 0.9853 – (0.0010 × V_r) UEF ≥ 0.9720 – (0.0007 × V_r)	DOE 10 CFR 430 App. E
Electric instantaneous water heaters[h]	≤ 12 kW	< 2 gal[d]	Very small Low Medium High	UEF ≥ 0.91 UEF ≥ 0.91 UEF ≥ 0.91 UEF ≥ 0.92	DOE 10 CFR Part 430
	> 12 kW & ≤ 58.6 kW[i]	≤ 2 gal & ≤180ºF	All	UEF ≥ 0.80	DOE 10 CFR Part 430
Gas storage water heaters [e, m]	≤ 75,000 Btu/h	≥20 gal & ≤ 55 gal[d]	Very small Low Medium High	UEF ≥ 0.3456 – (0.0020 × V_r) UEF ≥ 0.5982 – (0.0019 × V_r) UEF ≥ 0.6483 – (0.0017 × V_r) UEF ≥ 0.6920 – (0.0013 × V_r)	DOE 10 CFR Part 430 App. E
	≤ 75,000 Btu/h	> 55 gal & ≤ 100 gal[d]	Very small Low Medium High	UEF ≥ 0.6470 – (0.0006 × V_r) UEF ≥ 0.7689 – (0.0005 × V_r) UEF ≥ 0.7897 – (0.0004 × V_r) UEF ≥ 0.8072 – (0.0003 × V_r)	DOE 10 CFR Part 430 App. E
	> 75,000 Btu/h and ≤ 105,000 Btu/h[j, k]	≤ 120 gal & ≤180ºF	Very small Low Medium High	UEF ≥ 0.2674 – (0.0009 × V_r) UEF ≥ 0.5362 – (0.0012 × V_r) UEF ≥ 0.6002 – (0.0011 × V_r) UEF ≥ 0.6597 – (0.0009 × V_r)	DOE 10 CFR Part 430 App. E
	> 105,000 Btu/h[k]	—	—	80% E_t $SL \le Q / (800 + 110\sqrt{V})$, Btu/ h	DOE 10 CFR 431.106

TABLE C404.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT—continued

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Parts 430 & 431 included here as a convenience to the users of this code)

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	DRAW PATTERN	PERFORMANCE REQUIRED[a]	TEST PROCEDURE[b]
Gas instantaneous water heater[i]	> 50,000 Btu/h and < 200,000 Btu/h[k]	< 2 gal[d]	Very small Low Medium High	UEF ≥ 0.80 UEF ≥ 0.81 UEF ≥ 0.81 UEF ≥ 0.81	DOE 10 CFR Part 430 App. E
	≥ 200,000 Btu/h[k]	< 10 gal	—	80% E_t	DOE 10 CFR 431.106
	≥ 200,000 Btu/h[k]	≥10 gal	—	80% E_t $SL \le Q/(800 + 110\sqrt{V})$ Btu/h	
Oil storage water heaters[e, m]	≤ 105,000 Btu/h	≤ 50 gal[d]	Very small Low Medium High	UEF = 0.2509 – (0.0012 × V_r) UEF = 0.5330 – (0.0016 × V_r) UEF = 0.6078 – (0.0016 × V_r) UEF = 0.6815 – (0.0014 × V_r)	DOE 10 CFR Part 430
	> 105,000 Btu/h and ≤ 140,000 Btu/h[l]	≤ 120 gal & ≤180°F	Very small Low Medium High	UEF ≥ 0.2932 – (0.0015 × V_r) UEF ≥ 0.5596 – (0.0018 × V_r) UEF ≥ 0.6194 – (0.0016 × V_r) UEF ≥ 0.6740 – (0.0013 × V_r)	DOE 10 CFR Part 430 App. E
	> 140,000 Btu/h	All	—	80% E_t $SL \le Q/(800 + 110\sqrt{V})$ Btu/h	DOE 10 CFR 431.106
Oil instantaneous water heaters[h, m]	≤ 210,000 Btu/h	< 2 gal	—	80% E_t EF ≥ 0.59 – (0.0005 × V)	DOE 10 CFR Part 430 App. E
	> 210,000 Btu/h	< 10 gal	—	80% E_t	DOE 10 CFR 431.106
	> 210,000 Btu/h	≥ 10 gal	—	78% E_t $SL \le Q/(800 + 110\sqrt{V})$ Btu/h	DOE 10 CFR 431.106
Hot water supply boilers, gas and oil[h]	≥ 300,000 Btu/h and < 12,500,000 Btu/h	< 10 gal	—	80% E_t	DOE 10 CFR 431.106
Hot water supply boilers, gas[j, m]	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 10 gal	—	80% E_t $SL \le Q/(800 + 110\sqrt{V})$ Btu/h	DOE 10 CFR 431.106
Hot water supply boilers, oil[h, m]	≥ 300,000 Btu/h and < 12,500,000 Btu/h	≥ 10 gal	—	78% E_t $SL \le Q/(800 + 110\sqrt{V})$ Btu/h	DOE 10 CFR 431.106
Pool heaters, gas[d]	All	—[f]	—	82% E_t	DOE 10 CFR Part 430 App. P
Heat pump pool heaters	All	50°F db and 44.2°F wb outdoor air 80.0°F entering water	—	4.0 COP	DOE 10 CFR Part 430 App. P
Unfired storage tanks	All	—	—	Minimum insulation requirement R-12.5 (h × ft^2 × °F)/Btu	(none)

TABLE C404.2
MINIMUM PERFORMANCE OF WATER-HEATING EQUIPMENT—continued

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Parts 430 & 431 included here as a convenience to the users of this code)

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m2, °C = (°F – 32)/1.8, 1 British thermal unit per hour = 0.2931 W, 1 gallon = 3.785 L, 1 British thermal unit per hour per gallon = 0.078 W/L.

a. Thermal efficiency (Et) is a minimum requirement, while standby loss is a maximum requirement. In the standby loss equation, V is the rated volume in gallons and Q is the nameplate input rate in Btu/h. Vm is the measured volume in the tank in gallons. Standby loss for electric water heaters is in terms of %/h and denoted by the term "S," and standby loss for gas and oil water heaters is in terms of Btu/h and denoted by the term "SL." Draw pattern (DP) refers to the water draw profile in the Uniform Energy Factor (UEF) test. UEF and Energy Factor (EF) are minimum requirements. In the UEF standard equations, Vr refers to the rated volume in gallons.
b. Chapter 6 contains a list of the referenced standards, which include test procedures, including the year version, of the referenced test procedure.
c. A tabletop water heater is a storage water heater that is enclosed in a rectangular cabinet with a flat top surface not more than 3 feet in height and has a ratio of input capacity (Btu/h) to tank volume (gal) < 4,000.
d. Water heaters or gas pool heaters in this category are regulated as consumer products by the US DOE, as defined in 10 CFR 430.
e. Storage water heaters have a ratio of input capacity (Btu/h) to tank volume (gal) < 4,000.
f. Efficiency requirements for electric storage water heaters ≤ 12 kW apply to both electric-resistance and heat pump water heaters. There are no minimum efficiency requirements for electric heat pump water heaters greater than 12 kW or for gas heat pump water heaters.
g. A grid-enabled water heater is an electric-resistance water heater that meets all of the following:
    1. Has a rated storage tank volume of more than 75 gallons.
    2. Is manufactured on or after April 16, 2015.
    3. Is equipped at the point of manufacture with an activation lock.
    4. Bears a permanent label applied by the manufacturer that complies with all of the following:
        4.1. Is made of material not adversely affected by water.
        4.2. Is attached by means of nonwater soluble adhesive.
        4.3. Advises purchasers and end users of the intended and appropriate use of the product with the following notice printed in 16.5 point Arial Narrow Bold font: "IMPORTANT INFORMATION: This water heater is intended only for use as a part of an electric thermal storage or demand response program. It will not provide adequate hot water unless enrolled in such a program and activated by your utility company or another program operator. Confirm the availability of a program in your local area before purchasing or installing this product."
h. Instantaneous water heaters and hot water supply boilers have an input capacity (Btu/h) divided by storage volume (gal) ≥ 4,000 (Btu/h)/gal.
i. Electric instantaneous water heaters with input capacity >12 kW and ≤ 58.6 kW that (1) have a storage volume > 2 gallons, (2) are designed to provide outlet hot water at temperatures greater than 180°F, or (3) use three-phase power have no efficiency standard.
j. Gas storage water heaters with input capacity > 75,000 Btu/h and ≤ 105,000 Btu/h must comply with the requirements for the > 105,000 Btu/h if the water heater (1) has a storage volume > 120 gallons, (2) is designed to provide outlet hot water at temperatures greater than 180°F, or (3) uses three-phase power.
k. Refer to Section C404.2.1 for additional requirements for gas storage and instantaneous water heaters and gas hot water supply boilers.
l. Oil storage water heaters with input capacity > 105,000 Btu/h and ≤ 140,000 Btu/h must comply with the requirements for the > 140,000 Btu/h if the water heater either (1) has a storage volume > 120 gallons, (2) is designed to provide outlet hot water at temperatures greater than 180ºF, or (3) uses three-phase power.
m. Water heaters and hot water supply boilers with more than 140 gallons of storage capacity need not meet the standby loss requirement where: (1) the tank surface area is thermally insulated to R-12.5 or more, (2) there is no standing pilot light, and (3) for gas- or oil-fired storage water heaters, the heater is equipped with a fire damper or fan-assisted combustion.

C404.2.1 High-input service water-heating systems. Gas-fired water heaters installed in new buildings where the total input capacity provided by high-capacity gas-fired water heaters is 1,000,000 Btu/h (293 kW) or greater shall comply with either or both of the following requirements:

1. Where a singular piece of a high-capacity gas-fired water heater is installed, the water heater shall have a thermal efficiency, Et, of not less than 92 percent.
2. Where multiple pieces of high-capacity gas-fired water heaters are connected to the same service water-heating system, the combined input-capacity-weighted average thermal efficiency, Et, shall be not less than 90 percent, and a minimum of 30 percent of the input to the high-capacity gas-fired water heaters in the service water-heating system shall have an Et of not less than 92 percent.

Exceptions:

1. The input rating of water heaters installed in individual dwelling units shall not be required to be included in the total input rating of service water-heating equipment for a building.
2. The input rating of water heaters with an input rating of not greater than 105,000 Btu/h (30.8 kW) shall not be required to be included in the total input rating of service water-heating equipment for a building.
3. Where not less than 25 percent of the annual service water-heating requirement is provided by on-site renewable energy or site-recovered energy, the minimum Et requirements of this section shall not apply. On-site renewable energy used to meet Section C405.15.1 or C406.3.1 shall not be used to meet this exception.

C404.3 Heat traps for hot water storage tanks. Storage tank-type water heaters and hot water storage tanks that have vertical water pipes connecting to the inlet and outlet of the tank shall be provided with integral heat traps at those inlets and outlets or shall have pipe-configured heat traps in the piping connected to those inlets and outlets. Tank inlets and outlets associated with solar water-heating system circulation loops shall not be required to have heat traps.

C404.4 Service water heating system piping insulation. Service water heating system piping shall be surrounded by uncompressed insulation. The wall thickness of the insulation shall be not less than the thickness shown in Table C404.4.1. Where the insulation thermal conductivity is not within the range in the table, Equation 4-8 shall be used to calculate the minimum insulation thickness:

Equation 4-8 $$t_{alt} = r \times [(1 + t_{table}/r)k_{alt}/k_{upper} - 1$$

where:

t_{alt} = Minimum insulation thickness of the alternate material (in) (mm).
r = Actual outside radius of the pipe (in) (mm).
t_{table} = Insulation thickness listed in this table for applicable fluid temperature and pipe size.
k_{alt} = Thermal conductivity of the alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu × in/h × ft^2 × °F] [W(m × °C)].
k_{upper} = The upper value of the thermal conductivity range listed in this table for the applicable fluid temperature [Btu × in/h× ft^2 × °F] [W(m × °C)].

For nonmetallic piping thicker than Schedule 80 and having thermal resistance greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat trans- fer per foot (meter) than a steel pipe of the same size with the insulation thickness shown in the table.

Exception: Tubular pipe insulation shall not be required on the following:

1. Factory-installed piping within water heaters and hot water storage tanks.
2. Valves, pumps, strainers and threaded unions in piping that is 1 inch (25 mm) or less in nominal diameter.
3. Piping that conveys hot water that has not been heated through the use of fossil fuels or electricity.
4. Piping from user-controlled shower and bath mixing valves to the water outlets.
5. Cold-water piping of a demand recirculation water system.
6. Piping in existing buildings where alterations are made to existing service water heating systems where there is insufficient space or access to meet the requirements.
7. Piping at locations where a vertical support of the piping is installed.
8. Where piping passes through a framing member if it requires increasing the size of the framing member.

C404.4.1 Installation requirements. The following piping shall be insulated per the requirements of this section:

1. Recirculating system piping, including the supply and return piping.
2. The first 8 feet (2.4 m) of outlet piping from:
   2.1. Storage water heaters.
   2.2. Hot water storage tanks.
   2.3. Any water heater and hot water supply boiler containing not less than 10 gallons (37.9 L) of water heated by a direct heat source, an indirect heat source, or both a direct heat source and an indirect heat source.
3. The first 8 feet (2.4 m) of branch piping connecting to recirculated, heat traced or impedance-heated piping.
4. The makeup water inlet piping between heat traps and the storage water heaters and the storage tanks they are serving, in a nonrecirculating service water heating storage system.
5. Hot water piping between multiple water heaters, between multiple hot water storage tanks, and between water heaters and hot water storage tanks.
6. Piping that is externally heated (such as heat trace or impedance heating).
7. For direct-buried service water heating system piping, reduction of these thicknesses by 1½ inches (38.1 mm) shall be permitted (before thickness adjustment required in Section C404.4) but not to thicknesses less than 1 inch (25.4 mm).

TABLE C404.4.1
MINIMUM PIPING INSULATION THICKNESS FOR SERVICE WATER HEATING SYSTEMS[a]

SERVICE HOT-WATER TEMPERATURE RANGE	INSULATION THERMAL CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity (Btu × in/h × ft² × °F)	Mean Rating Temperature (°F)	< 1	1 to < 1 ½	1 ½ to < 4	4 to < 8	≥ 8
			Insulation Thickness (inches)				
105°F to 140°F	0.22 to 0.28	100	1.0	1.0	1.5	1.5	1.5
> 140°F to 200°F	0.25 to 0.29	125	1.0	1.0	2.0	2.0	2.0
> 200°F	0.27 to 0.30	150	1.5	1.5	2.5	3.0	3.0

For SI: 1 inch = 25.4 mm, 1 Btu/h × ft × °F = 1.73 W/mK, °C = [(°F) – 32]/1.8.

a. These thicknesses are based on energy efficiency considerations only. Additional insulation may be necessary for safety.

C404.5 Heated water supply piping. Heated water supply piping shall be in accordance with Section C404.5.1 or C404.5.2. The flow rate through 1/4-inch (6.4 mm) piping shall be not greater than 0.5 gpm (1.9 L/m). The flow rate through 5/16-inch (7.9 mm) piping shall be not greater than 1 gpm (3.8 L/m). The flow rate through 3/8-inch (9.5 mm) piping shall be not greater than 1.5 gpm (5.7 L/m).

C404.5.1 Maximum allowable pipe length method. The maximum allowable piping length from the nearest source of heated water to the termination of the fixture supply pipe shall be in accordance with the following. Where the piping contains more than one size of pipe, the largest size of pipe within the piping shall be used for determining the maximum allowable length of the piping in Table C404.5.1.

1. For a public lavatory faucet, use the “Public lavatory faucets” column in Table C404.5.1.
2. For all other plumbing fixtures and plumbing appliances, use the “Other fixtures and appliances” column in Table C404.5.1.

TABLE C404.5.1
PIPING VOLUME AND MAXIMUM PIPING LENGTHS

NOMINAL PIPE SIZE (inches)	VOLUME (liquid ounces per foot length)	MAXIMUM PIPING LENGTH (feet)	
		Public Lavatory Faucets	Other Fixtures and Appliances
1/4	0.33	6	50
5/16	0.5	4	50
3/8	0.75	3	50
1/2	1.5	2	43
5/8	2	1	32
3/4	3	0.5	21
7/8	4	0.5	16
1	5	0.5	13
1 ¼	8	0.5	8
1 ½	11	0.5	6
2 or larger	18	0.5	4

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 liquid ounce = 0.030 L, 1 gallon = 128 ounces.

C404.5.2 Maximum allowable pipe volume method. The water volume in the piping shall be calculated in accordance with Section C404.5.2.1. Water heaters, circulating water systems and heat trace temperature maintenance systems shall be considered to be sources of heated water.

The volume from the nearest source of heated water to the termination of the fixture supply pipe shall be as follows:

1. For a public lavatory faucet: not more than 2 ounces (0.06 L).
2. For other plumbing fixtures or plumbing appliances; not more than 0.5 gallon (1.89 L).

C404.5.2.1 Water volume determination. The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters and manifolds between the nearest source of heated water and the termination of the fixture supply pipe. The volume in the piping shall be determined from the "Volume" column in Table C404.5.1 or from Table C404.5.2.1. The volume contained within fixture shutoff valves, within flexible water supply connectors to a fixture fitting and within a fixture fitting shall not be included in the water volume determination. Where heated water is supplied by a recirculating system or heat-traced piping, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

TABLE C404.5.2.1
INTERNAL VOLUME OF VARIOUS WATER DISTRIBUTION TUBING

Nominal Size (inches)	Copper Type L	Copper Type K
$^3/_8$	0.97	0.84
$^1/_2$	1.55	1.45
$^3/_4$	3.22	2.90
1	5.49	5.17
$1^1/_4$	8.36	8.09
$1^1/_2$	11.83	11.45
2	20.58	20.04

For SI: 1 foot = 304.8 mm, 1 inch = 25.4 mm, 1 liquid ounce = 0.030 L, 1 oz/ft^2 = 305.15 g/m^2.
N/A = Not Available.

C404.6 Heated-water circulating and temperature maintenance systems. Heated-water circulation systems shall be in accordance with Section C404.6.1. Heat trace temperature maintenance systems shall be in accordance with Section C404.6.2. Controls for hot water storage shall be in accordance with Section C404.6.3. Automatic controls, temperature sensors and pumps shall be in a location with access. Manual controls shall be in a location with ready access.

C404.6.1 Circulation systems. Heated-water circulation systems shall be provided with a circulation pump. Gravity and thermo- syphon circulation systems shall be prohibited. The system return pipe shall be a dedicated return pipe. Controls shall be configured to automatically turn off the pump when the water in the circulation loop is at the desired temperature and when there is not a demand for hot water. Where a circulation pump serves multiple risers or piping zones, controls shall include self-actuating thermostatic balancing valves or another means of flow control to automatically balance the flow rate through each riser or piping zone.

C404.6.1.1 Demand recirculation controls. 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.

C404.6.2 Heat trace systems. Electric heat trace systems shall comply with IEEE 515.1. Controls for such systems shall be able to 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. Heat trace shall be arranged to be turned off automatically when there is not a demand for hot water.

C404.6.3 Controls for hot water storage. The controls on pumps that circulate water between a water heater and a heated-water storage tank shall limit operation of the pump from heating cycle startup to not greater than 5 minutes after the end of the cycle.

C404.7 Drain water heat recovery units. Drain water heat recovery units shall comply with CSA B55.2. Potable water-side pressure loss shall be less than 10 psi (69 kPa) at maximum design flow. For Group R occupancies, the efficiency of drain water heat recovery unit efficiency shall be in accordance with CSA B55.1.

C404.8 Demand responsive water heating. 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 C404.10.

Exceptions:

1. Water heaters that provide a hot water delivery 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 C404.8
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 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

C404.9 Energy consumption of pools and permanent spas. The energy consumption of pools and permanent spas shall be controlled by the requirements in Sections C404.9.1 through C404.9.3.

C404.9.1 Heaters. The electric power to all heaters shall be controlled by an on-off switch that is an integral part of the heater, mounted on the exterior of the heater, or external to and within 3 feet (914 mm) of the heater in a location with ready access. 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.

C404.9.2 Time switches. Time switches or other control methods that can automatically turn off and on heaters and pump motors 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 solar- and waste-heat-recovery pool heating systems.

C404.9.3 Covers. Outdoor heated pools and outdoor permanent spas shall be provided with a vapor-retardant cover or other approved vapor-retardant means.

Exception: Where more than 75 percent of the energy for heating, computed over an operating 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. On-site renewable energy used to meet Section C405.15.1 or C406.3.1 shall not be used to meet this exception.

C404.10 Portable spas. The energy consumption of electric-powered portable spas shall be controlled by the requirements of APSP 14.

SECTION ECC C405
LIGHTING, ELECTRICAL POWER, AND RENEWABLE ENERGY SYSTEMS

C405.1 General. Electrical power and lighting systems and generation shall comply with this section. General lighting consists of all lighting included when calculating the total connected interior lighting power in accordance with Section C405.3.1 and which does not require specific application controls in accordance with Section C405.2.5.

Lighting controls shall be commissioned and completed in accordance with the requirements of Section C408.3.

Exception: Dwelling units and sleeping units that comply with Section C405.2.10, Section C405.3.3 and Section C405.6.

C405.2 Lighting controls. Lighting systems in *interior parking areas* shall be provided with controls that comply with Section C405.2.9. All other lighting systems powered through the energy service for the *building* and building site lighting for which the *building owner* is responsible shall be provided with controls that comply with Sections C405.2.1 through C405.2.8.

Exceptions: Lighting controls are not required for the following:

1. Spaces where an *automatic* shutoff could endanger occupant safety or security.
2. Interior exit stairways, interior exit ramps and exit passageways.
3. Emergency lighting that is *automatically* off during normal operations.
4. Emergency lighting required by the *New York City Building Code* in exit access components that are not provided with fire alarm systems.
5. Up to 0.02 watts per square foot (0.22 W/m^2) of lighting in exit access components that are provided with fire alarm systems.

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

1. Classrooms/lecture/training rooms.
2. Computer rooms, data centers.
3. Conference/meeting/multipurpose rooms.
4. Copy/print rooms.
5. Lounges/breakrooms.
6. Cafeteria and fast food dining areas.
7. Medical supply rooms in a healthcare facility.
8. Enclosed offices.
9. Laundry/washing areas.
10. Open plan office areas.
11. Restrooms.
12. Storage rooms.
13. Telemedicine rooms in a healthcare facility.
14. Locker rooms.
15. Corridors/transition areas/stairways.
16. Warehouse storage areas.
17. Other spaces 300 square feet (28 m2) or less that are enclosed by floor-to-ceiling height partitions.
18. Janitorial closets.

C405.2.1.1 Occupant sensor control function. Occupant sensor controls in warehouses storage areas shall comply with Section C405.2.1.2. Occupant sensor controls in open plan office areas, cafeteria dining areas, and fast food dining areas, 300 square feet (28 m^2) or greater in area shall comply with Section C405.2.1.3. Occupant sensor controls in corridors shall comply with Section C405.2.1.4. Occupant sensor control function for egress illumination shall comply with Section C405.2.1.5. Occupant sensor controls for all other spaces specified in Section C405.2.1 shall comply with the following:

1. They shall automatically turn off lights within 15 minutes after all occupants have left the space.
2. They shall be manual-on or controlled to automatically turn on the lighting to not more than 50-percent power of full power.
3. They shall incorporate a manual control to allow occupants to turn off lights.

Exceptions:

1. Full automatic-on controls with no manual control shall be permitted in corridors, interior parking areas, stairways, restrooms, locker rooms, lobbies, library stacks and areas where manual operation would endanger occupant safety or security.
2. Manual-on controls shall be required for classrooms (not including shop classrooms, laboratory classrooms, and preschool classrooms), conference/meeting rooms, employee lunch and break rooms, and offices smaller than 200 square feet (18.5 m^2) in area. Such sensors and controls shall not have an override switch that converts from manual-on to automatic-on functionality, and may have a grace period of up to 30 seconds to turn on the lighting automatically after the sensor has turned off the lighting if occupancy is detected.
3. Remote location of this local control device or devices shall be permitted for reasons of safety or security when each remote control device has an indicator pilot light as part of or next to the control device and the light is clearly labeled to identify the controlled lighting.

C405.2.1.2 Occupant sensor control function in warehouse storage areas. Lighting in warehouse storage areas shall be controlled as follows:

1. Lighting in each aisleway shall be controlled independently of lighting in all other aisleways and open areas.
2. Occupant sensors shall automatically reduce lighting power within each controlled area to an unoccupied setpoint of not more than 30 percent of full power within 15 minutes after all occupants have left the controlled area.
3. Lights that are not turned off by occupant sensors shall be turned off by *time-switch control* complying with Section C405.2.2.1.
4. A *manual* control shall be provided to allow occupants to turn off lights in the space.

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

1. The controls shall be configured so that general lighting can be separated into control zones with floor areas not greater than 600 square feet (55 m2) within the open plan office space or dining space. Where a through aisle traverses a control zone or separates two control zones, the luminaires serving the aisle shall be controlled separately from the general lighting in the control zones.
2. General lighting in each control zone shall be permitted to automatically turn on upon occupancy within the control zone. General lighting in other unoccupied zones within the open plan office space shall be permitted to turn on to not more than 20 percent of full power or remain unaffected.
3. The controls shall automatically turn off general lighting in all control zones within 15 minutes after all occupants have left the open plan office space.

   Exception: Where general lighting is turned off by time-switch control complying with Section C405.2.2.1.
4. General lighting in each control zone shall turn off or uniformly reduce lighting power to an unoccupied setpoint of not more than 20 percent of full power within 15 minutes after all occupants have left the control zone.

C405.2.1.4 Occupant sensor control function in corridors. Occupant sensor controls in corridors shall uniformly reduce lighting power to an occupied setpoint not more than 50 percent of full power within 15 minutes after all occupants have left the space**.**

Exception: Corridors provided with less than two footcandles of illumination on the floor at the darkest point with all lights on.

C405.2.1.5 Occupant sensor control function for egress illumination. In new buildings, luminaires serving the exit access and providing means of egress illumination required by the New York City Building Code, including luminaires that function as both normal and emergency means of egress illumination, operating under normal conditions shall be controlled by a combination of listed emergency relay and occupancy sensors, or signal from another building control system, that automatically reduces the lighting power by at least 50% percent when unoccupied for a period longer than 15 minutes.

Exceptions:

1. Means of egress illumination serving the exit access that does not exceed 0.02 watts per square foot of building area is exempt from this requirement.
2. Emergency lighting designated to meet the requirements of the *New York City Building Code.*

C405.2.2 Time-switch controls. Each area of the *building* that is not provided with *occupant sensor controls* complying with Section C405.2.1.1 shall be provided with *time-switch controls* complying with Section C405.2.2.1.

Exceptions:

1. Luminaires that are required to have specific application controls in accordance with Section C405.2.4.
2. Spaces where patient care is directly provided.

C405.2.2.1 Time-switch control function. *Time-switch controls* shall comply with all of the following:

1. Programmed to automatically turn off lights when the space is scheduled to be unoccupied.
2. Have a minimum 7-day clock.
3. Be capable of being set for seven different day types per week.
4. Incorporate an *automatic* holiday "shutoff" feature, which turns off all controlled lighting loads for not fewer than 24 hours and then resumes normally scheduled operations.
5. Have program backup capabilities, which prevent the loss of program and time settings for not fewer than 10 hours, if power is interrupted.
6. Include an override switch that complies with the following:
   6.1. The override switch shall be a *manual* control.
   6.2. The override switch, when initiated, shall permit the controlled lighting to remain on for not more than 2 hours.
   6.3. Any individual override switch shall control the lighting for an area not larger than 5,000 square feet (465 m^2).
7. For spaces where schedules are not defined time switch controls are programmed by default to a schedule that turns off lights not less than 12 hours per day.

Exception: Within mall concourses, auditoriums, sales areas, manufacturing facilities and sports arenas:

1. The time limit shall be permitted to be greater than 2 hours, provided that the switch is a captive key device.
2. The area controlled by the override switch shall not be limited to 5,000 square feet (465 m^2) provided that such area is less than 20,000 square feet (1860 m^2).

C405.2.3 Dimming controls. Dimming controls complying with Section C405.2.3.1 are required for general lighting in the following space types:

1. Classrooms/lecture hall/training rooms.
2. Conference/multipurpose/meeting rooms.
3. Dining areas for bar/lounge, leisure, or family dining.
4. Gymnasiums/fitness centers.
5. Health care facility imaging rooms, exam rooms, nurseries or nurses' stations.
6. Laboratories.
7. Library reading rooms.
8. Lobbies.
9. Lounge/break rooms.

10. Offices.
11. Spaces not provided with *occupant sensor controls* complying with Section C405.2.1.1.

Exception: Luminaires controlled by special application controls complying with Section C405.2.5.

C405.2.3.1 Dimming control function. Spaces required to have dimming control shall be provided with *manual* controls that allow lights to be dimmed from full output to 10 percent of full power or lower with continuous dimming, as well as turning off lights. *Manual* control shall be provided within each room to dim lights.

Exceptions: *Manual* dimming control is not required in spaces where *high-end trim* lighting controls are provided that comply with the following:

1. The calibration adjustment equipment is located for ready *access* only by authorized personnel.
2. Lighting controls with ready *access* for users cannot increase the lighting power above the maximum level established by the *high-end trim* controls.

C405.2.4 Daylight responsive controls. Daylight responsive controls complying with Section C405.2.4.1 shall be provided to control the general lighting within daylight zones in the following spaces:

1. Spaces with a total of more than 75 watts of *general lighting* within primary sidelit *daylight zones* complying with Section C405.2.4.2.
2. Spaces with a total of more than 150 watts of *general lighting* within sidelit *daylight zones* complying with Section C405.2.4.2.
3. Spaces with a total of more than 75 watts of *general lighting* within toplit *daylight zones* complying with Section C405.2.4.3.

Exceptions: *Daylight responsive controls* are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Sidelit *daylight zones* on the first floor above grade in Group A-2 and Group M occupancies.
3. Enclosed office spaces less than 250 square feet (23.2 m^2).

C405.2.4.1 Daylight responsive control function. Where required, daylight responsive controls shall be provided within each space for control of lights in that space and shall comply with all of the following:

1. Lights in toplit daylight zones in accordance with Section C405.2.4.3 shall be controlled independently of lights in sidelit daylight zones in accordance with Section C405.2.4.2.
2. Lights in the primary sidelit daylight zone shall be controlled independently of lights in the secondary sidelit daylight zone.
3. Daylight responsive controls within each space shall be configured so that they can be calibrated from within that space by authorized personnel.
4. Calibration mechanisms shall be in a location with ready access.
5. Daylight responsive controls shall dim lights continuously from full light output to 15 percent of full light output or lower.
6. Daylight responsive controls shall be configured to completely shut off all controlled lights.
7. When occupant sensor controls have reduced the lighting power to an unoccupied setpoint in accordance with Sections C405.2.1.2 through

C405.2.1.4, daylight responsive controls shall continue to adjust electric light levels in response to available daylight, but shall be configured to not increase the lighting power above the specified unoccupied setpoint.

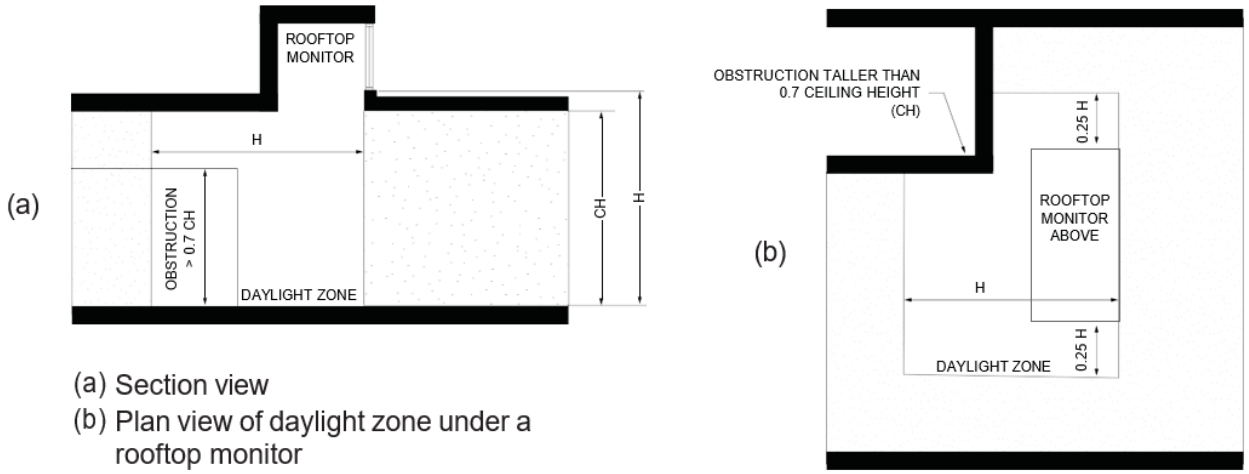
8. Lights in sidelit daylight zones in accordance with Section C405.2.4.2 facing different cardinal orientations [within 45 degrees (0.79 rad) of due north, east, south, west] shall be controlled independently of each other.

Exceptions:

1. Within each space, up to 100 watts of lighting within the primary sidelit daylight zone is permitted to be controlled together with lighting in a primary sidelit daylight zone facing a different cardinal orientation.
2. Within each space, up to 100 watts of lighting within the secondary sidelit daylight zone is permitted to be controlled together with lighting in a secondary sidelit daylight zone facing a different cardinal orientation.

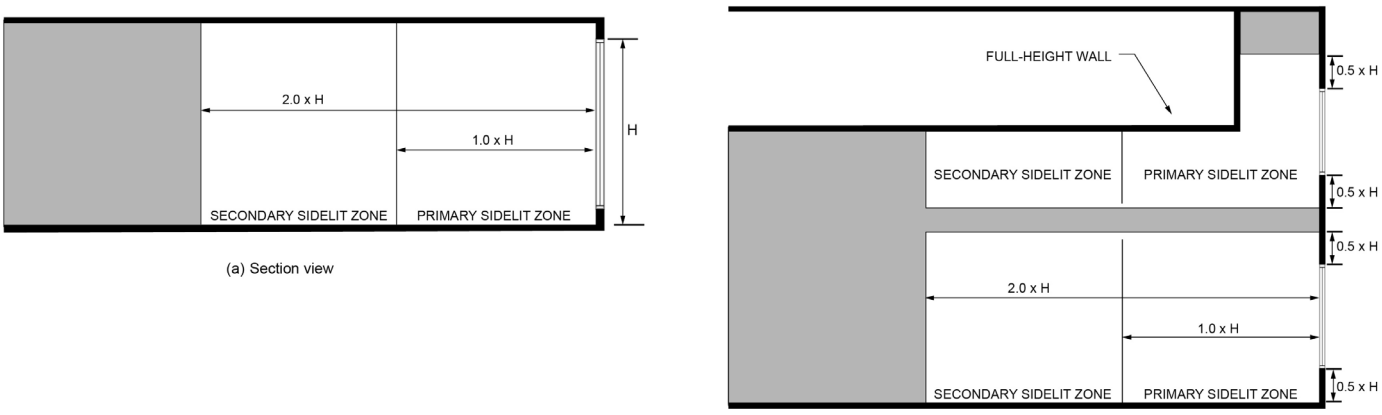
C405.2.4.2 Sidelit daylight zone. The sidelit daylight zone is the floor area adjacent to vertical fenestration that complies with all of the following:

1. Where the fenestration is located in a wall, the primary sidelit daylight zone shall extend laterally to the nearest full- height wall, or up to 1.0 times the height from the floor to the top of the fenestration, and longitudinally from the edge of the fenestration to the nearest full-height wall, or up to 0.5 times the height from the floor to the top of the fenestration, whichever is less, as indicated in Figure C405.2.4.2(1).
2. Where the fenestration is located in a rooftop monitor, the primary sidelit daylight zone shall extend laterally to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 1.0 times the height from the floor to the bottom of the fenestration, whichever is less, and longitudinally from the edge of the fenestration to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 0.25 times the height from the floor to the bottom of the fenestration, whichever is less, as indicated in Figures C405.2.4.2(2) and C405.2.4.2(3).
3. Where the fenestration is located in a wall, the secondary sidelit daylight zone is directly adjacent to the primary sidelit daylight zone and shall extend laterally to 2.0 times the height from the floor to the top of the fenestration or to the nearest full height wall, whichever is less, and longitudinally from the edge of the fenestration to the nearest full height wall, or up to 0.5 times the height from the floor to the top of the fenestration, whichever is less, as indicated in Figure C405.2.4.2(1).
4. The area of the fenestration is not less than 24 square feet (2.23 m2).
5. The distance from the fenestration to any building or geological formation that would block access to daylight is greater than one-half of the height from the bottom of the fenestration to the top of the building or geologic formation.
6. The visible transmittance of the fenestration is not less than 0.20.
7. The projection factor (determined in accordance with Equation 4-4) for any overhanging projection that is shading the fenestration is not greater than 1.0 for fenestration oriented 45 degrees or less from true north and not greater than 1.5 for all other orientations.



(a) Section view
(b) Plan view of daylight zone under a rooftop monitor

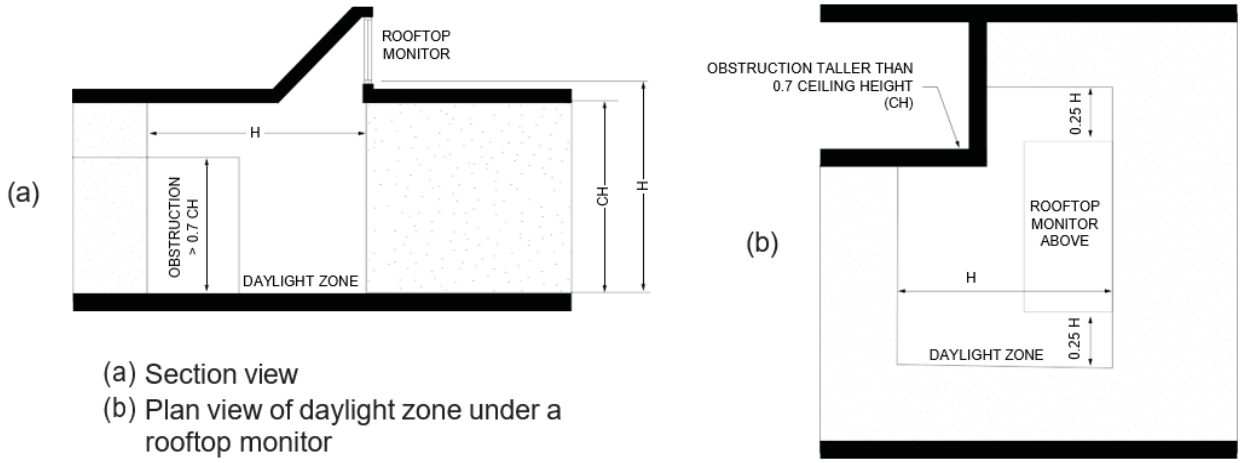
FIGURE C405.2.4.2(1)
PRIMARY AND SECONDARY SIDELIT DAYLIGHT ZONE



(a) Section view

(b) Plan view

FIGURE C405.2.4.2(2)
DAYLIGHT ZONE UNDER A ROOFTOP MONITOR

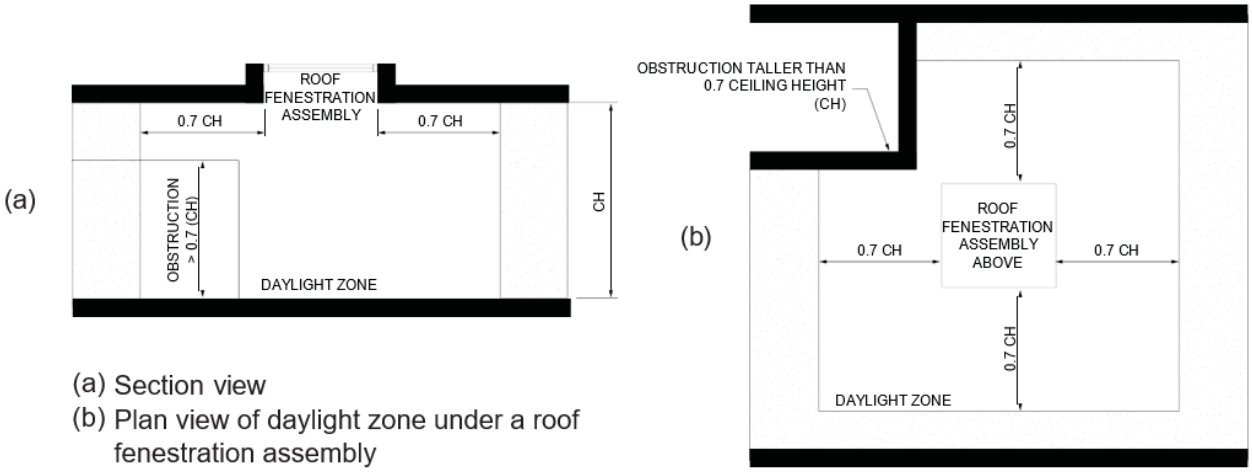


(a) Section view
(b) Plan view of daylight zone under a rooftop monitor

FIGURE C405.2.4.2(3)
DAYLIGHT ZONE UNDER A SLOPED ROOFTOP MONITOR

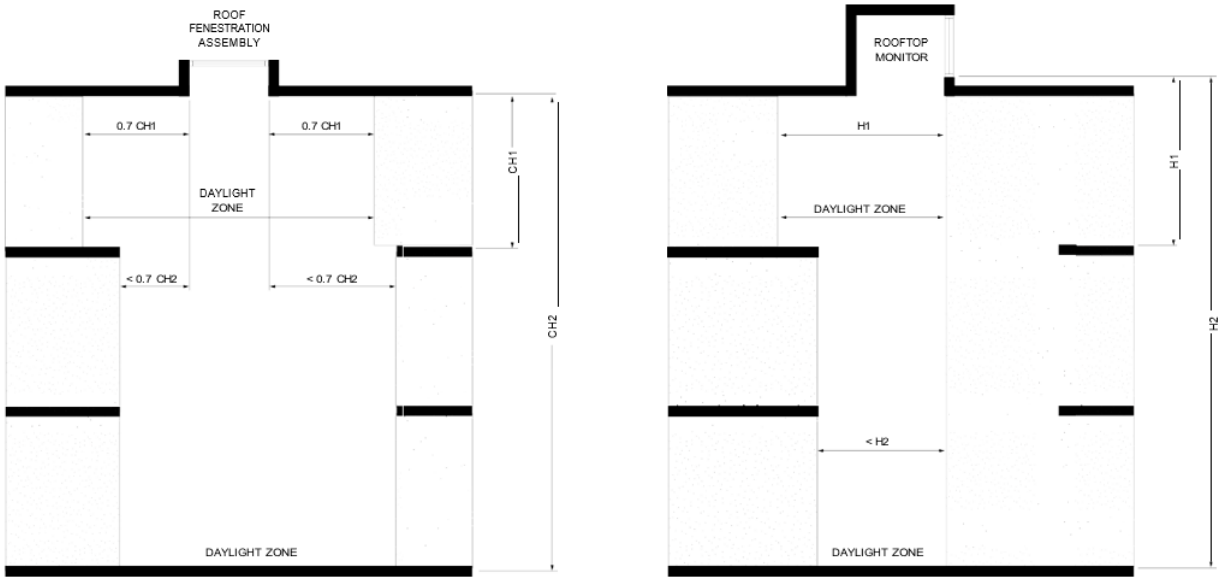
C405.2.4.3 Toplit daylight zone. The toplit daylight zone is the floor area underneath a roof fenestration assembly that complies with all of the following:

1. The toplit daylight zone shall extend laterally and longitudinally beyond the edge of the roof fenestration assembly to the nearest obstruction that is taller than 0.7 times the ceiling height, or up to 0.7 times the ceiling height, whichever is less, as indicated in Figure C405.2.4.3.
2. Direct sunlight is not blocked from hitting the roof fenestration assembly at the peak solar angle on the summer solstice by buildings or geological formations.
3. The product of the visible transmittance of the roof fenestration assembly and the area of the rough opening of the roof fenestration assembly divided by the area of the toplit zone is not less than 0.008.



(a) Section view
(b) Plan view of daylight zone under a roof fenestration assembly

FIGURE C405.2.4.3
TOPLIT DAYLIGHT ZONE



(a) Section view of roof fenestration assembly at atrium

(b) Section view of roof monitor at atrium

FIGURE C405.2.4.4
DAYLIGHT ZONES AT A MULTISTORY ATRIUM

C405.2.4.4 Atriums. Daylight zones at atrium spaces shall be established at the top floor surrounding the atrium and at the floor of the atrium space, and not on intermediate floors, as indicated in Figure C405.2.4.4.

C405.2.5 Specific application controls. Specific application controls shall be provided for the following:

1. The following lighting shall be controlled by an occupant sensor complying with Section C405.2.1.1 or a time-switch control complying with Section C405.2.2.1. In addition, a manual control shall be provided to control such lighting separately from the general lighting in the space:
    1.1. Luminaires for which additional lighting power is claimed in accordance with Section C405.3.2.2.1.
    1.2. Display and accent, including lighting in display cases.
    1.3. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting.
    1.4. Lighting equipment that is for sale or demonstration in lighting education.
2. Lighting for nonvisual applications, such as plant growth and food warming, shall be controlled by a time switch control complying with Section C405.2.2.1 that is independent of the controls for other lighting within the room or space.
3. Task lighting for medical and dental purposes that is in addition to general lighting shall be provided with a manual control.
4. Lighting integrated into range hoods and exhaust fans shall be controlled independently of fans.

C405.2.6 Manual controls. Where required by this code, manual controls for lights shall comply with the following:

1. They shall be in a location with ready access to occupants.
2. They shall be located where the controlled lights are visible, or shall identify the area served by the lights and indicate their status.

C405.2.7 Exterior lighting controls. Exterior lighting systems shall be provided with controls that comply with Sections C405.2.7.1 through C405.2.7.4.

Exceptions:

1. Lighting for covered vehicle entrances to buildings where required for eye adaptation.
2. Lighting controlled from within dwelling units.

C405.2.7.1 Daylight shutoff. Lights shall be automatically turned off when daylight is present and satisfies the lighting needs.

C405.2.7.2 Building facade and landscape lighting. Building facade and landscape lighting shall automatically shut off, when sufficient daylight is present or not later than 1 hour after building or business closing until not earlier than 1 hour before building or business opening. For buildings that operate 24 hours, building's façade lighting shall shut off at midnight.

Exception: Designated areas in zones 3 and 4 during special events may be permitted to extend hours of façade lighting at the discretion of the commissioner.

C405.2.7.3 Lighting setback. Lighting that is not controlled in accordance with Section C405.2.7.2 shall comply with the following:

1. Be controlled so that the total wattage of such lighting is automatically reduced by not less than 50 percent by selectively switching off or dimming luminaires at one of the following times:
   1.1. From not later than midnight to not earlier than 6 a.m.
   1.2. From not later than 1 hour after building or business closing to not earlier than 1 hour before building or business opening.
   1.3. During any time where activity has not been detected for 15 minutes or more.
2. Luminaires serving exterior parking areas and having a rated input wattage of greater than 40 watts and a mounting height of 24 feet (7315 mm) or less above the ground shall be controlled so that the total wattage of such lighting is automatically reduced by not less than 50 percent during any time where activity has not been detected for 15 minutes or more. Not more than 1,500 watts of lighting power shall be controlled together.

C405.2.8 Demand responsive lighting controls. Interior general lighting in group B, E, M, and S occupancies shall have demand responsive controls complying with C405.2.8.1 in not less than 75 percent of the interior floor area.

Exceptions:

1. Where the combined interior floor area of group B, E, M, and S occupancies is less than 10,000 square feet.
2. Buildings where a demand response signal is not available from a controlling entity other than the owner.
3. Parking garages.
4. Ambulatory care facilities.
5. Outpatient clinics.
6. Physician or dental offices.

C405.2.8.1 Demand responsive lighting controls function. Demand responsive controls for lighting shall be capable of the following:

1. Automatically reducing the output of controlled lighting to 80 percent or less of full power or light output upon receipt of a demand response signal.
2. Where high-end trim has been set, automatically reducing the output of controlled lighting to 80 percent or less of the high-end trim setpoint upon receipt of a demand response signal.
3. Dimming controlled lights gradually and continuously over a period of not longer than 15 minutes to achieve their demand response setpoint.
4. Returning controlled lighting to its normal operational settings at the end of the demand response period.

Exception: Storage rooms and warehouse storage areas shall be permitted to switch off 25 percent or more of general lighting power rather than dimming.

C405.2.9 Interior parking area lighting control. Interior parking area lighting shall be controlled by an occupant sensor complying with Section C405.2.1.1 or a time-switch control complying with Section C405.2.2.1. Additional lighting controls shall be provided as follows:

1. Lighting power of each luminaire shall be automatically reduced by not less than 30 percent when there is no activity detected within a lighting zone for 15 minutes. Lighting zones for this requirement shall be no larger than 3,600 square feet (334.5 m^2).

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

2. Where lighting for eye adaptation is provided at vehicle entrances to buildings, such lighting shall be separately controlled by a device that automatically reduces lighting power by at least 50 percent from sunset to sunrise.

3. The power to luminaires within 20 feet (6096 mm) of perimeter wall openings or skylights shall automatically reduce in response to daylight by at least 50 percent.

   Exceptions:

   1. Where the opening-to-wall ratio is less than 40 percent as viewed from the interior and encompassing the vertical distance from the driving surface to the lowest structural element.

   2. Where the distance from the opening to any exterior daylight blocking obstruction is less than one-half the height from the bottom of the opening or fenestration to the top of the obstruction.

   3. Where openings are obstructed by permanent screens or architectural elements restricting daylight entering the interior space.

C405.2.10 Sleeping unit and dwelling unit lighting and switched receptacle controls. Sleeping units and dwelling units shall be provided with lighting controls and switched receptacles as specified in Sections C405.2.10.1 and C405.2.10.2.

C405.2.10.1 Sleeping units and dwelling units in hotels, motels and vacation timeshare properties. Sleeping units and dwelling units in hotels, motels and vacation timeshare properties shall be provided with the following:

1. Not less than two 125V, 15- and 20-amp switched receptacles in each room, except for bathrooms, kitchens, foyers, hallways and closets.

2. Lighting controls that automatically turn off all lighting and switched receptacles within 15 minutes after all occupants have left the unit.

C405.2.10.2 Sleeping units in congregate living facilities. Sleeping units in congregate living facilities shall be provided with the following controls:

1. Lighting in bathrooms shall be controlled by an occupant sensor control that automatically turns off lights within 15 minutes after all occupants have left the space.

2. Each unit shall have a manual control by the entrance that turns off all lighting and switched receptacles in the unit, except for lighting in bathrooms and kitchens. The manual control shall be marked to indicate its function.

C405.3 Interior lighting power requirements. A building complies with this section where its total connected interior lighting power calculated under Section C405.3.1 is not greater than the interior lighting power allowance calculated under Section C405.3.2. Sleeping units and dwelling units shall comply with Section C405.3.3.

C405.3.1 Total connected interior lighting power. The total connected interior lighting power shall be determined in accordance with Equation 4-9.

Equation 4-9 TCLP = [LVL + BLL + LED + TRK + Other]

where:

TCLP = Total connected lighting power (watts).

LVL = For luminaires with lamps connected directly to building power, such as line voltage lamps, the rated wattage of the lamp.

BLL = For luminaires incorporating a ballast or transformer, the rated input wattage of the ballast or transformer when operating that lamp.

LED = For light-emitting diode luminaires with either integral or remote drivers, the rated wattage of the luminaire.

TRK = For lighting track, cable conductor, rail conductor, and plug-in busway systems that allow the addition and relocation of luminaires without rewiring, the wattage shall be one of the following:

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

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

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

1. Emergency lighting automatically off during normal building operation.
2. Lighting in spaces specifically designed for use by occupants with special lighting needs, including those with visual impairment and other medical and age-related issues.
3. Mirror lighting in makeup or dressing areas used for video broadcasting, video or film recording, or live theatrical and music performance.
4. Task lighting for medical and dental purposes that is in addition to general lighting.
5. Display lighting for exhibits in galleries, museums and monuments that is in addition to general lighting.
6. Lighting in any location that is specifically used for video broadcasting, video or film recording, or live theatrical and music performance.
7. Lighting for photographic processes.

8. Lighting integral to equipment or instrumentation and installed by the manufacturer.
9. Task lighting for plant growth or maintenance.
10. Advertising signage or directional signage.
11. Lighting for food warming.
12. Lighting equipment that is for sale.
13. Lighting demonstration equipment in lighting education facilities.
14. Lighting approved because of safety considerations.
15. Lighting in retail display windows, provided that the display area is enclosed by ceiling-height partitions.
16. Furniture-mounted supplemental task lighting that is controlled by automatic shutoff.
17. Exit signs.
18. Antimicrobial lighting used for the sole purpose of disinfecting a space.
19. Lighting in dwelling units.
20. For exit access and exit stairways, including landings, where the applicable code requires an illuminance of 10 footcandles or more on the walking surface, the power in excess of the allowed power calculated according to Section C405.3.2.2 is not included.

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

C405.3.2.1 Building Area Method. For the Building Area Method, the interior lighting power allowance is calculated as follows:

1. For each building area type inside the building, determine the applicable building area type and the allowed lighting power density for that type from Table C405.3.2(1). For building area types not listed, select the building area type that most closely represents the use of that area. For the purposes of this method, an “area” shall be defined as all contiguous spaces that accommodate or are associated with a single building area type.
2. Determine the floor area for each building area type listed in Table C405.3.2(1) and multiply this area by the applicable value from Table C405.3.2(1) to determine the lighting power (watts) for each building area type. Sleeping units and dwelling units are excluded from lighting power allowance calculations by application of Section C405.3.3. The area of dwelling units is not included in the calculation.
3. The total interior lighting power allowance (watts) for the entire building is the sum of the lighting power from each building area type.

TABLE C405.3.2(1)
INTERIOR LIGHTING POWER ALLOWANCES: BUILDING AREA METHOD

BUILDING AREA TYPE	LPD (watts/ft^2)
Automotive facility	0.64
Convention center	0.64
Courthouse	0.74
Dining: bar lounge/leisure	0.69
Dining: cafeteria/fast food	0.66
Dining: family	0.61
Dormitory	0.52
Exercise center	0.65
Fire station	0.50
Gymnasium	0.67
Health care clinic	0.68
Hospital	0.86
Hotel/Motel	0.53
Library	0.78
Manufacturing facility	0.60
Motion picture theater	0.43
Multiple-family	0.46
Museum	0.56
Office	0.62
Parking garage	0.12
Penitentiary	0.65
Performing arts theater	0.82
Police station	0.62
Post office	0.62
Religious building	0.66
Retail	0.78
School/university	0.67
Sports arena	0.73
Town hall	0.67
Transportation	0.51
Warehouse	0.41
Workshop	0.83

For SI: 1 watt per square foot = 10.76 w/m^2.

C405.3.2.2 Space-by-Space Method. Where a building has unfinished spaces, the lighting power allowance for the unfinished spaces shall be the total connected lighting power for those spaces, or 0.1 watts per square foot (1.08 w/m^2), whichever is less. For the Space-by-Space Method, the interior lighting power allowance is calculated as follows:

1. For each space enclosed by partitions that are not less than 80 percent of the ceiling height, determine the applicable space type from Table C405.3.2(2). For space types not listed, select the space type that most closely represents the proposed use of the space. Where a space has multiple functions, that space may be divided into separate spaces.
2. Determine the total floor area of all the spaces of each space type and multiply by the value for the space type in Table C405.3.2(2) to determine the allowed lighting power (watts) for each space type. Sleeping units and dwelling units are excluded from lighting power allowance calculations by application of Section C405.3.3. The area of dwelling units is not included in the calculation.
3. The total interior lighting power allowance (watts) shall be the sum of the lighting power allowances for all space types.

C405.3.2.2.1 Additional interior lighting power. Where using the Space-by-Space Method, an increase in the interior lighting power allowance is permitted for specific lighting functions. Additional power shall be permitted only where the specified lighting is installed and controlled in accordance with Section C405.2.5. These additional power allowances shall be used only for the luminaires serving the specific lighting function and shall not be used for any other purpose. An increase in the interior lighting power allowance is permitted in the following cases:

1. For lighting equipment to be installed in sales areas specifically to highlight merchandise, the additional lighting power allowance shall be the connected lighting power of the luminaires specifically highlighting merchandise, calculated in accordance with Equation 4-9, or the additional power allowance calculated in accordance with Equation 4-10, whichever is less.

Equation 4-10

Additional lighting power allowance = 750 W + (Retail Area 1 × 0.40 W/ft^2) + (Retail Area 2 × 0.40W/ft^2) + (Retail Area 3 × 0.70 W/ft^2) + (Retail Area 4 × 1.00 W/ft^2)

For SI units:
Additional lighting power allowance = 750 W + (Retail Area 1 × 4.3 W/m^2) + (Retail Area 2 × 4.3 W/m^2) + (Retail Area 3 × 7.5 W/m^2) + (Retail Area 4 × 10.8 W/m^2)

where:

Retail Area 1 = The floor area for all products not listed in Retail Area 2, 3 or 4.
Retail Area 2 = The floor area used for the sale of vehicles, sporting goods and small electronics.
Retail Area 3 = The floor area used for the sale of furniture, clothing, cosmetics and artwork.
Retail Area 4 = The floor area used for the sale of jewelry, crystal and china.

Exception: Other merchandise categories are permitted to be included in Retail Areas 2 through 4, provided that justification documenting the need for additional lighting power based on visual inspection, contrast or other critical display is approved by the building official.

2. For spaces in which lighting is specified to be installed in addition to the general lighting for the purpose of decorative appearance or for highlighting art or exhibits, the additional lighting power allowance for that space shall be the smallest of the following:

   2.1. 0.66 W/ft^2 (7.1W/m^2) in lobbies,

   2.2. 0.55 W/ft^2 (5.9 W/m^2) in other spaces, or

   2.3. The connected lighting power of the luminaires specifically for decorative appearance or for highlighting art or exhibits, calculated according to Equation 4-9.

TABLE C405.3.2(2)
INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD

COMMON SPACE TYPES[a]	LPD (watts/ft²)
Atrium	
Less than 40 feet in height	0.41
Greater than 40 feet in height	0.51
Audience seating area	
In an auditorium	0.57
In a gymnasium	0.23
In a motion picture theater	0.27
In a penitentiary	0.28
In a performing arts theater	1.09
In a religious building	0.72
In a sports arena	0. 27
Otherwise	0.33
Banking activity area	0.56
Breakroom (See Lounge/breakroom)	
Classroom/lecture hall/training room	
In a penitentiary	0.74
Otherwise	0.72
Computer room, data center	0.75
Conference/meeting/multipurpose room	0.88
Confinement cells	0.52
Copy/print room	0.50
Corridor	
In a facility for the visually impaired (and not used primarily by the staff)[b]	0.71
In a hospital	0.61
Otherwise	0.44
Courtroom	1.06
Dining area	
In bar/lounge or leisure dining	0.62
In cafeteria or fast food dining	0.36
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.22
In family dining	0.52
In a penitentiary	0.35
Otherwise	0.42
Electrical/mechanical room	0.39
Emergency vehicle garage	0.41
Food preparation area	0.92
Guestroom[c, d]	0.41

TABLE C405.3.2(2)
INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD-continued

COMMON SPACE TYPES[a]	LPD (watts/ft²)
Laboratory	
In or as a classroom	1.04
Otherwise	1.21
Laundry/washing area	0.43
Loading dock, interior	0.51
Lobby	
For an elevator	0.52
In a facility for the visually impaired (and not used primarily by the staff)[b]	1.44
In a motion picture theater	0.20
In a performing arts theater	0.82
Otherwise	0.80
Locker room	0.43
Lounge/breakroom	
In a healthcare facility	0.53
Mother's wellness room	0.68
Otherwise	0.44
Office	
Enclosed	0.73
Open plan	0.56
Parking area daylighting transition zone	1.06
Parking area, interior[i]	0.11
Patient room	0.78
Pharmacy area	1.23
Restroom	
In a facility for the visually impaired (and not used primarily by the staff[b]	0.81
Otherwise	0.74
Sales area	0.85
Seating area, general	0.21
Security screening general areas	0.64
Security screening in transportation facilities	0.93
Security screening transportation waiting area	0.56
Stairway (see Space containing stairway)	
Stairwell	0.47
Storage room	0.35
Vehicular maintenance area	0.53
Workshop	1.09

TABLE C405.3.2(2)
INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD-continued

BUILDING TYPE SPECIFIC SPACE TYPES[a]	LPD (watts/ft²)
Automotive (see Vehicular maintenance area)	
Convention Center—exhibit space	0.50
Dormitory—living quarters[c, d]	0.46
Facility for the visually impaired[b]	
In a chapel (and not used primarily by the staff)	0.58
In a recreation room (and not used primarily by the staff)	1.20
Fire station—sleeping quarters	0.19
Gaming establishments	
High limits game	1.68
Slots	0.54
Sportsbook	0.82
Table Games	1.09
Gymnasium/fitness center	
In an exercise area	0.50
In a playing area	0.75
Healthcare facility	
In an exam/treatment room	1.16
In an imaging room	0.94
In a medical supply room	0.54
In a nursery	0.87
In a nurse's station	0.75
In an operating room	1.87
In a patient room[c]	0.45
In a physical therapy room	0.82
In a recovery room	0.89
In a telemedicine room	1.44
Library	
In a reading area	0.77
In the stacks	1.18
Manufacturing facility	
In a detailed manufacturing area	0.75
In an equipment room	0.61
In an extra-high-bay area (greater than 50 feet floor-to-ceiling height)	0.73
In a high-bay area (25–50 feet floor-to-ceiling height)	0.58
In a low-bay area (less than 25 feet floor-to-ceiling height)	0.61
Museum	
In a general exhibition area	0.31
In a restoration room	0.77

TABLE C405.3.2(2)
INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD-continued

BUILDING TYPE SPECIFIC SPACE TYPES[a]	LPD (watts/ft²)
Performing arts theater—dressing room	0.35
Post office—sorting area	0.66
Religious buildings	
In a fellowship hall	0.50
In a worship/pulpit/choir area	0.75
Retail facilities	
In a dressing/fitting room	0.45
Hair salon	0.65
Nail salon	0.75
In a mall concourse	0.57
Massage space	0.81
Sports arena—playing area	
For a Class I facility[c]	2.26
For a Class II facility-[d]	1.45
For a Class III facility [e]	1.08
For a Class IV facility [f]	0.72
Sports arena—pools	
For a Class I facility	2.20
For a Class II facility	1.47
For a Class III facility	0.99
For a Class IV facility	0.59
Transportation facility	
Airport hanger	1.36
Passenger loading area	0.71
In a baggage/carousel area	0.28
In an airport concourse	0.31
At a terminal ticket counter	0.40
Warehouse—storage area	
For medium to bulky, palletized items	0.27
For smaller, hand-carried items	0.65

For SI: 1 foot = 304.8 mm, 1 watt per square foot = 10.76 w/m^2.

a. In cases where both a common space type and a building area specific space type are listed, the building area specific space type shall apply.
b. A 'Facility for the Visually Impaired' is a facility that is licensed or will be licensed by local or state authorities for senior long-term care, adult daycare, senior support or people with special visual needs.
c. Class I facilities consist of professional facilities; and semiprofessional, collegiate, or club facilities with seating for 5,000 or more spectators.
d. Class II facilities consist of collegiate and semiprofessional facilities with seating for fewer than 5,000 spectators; club facilities with seating for between 2,000 and 5,000 spectators; and amateur league and high school facilities with seating for more than 2,000 spectators.
e. Class III facilities consist of club, amateur league and high school facilities with seating for 2,000 or fewer spectators.
f. Class IV facilities consist of elementary school and recreational facilities; and amateur league and high school facilities without provision for spectators.
g. The wattage of lighting in daylight transition zones and ramps without parking is excluded.

C405.3.3 Lighting power for sleeping units and dwelling units. Sleeping units in Group I-2 occupancies that are patient rooms shall comply with Sections C405.3.1 and C405.3.2. For all other sleeping units and dwelling units, permanently installed lighting, including lighting integrated into range hoods and exhaust fans, shall be provided by lamps capable of operating with an efficacy of not less than 65 lumens per watt or luminaires capable of operating with an efficacy of not less than 45 lumens per watt.

Exceptions:

1. Lighting integral to other appliances.
2. Antimicrobial lighting used for the sole purpose of disinfecting.
3. Luminaires with an input rating of less than 3 watts.

C405.4 Horticultural lighting. Permanently installed luminaires for horticultural lighting shall have a photosynthetic photon efficacy of not less than 2.1 micromoles per joule (μmol/J). Luminaires for horticultural lighting in greenhouses shall be controlled by a device that automatically turns off the luminaire when sufficient daylight is available. Luminaires for horticultural lighting shall be controlled by a device that automatically turns off the luminaire at specific programmed times.

C405.5 Exterior lighting power requirements. The total connected exterior lighting power calculated in accordance with Section C405.5.1 shall be not greater than the exterior lighting power allowance calculated in accordance with Section C405.5.2.

C405.5.1 Total connected exterior lighting power. The total exterior connected lighting power shall be the total maximum rated wattage of all exterior lighting that is powered through the energy service for the building and building site lighting for which the building owner is responsible.

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

1. Lighting approved because of safety considerations.
2. Emergency lighting automatically off during normal business operation.
3. Exit signs.
4. Specialized signal, directional and marker lighting associated with transportation.
5. Advertising signage or directional signage.
6. Integral to equipment or instrumentation and installed by its manufacturer.
7. Lighting in any location that is specifically used for video broadcasting, video or film recording, or live theatrical and music performances.
8. Athletic playing areas.
9. Temporary lighting.
10. Industrial production, material handling, transportation sites and associated storage areas.
11. Theme elements in theme/amusement parks.
12. Used to highlight features of art, public monuments and the national flag.
13. Lighting for water features and swimming pools.
14. Lighting controlled from within sleeping units and dwelling units.
15. Lighting of the exterior means of egress as required by the *New York City Building Code*.

C405.5.2 Exterior lighting power allowance. The exterior lighting power allowance (watts) is calculated as follows:

1. Determine the Lighting Zone (LZ) for the building according to Table C405.5.2(1), unless otherwise specified by the build- ing official.
2. For each exterior area that is to be illuminated by lighting that is powered through the energy service for the building and building site lighting for which the building owner is responsible, determine the applicable area type from Table C405.5.2(2). For area types not listed, select the area type that most closely represents the proposed use of the area.
3. Determine the total area or length of each area type and multiply by the value for the area type in Table C405.5.2(2) to determine the lighting power (watts) allowed for each area type.
4. The total exterior lighting power allowance (watts) is the sum of the base site allowance determined according to Table C405.5.2(2), plus the watts from each area type.

TABLE C405.5.2(1)
EXTERIOR LIGHTING ZONES

LIGHTING ZONE	DESCRIPTION
1	Developed areas of national parks, state parks, forest land and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited night- time use and residential mixed-use areas
3	All other areas not classified as lighting zone 1, 2 or 4
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority

TABLE C405.5.2(2)
LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

	LIGHTING ZONES			
	Zone 1	**Zone 2**	**Zone 3**	**Zone 4**
Base Site Allowance	160 W	280 W	400 W	560 W
Uncovered Parking Areas				
Parking area, exterior	0.015 W/ft^2	0.026 W/ft^2	0.037 W/ft^2	0.05- W/ft^2
Building Grounds				
Walkways and ramps	0.50 W/linear foot	0.50 W/linear foot	0.55 W/linear foot	0.60 W/linear foot
Plaza areas	0.028 W/ft^2	-0.049 W/ft^2	0.070 W/ft^2	0.098 W/ft^2
Dining areas	0.156 W/ft^2	0.273 W/ft^2	0.390 W/ft^2	0.546 W/ft^2
Stairways	Exempt	Exempt	Exempt	Exempt
Pedestrian tunnels	0.063 W/ft^2	0.110 W/ft^2	0.157 W/ft^2	0.220 W/ft2
Landscaping	0.014 W/ft^2	0.025 W/ft^2	0.036 W/ft^2	0.04 W/ft^2

TABLE C405.5.2(2)
LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS-continued

	Zone 1	Zone 2	Zone 3	Zone 4
Building Entrances and Exits				
Pedestrian and vehicular entrances and exits	5.6 W/linear foot of opening	9.8 W/linear foot of opening	14 W/linear foot of opening	19.6 W/linear foot of opening
Entry canopies	0.072 W/ft^2	0.126 W/ft^2	0.180 W/ft^2	0.252W/ft^2
Loading docks	0.104 W/ft^2	0.182 W/ft^2	0.260 W/ft^2	0.35 W/ft^2
Sales Canopies				
Free-standing and attached	0.20 W/ft^2	0.35 W/ft^2	0.50 W/ft^2	0.70 W/ft^2
Outdoor Sales				
Open areas (including vehicle sales lots)	0.072 W/ft^2	0.126 W/ft^2	0.180 W/ft^2	0.252 W/ft^2
Street frontage for vehicle sales lots in addition to “open area” allowance	No allowance	7 W/linear foot	7 W/linear foot	14.4 W/linear foot

For SI: 1 foot = 304.8 mm, 1 watt per square foot = W/0.0929 m^2.
W = watts.

TABLE C405.5.2(3)
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS

LIGHTING ZONES				
	Zone 1	**Zone 2**	**Zone 3**	**Zone 4**
Building facades	No allowance	0.075 W/ft^2 of gross above-grade wall area	0.113 W/ft^2 of gross above-grade wall area	0.15 W/ft^2 of gross above-grade wall area
Automated teller machines (ATM) and night depositories	90 W per location plus 35W per additional ATM per location			
Uncovered entrances and gatehouse inspection stations at guarded facilities	0.144 W/ft^2 of area	0.252 W/ft^2 of area	0.360 W/ft^2 of area	0.504 W/ft^2 of area
Uncovered loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.104 W/ft^2 of area	0.182 W/ft^2 of area	0.260 W/ft^2 of area	0.364 W/ft^2 of area
Drive-up windows and doors	53 W per drive-through	92 W per drive-through	132 W per drive-through	185 W per drive-through
Parking area near 24-hour retail entrances	80 W per main entry	140 W per main entry	200 W per main entry	280 W per main entry

For SI: 1 watt per square foot = 10.76 W/m^2. W = Watts.

C405.5.2.1 Additional exterior lighting power. Additional exterior lighting power allowances are available for the specific lighting applications listed in Table C405.5.2(3). These additional power allowances shall be used only for the luminaires serving these specific applications and shall not be used to increase any other lighting power allowance.

C405.5.3 Gas lighting. Gas-fired lighting appliances shall not be equipped with continuously burning pilot ignition systems.

C405.6 Electrical meter. Electrical service within buildings shall comply with the following:

C405.6.1 Dwelling electrical meter. Each dwelling unit located in a Group R-2 building shall have a separate electrical meter.

C405.6.2 Electrical meters for tenant spaces in covered buildings. Each covered tenant space in a new building shall be equipped with a separate meter or sub-meter to measure the electrical consumption of such space when let or sublet. The terms covered building, meter, sub-meter, tenant space and covered tenant space shall have the same meanings as defined in Section 28-311.2 of the NYC Administrative Code.

C405.7 Electrical transformers. Low-voltage dry-type distribution electric transformers shall meet the minimum efficiency requirements of Table C405.7 as tested and rated in accordance with the test procedure listed in DOE 10 CFR 431. The efficiency shall be verified through certification under an approved certification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data furnished by the transformer manufacturer.

Exceptions: The following transformers are exempt in accordance with the DOE definition of Distribution Transformers found in 10 CFR 431.192:

1. Transformers with a tap range of 20 percent or more.
2. Drive (isolation) transformers.
3. Rectifier transformers.
4. Auto-transformers.
5. Uninterruptible power system transformers.
6. Special impedance transformers.
7. Regulating transformers.
8. Sealed transformers.
9. Machine tool (control) transformers.
10. Welding transformers.
11. Grounding transformers.
12. Testing transformers.
13. Nonventilated transformers.

TABLE C405.7
MINIMUM NOMINAL EFFICIENCY LEVELS FOR DOE 10 CFR 431 LOW-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMERS

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

SINGLE-PHASE TRANSFORMERS[a]		THREE-PHASE TRANSFORMERS[a]	
kVA[b]	Efficiency (%)[c]	kVA[b]	Efficiency (%)[c]
15	97.70	15	97.89
25	98.00	30	98.23
37.5	98.20	45	98.40
50	98.30	75	98.60
75	98.50	112.5	98.74
100	98.60	150	98.83
167	98.70	225	98.94
250	98.80	300	99.02
333	98.90	500	99.14
—	—	750	99.23
—	—	1000	99.28

a. A low-voltage dry-type distribution transformer with a kVA rating not listed in the table shall have its minimum efficiency level determined by linear interpolation of the kVA and efficiency values listed in the table immediately above and below its kVA rating. Extrapolation shall not be used below the minimum values or above the maximum values shown for single-phase transformers and three-phase transformers.
b. kiloVolt-Amp rating.
c. Nominal efficiencies shall be established in accordance with the DOE 10 CFR 431 test procedure for low-voltage dry-type transformers.

C405.8 Electric motors. Electric motors shall meet the minimum efficiency requirements of Tables C405.8(1) through C405.8(4) when tested and rated in accordance with the DOE 10 CFR 431. The efficiency shall be verified through certification under an approved certification program or, where a certification program does not exist, the equipment efficiency ratings shall be supported by data furnished by the motor manufacturer.

Exception: The standards in this section shall not apply to the following exempt electric motors:

1. Air-over electric motors.
2. Component sets of an electric motor.
3. Liquid-cooled electric motors.
4. Submersible electric motors.
5. Inverter-only electric motors.
6. Definite-purpose machines within the scope of ANSI/NEMA MG 1, Part 18.

TABLE C405.8(1)
MINIMUM NOMINAL FULL-LOAD EFFICIENCY FOR NEMA DESIGN A, NEMA DESIGN B, AND IEC DESIGN N MOTORS (EXCLUDING FIRE PUMP) ELECTRIC MOTORS AT 60 HZ[a, b]

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

MOTOR HORSEPOWER (STANDARD KILOWATT EQUIVALENT)	NOMINAL FULL-LOAD EFFICIENCY (%) AS OF JUNE 1, 2016							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1 (0.75)	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5 (1.1)	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2 (1.5)	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3 (2.2)	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5 (3.7)	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5 (5.5)	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10 (7.5)	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15 (11)	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20 (15)	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25 (18.5)	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30 (22)	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40 (30)	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50 (37)	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60 (45)	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75 (55)	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100 (75)	94.1	93.6	95.4	95.4	95.0	95.0	93.6	94.1
125 (90)	95.0	94.1	95.4	95.4	95.0	95.0	94.1	94.1
150 (110)	95.0	94.1	95.8	95.8	95.8	95.4	94.1	94.1
200 (150)	95.4	95.0	96.2	95.8	95.8	95.4	94.5	94.1
250 (186)	95.8	95.0	96.2	95.8	95.8	95.8	95.0	95.0
300 (224)	95.8	95.4	96.2	95.8	95.8	95.8	—	—
350 (261)	95.8	95.4	96.2	95.8	95.8	95.8	—	—
400 (298)	95.8	95.8	96.2	95.8	—	—	—	—
450 (336)	95.8	96.2	96.2	96.2	—	—	—	—
500 (373)	95.8	96.2	96.2	96.2	—	—	—	—

a. Nominal efficiencies shall be established in accordance with DOE 10 CFR 431.

b. For purposes of determining the required minimum nominal full-load efficiency of an electric motor that has a horsepower or kilowatt rating between two horsepower or two kilowatt ratings listed in this table, each such motor shall be deemed to have a listed horsepower or kilowatt rating, determined as follows:

1. A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.
2. A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.
3. A kilowatt rating shall be directly converted from kilowatts to horsepower using the formula: 1 kilowatt = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with No. 1 or No. 2 above, as applicable.

TABLE C405.8(2)
MINIMUM NOMINAL FULL-LOAD EFFICIENCY FOR NEMA DESIGN C AND IEC DESIGN H MOTORS AT 60 HZ[a, b]

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

MOTOR HORSEPOWER (STANDARD KILOWATT EQUIVALENT)	NOMINAL FULL-LOAD EFFICIENCY (%) AS OF JUNE 1, 2016					
	4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open
1 (0.75)	85.5	85.5	82.5	82.5	75.5	75.5
1.5 (1.1)	86.5	86.5	87.5	86.5	78.5	77.0
2 (1.5)	86.5	86.5	88.5	87.5	84.0	86.5
3 (2.2)	89.5	89.5	89.5	88.5	85.5	87.5
5 (3.7)	89.5	89.5	89.5	89.5	86.5	88.5
7.5 (5.5)	91.7	91.0	91.0	90.2	86.5	89.5
10 (7.5)	91.7	91.7	91.0	91.7	89.5	90.2
15 (11)	92.4	93.0	91.7	91.7	89.5	90.2
20 (15)	93.0	93.0	91.7	92.4	90.2	91.0
25 (18.5)	93.6	93.6	93.0	93.0	90.2	91.0
30 (22)	93.6	94.1	93.0	93.6	91.7	91.7
40 (30)	94.1	94.1	94.1	94.1	91.7	91.7
50 (37)	94.5	94.5	94.1	94.1	92.4	92.4
60 (45)	95.0	95.0	94.5	94.5	92.4	93.0
75 (55)	95.4	95.0	94.5	94.5	93.6	94.1
100 (75)	95.4	95.4	95.0	95.0	93.6	94.1
125 (90)	95.4	95.4	95.0	95.0	94.1	94.1
150 (110)	95.8	95.8	95.8	95.4	94.1	94.1
200 (150)	96.2	95.8	95.8	95.4	94.5	94.1

a. Nominal efficiencies shall be established in accordance with DOE 10 CFR 431.

b. For purposes of determining the required minimum nominal full-load efficiency of an electric motor that has a horsepower or kilowatt rating between two horsepower or two kilowatt ratings listed in this table, each such motor shall be deemed to have a listed horsepower or kilowatt rating, determined as follows:

1. A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.
2. A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.
3. A kilowatt rating shall be directly converted from kilowatts to horsepower using the formula: 1 kilowatt = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with No. 1 or No. 2 above, as applicable.

TABLE C405.8(3)
MINIMUM AVERAGE FULL-LOAD EFFICIENCY POLYPHASE SMALL ELECTRIC MOTORS[a]

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

MOTOR HORSEPOWER	OPEN MOTORS			
	Number of Poles	2	4	6
	Synchronous Speed (RPM)	3600	1800	1200
0.25	—	65.6	69.5	67.5
0.33	—	69.5	73.4	71.4
0.50	—	73.4	78.2	75.3
0.75	—	76.8	81.1	81.7
1	—	77.0	83.5	82.5
1.5	—	84.0	86.5	83.8
2	—	85.5	86.5	N/A
3	—	85.5	86.9	N/A

N/A = Not Applicable.

a. Average full-load efficiencies shall be established in accordance with DOE 10 CFR 431.

TABLE C405.8(4)
MINIMUM AVERAGE FULL-LOAD EFFICIENCY FOR CAPACITOR-START CAPACITOR-RUN AND CAPACITOR-START INDUCTION-RUN SMALL ELECTRIC MOTORS[a]

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

MOTOR HORSEPOWER	OPEN MOTORS			
	Number of Poles	2	4	6
	Synchronous Speed (RPM)	3600	1800	1200
0.25	—	66.6	68.5	62.2
0.33	—	70.5	72.4	66.6
0.50	—	72.4	76.2	76.2
0.75	—	76.2	81.8	80.2
1	—	80.4	82.6	81.1
1.5	—	81.5	83.8	N/A
2	—	82.9	84.5	N/A
3	—	84.1	N/A	N/A

N/A = Not Applicable.

a. Average full-load efficiencies shall be established in accordance with DOE 10 CFR 431.

C405.9 Data centers and computer rooms. Electrical equipment in data centers and computer rooms shall comply with this section.

C405.9.1 Data centers. Transformers, uninterruptible power supplies, motors and electrical power processing equipment in data centers shall comply with Section 8 of ASHRAE 90.4 in addition to this code.

C405.9.2 Computer rooms. Uninterruptible power supplies in computer rooms shall comply with the requirements in Tables 8.5 and 8.6 of ASHRAE 90.4 in addition to this code.

Exception: AC-output UPS that utilizes standardized NEMA 1-15P or NEMA 5-15P input plug, as specified in ANSI/NEMA WD-6.

C405.10 Vertical and horizontal transportation systems and equipment. Vertical and horizontal transportation systems and equipment shall comply with this section.

C405.10.1 Elevator equipment and cabs. For the luminaires in each elevator cab, not including signals and displays, the sum of the lumens divided by the sum of the watts shall be not less than 35 lumens per watt. Ventilation fans in elevators that do not have their own air-conditioning system shall not consume more than 0.33 watts/cfm at the maximum rated speed of the fan. Controls shall be provided that will de-energize ventilation fans and lighting systems when the elevator is stopped, unoccupied and with its doors closed for over 15 minutes.

C405.10.1.1 Power conversion system. New traction elevators with a rise of 75 feet (23 m) or more in new buildings shall have a power conversion system that complies with Sections C405.10.1.1.1 through C405.10.1.1.3.

C405.10.1.1.1 Motor. Induction motors with a Class IE2 efficiency rating, as defined by IEC EN 60034-30, or alternative technologies, such as permanent magnet synchronous motors that have equal or better efficiency, shall be used.

C405.10.1.1.2 Transmission. Transmissions shall not reduce the efficiency of the combined motor/transmission below that shown for the Class IE2 motor for elevators with capacities below 4,000 pounds (1814 kg). Gearless machines shall be assumed to have a 100 percent transmission efficiency.

C405.10.1.1.3 Drive. Potential energy released during motion shall be recovered with a regenerative drive that supplies electrical energy to the building electrical system.

C405.10.2 Escalators and moving walks. Escalators and moving walks shall comply with ASME A17.1/CSA B44 and shall have automatic controls that reduce speed as permitted in accordance with ASME A17.1/CSA B44 and applicable local code.

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

C405.10.2.1 Energy recovery. Escalators shall be designed to recover electrical energy when resisting overspeed in the down direction.

C405.10.3 Elevator energy recovery. New traction elevators with a rise of 75 feet or more in new buildings shall have a regenerative drive that recovers energy released during motion and supplies electrical energy to the building electrical system.

Exception: Stand-alone parking garages, where the calculated total building electrical load under normal operation is less than the load needed to absorb regenerated power from the elevator system.

C405.11 Voltage drop. The total *voltage drop* across the combination of customer-owned service conductors, feeder conductors and branch circuit conductors shall not exceed 5 percent.

C405.12 Commercial kitchen equipment. Commercial kitchen equipment shall comply with the minimum efficiency requirements of Tables C405.12(1) through C405.12(5).

TABLE C405.12(1)
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL FRYERS
(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

	HEAVY-LOAD COOKING ENERGY EFFICIENCY	IDLE ENERGY RATE	TEST PROCEDURE
Standard Open Deep-Fat Gas Fryers	≥ 50%	≤ 9,000 Btu/hr	ASTM Standard F1361-17
Standard Open Deep-Fat Electric Fryers	≥ 83%	≤ 800 watts	
Large Vat Open Deep-Fat Gas Fryers	≥ 50%	≤ 12,000 Btu/hr	ASTM Standard F2144-17
Large Vat Open Deep-Fat Electric Fryers	≥ 80%	≤ 1,100 watts	

TABLE C405.12(2)
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL HOT FOOD HOLDING CABINETS
(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

PRODUCT INTERIOR VOLUME (CUBIC FEET)	MAXIMUM IDLE ENERGY CONSUMPTION RATE (WATTS)	TEST PROCEDURE
0 < V < 13	≤ 21.5 V	ASTM Standard F2140-11
13 ≤ V < 28	≤ 2.0 V + 254.0	
28 ≤ V	≤ 3.8 V + 203.5	

TABLE C405.12(3)
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL STEAM COOKERS
(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

FUEL TYPE	PAN CAPACITY	COOKING ENERGY EFFICIENCY[a]	IDLE RATE	TEST PROCEDURE
Electric Steam	3-pan	50%	400 watts	ASTM Standard F1484-18
	4-pan	50%	530 watts	
	5-pan	50%	670 watts	
	6-pan and larger	50%	800 watts	
Gas Steam	3-pan	38%	6,250 Btu/h	
	4-pan	38%	8,350 Btu/h	
	5-pan	38%	10,400 Btu/h	
	6-pan and larger	38%	12,500 Btu/h	

a. Cooking Energy Efficiency is based on heavy load (potato) cooking capacity.

TABLE C405.12(4)
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL DISHWASHERS

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

MACHINE TYPE	HIGH TEMP EFFICIENCY REQUIREMENTS		LOW TEMP EFFICIENCY REQUIREMENTS		TEST PROCEDURE
	Idle Energy Rate[a]	Water Consumption[b]	Idle Energy Rate[a]	Water Consumption[b]	
Under Counter	≤ 0.50 kW	≤ 0.86 GPR	≤ 0.50 kW	≤ 1.19 GPR	ASTM F1696-18
Stationary Single Tank Door	≤ 0.70 kW	≤ 0.89 GPR	≤ 0.60 kW	≤ 1.18 GPR	
Pot, Pan, and Utensil	≤ 1.20 kW	≤ 0.58 GPSF	≤ 1.00 kW	≤ 0.58 GPSF	
Single Tank Conveyor	≤ 1.50 kW	≤ 0.70 GPR	≤ 1.50 kW	≤ 0.79 GPR	ASTM F1920-15
Multiple Tank Conveyor	≤ 2.25 kW	≤ 0.54 GPR	≤ 2.00 kW	≤ 0.54 GPR	
Single Tank Flight Type	Reported	GPH ≤ 2.975x + 55.00	Reported	GPH ≤ 2.975x + 55.00	
Multiple Tank Flight Type	Reported	GPH ≤ 4.96x + 17.00	Reported	GPH ≤ 4.96x + 17.00	

a. Idle results shall be measured with the door closed and represent the total idle energy consumed by the machine including all tank heater(s) andcontrols. Booster heater (internal or external) energy consumption should not be part of this measurement unless it cannot be separately monitored per US EPA Energy Star Commercial Dishwasher Specification Version 2.0.

b. GPR = gallons per rack; GPSF = gallons per square foot of rack; GPH = gallons per hour; x = sf of conveyer belt (i.e., W*L)/min (maximumconveyor speed

TABLE C405.12(5)
MINIMUM EFFICIENCY REQUIREMENTS: COMMERCIAL OVENS

(This table is intended to be a restatement of the legally binding provisions found in Title 10 CFR Part 431 included here as a convenience to the users of this code)

FUEL TYPE	CLASSIFICATION	IDLE RATE	COOKING-ENERGY EFFICIENCY, %	TEST PROCEDURE
Convection Ovens				
Gas	Full-Size	≤ 12,000 Btu/h	≥ 46	ASTM F1496 - 13
Electric	Half-Size	≤ 1.0 Btu/h	≥ 71	
	Full-Size	≤ 1.60 Btu/h		
Combination Ovens				
Gas	Steam Mode	≤ 200P[a] + 6,511 Btu/h	≥ 41	ASTM F2861 - 17
	Convection Mode	≤ 150P[a] + 5,425 Btu/h	≥ 56	
Electric	Steam Mode	≤ 0.133P[a] + 0.6400 kW	≥ 55	
	Convection Mode	≤ 0.080P[a] + 0.4989 kW	≥ 76	
Rack Ovens				
Gas	Single	≤ 25,000 Btu/h	≥ 48	ASTM F2093 - 18
	Double	≤ 30,000 Btu/h	≥ 52	

a. P = Pan Capacity: The number of steam table pans the combination oven is able to accommodate as per the ASTM F1495–05 standard specification.

C405.13 Automatic receptacle control. The following shall have automatic receptacle control complying with Section C405.13.1:

1. At least 50 percent of all 125V, 15- and 20-amp receptacles installed in the following space types:
   1.1 Enclosed offices.
   1.2 Conference rooms.
   1.3 Rooms used primarily for copy or print functions.
   1.4 Breakrooms.
   1.5 Classrooms.

1.6 Open plan office areas.
1.7 Individual workstations, including those installed in modular partitions and module office workstation systems.

2. At least 25 percent of branch circuit feeders installed for modular furniture not shown on the construction documents.

C405.13.1 Automatic receptacle control function. Automatic receptacle controls shall comply with the following:

1. Either split controlled receptacles shall be provided with the top receptacle controlled, or a controlled receptacle shall be located within 12 inches (304.8 mm) of each uncontrolled receptacle.
2. One of the following methods shall be used to provide control:
   2.1. A scheduled basis using a time-of-day operated control device that turns receptacle power off at specific programmed times and can be programmed separately for each day of the week. The control device shall be configured to provide an independent schedule for each portion of the building of not more than 5,000 square feet (464.5 m2) and not more than one floor. The occupant shall be able to manually override an area for not more than 2 hours. Any individual override switch shall control the receptacles in a portion of the building not more than 5,000 feet (1524 m).
   2.2. An occupant sensor control that shall turn off receptacles within 15 minutes of all occupants leaving a space.
   2.3. An automated signal from another control or alarm system that shall turn off receptacles within 15 minutes after determining that the area is unoccupied.
3. All controlled receptacles shall be permanently marked in accordance with the New York City Electrical Code and be uniformly distributed throughout the space.
4. Plug-in devices shall not comply.

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

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

C405.14 Energy monitoring. New buildings with a gross conditioned floor area of 10,000 square feet (929 m2) or larger shall be equipped to measure, monitor, record and report energy consumption in accordance with Sections C405.14.1 through C405.14.6 for load categories indicated in Table C405.14.2 and Sections C405.14.7 through C405.14.11 for end-use categories indicated in Table C405.14.8.

Exceptions:

1. Dwelling units in R-2 occupancies.
2. Individual tenant spaces are not required to comply with this section provided that the space has its own utility services and meters and has less than 5,000 square feet (464.5 m2) of conditioned floor area.

C405.14.1 Electrical energy metering. For electrical energy supplied to the building and its associated site, including but not limited to site lighting, parking, recreational facilities and other areas that serve the *building* and its occupants, meters or other measurement devices shall be provided to collect energy consumption data for each end-use category required by Section C405.14.2.

C405.14.2 End-use electric metering categories. Meters or other approved measurement devices shall be provided to collect energy use data for each end-use category indicated in Table C405.14.2. Where multiple meters are used to measure any end-use category, the data acquisition system shall total all of the energy used by that category. Not more than 5 percent of the design load for each of the end-use categories indicated in Table C405.14.2 shall be permitted to be from a load that is not within that category.

Exceptions:

1. HVAC and water heating equipment serving only an individual dwelling unit shall not require end-use metering.
2. End-use metering shall not be required for fire pumps, stairwell pressurization fans or any system that operates only during testing or emergency.
3. End-use metering shall not be required for an individual tenant space having a floor area not greater than 2,500 square feet (232 m^2) where a dedicated source meter complying with Section C405.14.3 is provided.

TABLE C405.14.2
ELECTRICAL ENERGY USE CATEGORIES

LOAD CATEGORY	DESCRIPTION OF ENERGY USE
Total HVAC system	Heating, cooling and ventilation, including but not limited to fans, pumps, boilers, chillers and water heating. Energy used by 120-volt equipment, or by 208/120-volt equipment that is located in a building where the main service is 480/277-volt power, is permitted to be excluded from total HVAC system energy use.
Interior lighting	Lighting systems located within the building.
Exterior lighting	Lighting systems located on the building site but not within the building.
Plug loads	Devices, appliances and equipment connected to convenience receptacle outlets.
Process load	Any single load that is not included in an HVAC, lighting or plug load category and that exceeds 5 percent of the peak connected load of the whole building, including but not limited to data centers, manufacturing equipment and commercial kitchens.
Building operations and other miscellaneous loads	The remaining loads not included elsewhere in this table, including but not limited to vertical transportation systems, automatic doors, motorized shading systems, ornamental fountains, fireplaces, swimming pools, spas and snow-melt systems.
Electric hot water heating for uses other than space conditioning	Electricity used to generate hot water. Exception: Electric water heating with design capacity that is less than 10 percent of the building service rating.
Electric vehicle charging	Electric vehicle charging loads that are powered through the building's electrical service.

C405.14.3 Electrical Meters. Meters or other measurement devices required by this section shall be configured to automatically communicate energy consumption data to the data acquisition system required by Section C405.14.4. Source meters shall be allowed to be any digital-type meter. Lighting, HVAC or other building systems that can self-monitor their energy consumption shall be permitted instead of meters. Current sensors shall be permitted, provided that they have a tested accuracy of ±2 percent. Required metering systems and equipment shall have the capability to provide at least hourly data that is fully integrated into the data acquisition system and graphical energy report in accordance with Sections C405.14.4 and C405.14.5. Nonintrusive load monitoring (NILM) packages that extract energy consumption data from detailed electric waveform analysis shall be permitted to substitute for individual meters if the equivalent data is available for collection in Section C405.14.4 and reporting in Section C405.14.5.

C405.14.4 Electrical energy data acquisition system. A data acquisition system shall have the capability to store the data from the required meters and other sensing devices for a minimum of 36 months. The data acquisition system shall have the capability to store real-time energy consumption data and provide hourly, daily, monthly and yearly logged data for each end-use category required by Section C405.14.2. The data acquisition system shall have the capability of providing building total peak electric demand and the time(s) of day and time(s) per month at which the peak occurs. Peak demand shall be integrated over the same time period as the underlying whole-building meter reading rate.

C405.14.5 Graphical energy report. A permanent and readily available reporting mechanism shall be provided in the building for access by building operation and management personnel. The reporting mechanism shall have the capability to graphically provide the energy consumption for each end-use category required by Section C405.14.2 not less than every hour, day, month and year for the previous 36 months.

C405.14.6 Renewable energy. On-site renewable energy sources shall be metered with no less frequency than nonrenewable energy systems in accordance with Section 405.14.3.

C405.14.7 Nonelectrical energy submetering. For all nonelectrical energy supplied to the building and its associated site that serves the building and its occupants, submeters or other measurement devices shall be provided to collect energy consumption data for each end-use category required by Section C405.14.8.

Exceptions:

1. HVAC and water heating equipment serving only an individual dwelling unit shall not require end-use submetering.
2. End-use submetering shall not be required for fire pumps, stairwell pressurization fans or any system that operates only during testing or emergency.
3. End-use submetering shall not be required for an individual tenant space having a floor area not greater than 2,500 square feet (232 m2) where a dedicated source meter complying with Section C405.14.9 is provided.
4. Equipment powered primarily by solid fuels serving loads other than building heating and service water heating loads.

C405.14.8 End-use nonelectrical submetering categories. Submeters or other approved measurement devices shall be provided to collect energy use data for each end-use category indicated in Table C405.14.8. Where multiple submeters are used to measure any end-use category, the data acquisition system shall total all of the energy used by that category. Not more than 5 percent of the design load for each of the end-use categories indicated in Table C405.14.8 shall be permitted to be from a load that is not within that category.

TABLE C405.14.8
NONELECTRICAL ENERGY USE CATEGORIES

END USE CATEGORY	DESCRIPTION OF END USE
Total HVAC system	Heating and cooling systems, including but not limited to boilers, chillers and furnaces. District heating and cooling energy entering the building's distribution system shall be monitored at the point of entry to the building distribution system.
Process loads	Any single load that is not included in the HVAC or service water heating categories where the rated fuel gas or fuel oil input of the load and that is not less than 5 percent of the sum of the rated fuel gas or fuel oil input of all monitored equipment, including but not limited to manufacturing equipment, process equipment, commercial kitchens, and commercial laundry equipment.
Other miscellaneous loads	The remaining loads not included elsewhere in this table, including but not limited to fireplaces, swimming pools, spas, gas lighting, and snow-melt systems.
Service water heating	Fuel used to heat potable water. Exception: Water heating with design capacity that is less than 10 percent of the sum of the rated fuel gas or fuel oil input of all monitored equipment.

C405.14.9 Nonelectrical submeters. Submeters or other measurement devices required by this section shall be configured to automatically communicate energy consumption data to the data acquisition system required by Section C405.14.10. Source submeters shall be allowed to be any digital-type meter that can provide a digital output to the data acquisition system. Required submetering systems and equipment shall be fully integrated into the data acquisition system and graphical energy report that updates at least hourly in accordance with Sections C405.14.10 and C405.14.11.

C405.14.10 Nonelectrical energy data acquisition system. A data acquisition system shall have the capability to store the data from the required submeters and other sensing devices for not less than 36 months. The data acquisition system shall have the capability to store real-time energy consumption data and provide hourly, daily, monthly and yearly logged data for each end-use category required by Section C405.14.8. The data acquisition system shall have the capability of providing building total nonelectrical peak demand and the time(s) of day and time(s) per month at which the peak occurs. Where applicable as determined by the authority having jurisdiction (AHJ), peak demand shall be integrated over the same time period as the underlying whole-building meter reading rate.

C405.14.11 Graphical energy report. A permanent and readily accessible reporting mechanism shall be provided in the building that is accessible by building operation and management personnel. The reporting mechanism shall have the capability to graphically provide the nonelectrical energy consumption for each end-use category required by Section C405.14.8 not less than every hour, day, month and year for the previous 36 months. The graphical report shall incorporate natural gas interval data from the submeter or the ability to enter gas utility bills into the report.

C405.15 Renewable energy systems. Buildings shall comply with Sections C405.15.1 through C405.15.4.

C405.15.1 On-site renewable energy systems. Buildings shall be provided with on-site renewable energy generation systems with a direct current (DC) nameplate power rating of not less than 0.75 watts per square foot (8.1 W/m^2) multiplied by the sum of the gross conditioned floor area of all floors, not to exceed the combined gross conditioned floor area of the three largest floors.

Exceptions: The following buildings or building sites shall comply with Section C405.15.2:

1. A building site located where an unshaded flat plate collector oriented toward the equator and tilted at an angle from horizontal equal to the latitude receives an annual daily average incident solar radiation less than 1.1 kBtu/ft^2 per day (3.5 kWh/m^2/day).
2. A building where more than 80 percent of the roof area is covered by any combination of permanent obstructions such as, but not limited to, mechanical equipment, vegetated space, access pathways or occupied roof terrace.
3. Any building where more than 50 percent of the roof area is shaded from direct-beam sunlight by natural objects or by structures that are not part of the building for more than 2,500 annual hours between 8:00 a.m. and 4:00 p.m.
4. A building with gross conditioned floor area less than 5,000 square feet (465 m^2).

C405.15.2 Off-site renewable energy. The applicant for buildings that qualify for one or more of the exceptions to Section C405.15.1 or do not meet the requirements of Section C405.15.1 with an on-site renewable energy system shall provide to the building official an attestation of having procured off-site renewable energy, in accordance with Sections C405.15.2.1 and C405.15.2.2, that shall be not less than the total off-site renewable energy determined in accordance with Equation 4-11.

Equation 4-11 $TRE_{off} = (REN_{off} \times 0.75\ W/ft^2 \times FLRA - IRE_{on}) \times 15$

where:

TRE_{off} = Total off-site renewable energy in kilowatt-hours (kWh) to be procured.
REN_{off} = Annual off-site renewable energy of 1.35 kilowatt-hours per watt of array capacity.
FLRA = The sum of the gross conditioned floor area of all floors not to exceed the combined floor area of the three largest floors.
IRE_{on} = Annual o*n-site renewable energy* generation of a new *on-site renewable system*, to be installed as part of the building project, whose rated capacity is less than the rated capacity required in Section C405.15.1.

C405.15.2.1 Off-site procurement. The building owner, as defined in the *New York City Building Code*, shall procure and be credited for the total amount of off-site renewable energy, not less than required in accordance with Equation 4-11, with one or more of the following:

1. Physical renewable energy power purchase agreement.
2. Financial renewable energy power purchase agreement.
3. Community renewable energy facility.
4. Off-site renewable energy system owned by the building property owner.
5. Renewable energy investment fund.
6. Green retail tariff.

The generation source shall be located where the energy can be delivered to the building site by any of the following:

1. Direct connection to the off-site renewable energy facility.
2. The local utility or distribution entity.
3. An interconnected electrical network where energy delivery capacity between the generator and the building site is available.

C405.15.2.2 Off-site contract. The renewable energy shall be delivered or credited to the building site under an energy contract with a duration of not less than 10 years. The contract shall be structured to survive a partial or full transfer of owner- ship of the building property.

C405.15.3 Renewable energy certificate (REC) documentation. The property owner or owner's authorized agent shall demonstrate that where renewable energy certificates (RECs) or energy attribute certificates (EACs) are associated with on-site and off- site renewable energy production required by Sections C405.15.1 and C405.15.2, all of the following criteria for RECs and EACs shall be met:

1. The RECs and EACs are retained and retired by or on behalf of the property owner or tenant for a period of not less than 15 years or the duration of the contract in Section C405.15.2.2, whichever is less.
2. The RECs and EACs are created within a 12-month period of the use of the REC.
3. The RECs and EACs are from a generating asset placed in service not more than 5 years before the issuance of the certificate of occupancy.

C405.15.4 Renewable energy certificate purchase. A building that qualifies for one or more of the exceptions to Section C405.15.1, and where it can be demonstrated to the building official that the requirements of Section C405.15.2 cannot be met, the building owner shall contract the purchase of renewable electricity products before the certificate of occupancy is issued. The purchase of renewable electricity products shall comply with the Green-e Energy National Standard for renewable electricity products equivalent to five times the amount of total off-site renewable energy calculated in accordance with Equation 4-11.

C405.16 Inverters. Direct-current-to-alternating-current inverters serving on-site renewable energy systems or on-site electrical energy storage systems (ESS) shall be compliant with IEEE 1547 and UL 1741.

SECTION ECC C406
ADDITIONAL EFFICIENCY, RENEWABLE AND LOAD MANAGEMENT REQUIREMENTS

C406.1 Compliance. Buildings shall comply as follows:

1. Buildings with greater than 2,000 square feet (186 m^2) of conditioned floor area shall comply with Section C406.1.1.
2. Buildings with greater than 5,000 square feet (465 m^2) of conditioned floor area shall comply with Sections C406.1.1 and C406.1.2.
3. Build-out construction greater than 1,000 square feet (93 m^2) of conditioned floor area that does not have final lighting or final HVAC systems installed under a prior building permit shall comply with Section C406.1.1.2.

Exceptions: Core and shell buildings where not less than 20 percent of the net floor area is without final lighting or final HVAC that comply with all of the following:

1. Buildings with greater than 5,000 square feet (465 m^2) of conditioned floor area shall comply with Section C406.1.2.
2. Portions of the building where the net floor area is without final lighting or final HVAC shall comply with Section C406.1.1.2.
3. Portions of the building where the net floor area has final lighting and final HVAC systems shall comply with Section C406.1.1.

C406.1.1 Additional energy efficiency credit requirements. *Buildings* shall comply with measures from Section C406.2 to achieve not less than the number of required efficiency credits from Table C406.1.1(1) based on building occupancy group and *climate zone.* Where a project contains multiple occupancies, the total required energy credits from each building occupancy shall be weighted by the gross *conditioned floor area* to determine the weighted-average project energy credits required. Accessory occupancies shall be included with the primary occupancy group for the purposes of Section C406.

Exceptions:

1. Portions of *buildings* devoted to manufacturing or industrial use.
2. Where a *building* achieves more renewable and load management credits in Section C406.3 than are required in Section C406.1.2, surplus credits shall be permitted to reduce the required energy efficiency credits as follows:

   Equation 4-12 $EEC_{red} = EEC_{tbl} - \{\text{the lesser of: } [SLRM_{lim}, SRLM_{adj} \times (RLM_{ach} - RLM_{req})]\}$

   where:

   EEC_{red} = Reduced required energy efficiency credits.
   EEC_{tbl} = Required energy efficiency credits from Table C406.1.1(1).
   $SRLM_{lim}$ = Surplus renewable and load management credit limit from Table C406.1.1(2).
   $SRLM_{adj}$ = 1.0 for all-electric or all-renewable buildings (excluding emergency generation); 0.7 for buildings with fossil fuel equipment (excluding emergency generation).
   RLM_{ach} = Achieved renewable and load management credits from Section C406.3.
   RLM_{req} = Required renewable and load management credits from Section C406.1.2.

TABLE C406.1.1(1)
ENERGY CREDIT REQUIREMENTS BY BUILDING OCCUPANCY GROUP

BUILDING OCCUPANCY GROUP	CLIMATE ZONE		
	4	5	6
R-2, R-4 and I-1	86	86	70
I-2	36	43	46
R-1	81	85	83
B	70	71	71
A-2	69	67	60
M	80	79	75
E	61	64	65
S-1 and S-2	85	90	90
All other	35	37	36

TABLE C406.1.1(2)
LIMIT TO ENERGY EFFICIENCY CREDIT CARRYOVER FROM RENEWABLE AND LOAD MANAGEMENT CREDITS

BUILDING OCCUPANCY GROUP	CLIMATE ZONE		
	4	5	6
R-2, R-4 and I-1	5	5	5
I-2	5	6	10
R-1	5	5	5
B	5	5	5
A-2	5	5	5
M	5	5	5
E	9	7	5
S-1 and S-2	5	5	5
All other	5	5	5

C406.1.1.1 Reserved.

C406.1.1.2 Building core/shell and build-out construction. Where separate permits are issued for core and shell buildings and build-out construction, compliance shall be in accordance with the following requirements.

1. Core and shell buildings or portions of buildings shall comply with one of the following:

   1.1. Where the permit includes a central HVAC system or service water heating system with chillers, heat pumps, boilers, service water heating equipment or loop pumping systems with heat rejection, the project shall achieve not less than 50 percent of the energy credits required by Section C406.1.1 in accordance with Section C406.2.

   1.2. Where the permit does not include a central HVAC system or service water heating system with chillers, heat pumps, boilers, service water heating equipment or loop pumping systems with heat rejection, the project shall achieve not less than 33 percent of the energy credits required by Section C406.1.1.

2. For core and shell buildings or portions of buildings, the energy credits achieved shall be subject to the following adjustments:

   2.1. Lighting measure credits shall be determined only for areas with final lighting installed.

   2.2. Where HVAC or service water heating systems are designed to serve the entire building, full HVAC or service water heating measure credits shall be achieved.

   2.3. Where HVAC or service water heating systems are designed to serve individual areas, HVAC or service water heating measure credits achieved shall be reduced in proportion to the floor area with final HVAC systems or final service water heating systems installed.

3. Build-out construction shall be deemed to comply with Section C406.1 where one of the following applies:

   3.1. Where heating and cooling generation is provided by a previously installed central system, the energy credits achieved in accordance with Section C406.2 under the build-out project are not less than 33 percent of the credits required by Section C406.1.1.

   3.2. Where heating and cooling generation is provided by an HVAC system installed in the build-out, the energy credits achieved in accordance with Section C406.2 under the build-out project are not less than 50 percent of the credits required by Section C406.1.1.

C406.1.2 Additional renewable and load management credit requirements. *Buildings* shall comply with measures from Section C406.3 to achieve not less than the number of required renewable and load management credits from Table C406.1.2 based on building occupancy group and *climate zone*. Where a project contains multiple occupancies, credits in Table C406.1.2 from each building occupancy shall be weighted by the gross floor area to determine the weighted-average project energy credits required. Accessory occupancies shall be included with the primary occupancy group for the purposes of Section C406.

Exception: Where a *building* achieves more energy efficiency credits in Section C406.2 than are required in Section C406.1.1, the renewable and load management credits required in Table C406.1.2 shall be permitted to be reduced by the amount of surplus energy efficiency credits.

TABLE C406.1.2
RENEWABLE AND LOAD MANAGEMENT CREDIT REQUIREMENTS BY BUILDING OCCUPANCY GROUP

BUILDING OCCUPANCY GROUP	CLIMATE ZONE		
	4	5	6
R-2, R-4 and I-1	31	26	23
I-2	25	25	26
R-1	32	28	25
B	44	38	38
A-2	8	8	8
M	42	38	42
E	42	38	42
S-1 and S-2	90	70	84
All other	40	37	36

C406.2 Additional energy efficiency credits achieved. Each energy efficiency credit measure used to meet credit requirements for the project shall have efficiency that is greater than the requirements in Sections C402 through C405. Measures installed in the project that meet the requirements in Sections C406.2.1 through C406.2.6 shall achieve the base credits listed for the measure and occupancy type in Tables C406.2(1) through C406.2(9) or, where calculations required by Sections C406.2.1 through C406.2.6 create or modify the table credits, the credits achieved shall be based on the calculations. Energy credits achieved for measures shall be determined by one of the following, as applicable:

1. The measure's energy credit shall be the base energy credit from Tables C406.2(1) through C406.2(9) for the measure where no adjustment factor or calculation is included in the description of the measure in Section C406.2.
2. The measure's energy credit shall be the base energy credit for the measure adjusted by a factor or equation as stated in the description of the measure in Section C406.2. Where adjustments are applied, each measure's energy credit shall be rounded to the nearest whole number.
3. The measure's energy credit shall be calculated as stated in the measure's description in Section C406.2, where each individual measure credit shall be rounded to the nearest whole number.

Energy credits achieved for the project shall be the sum of the individual measure's energy credits. Credits are available for the measures listed in this section. Where a project contains multiple building occupancy groups:

1. Credits achieved for each occupancy group shall be summed and then weighted by the conditioned floor area of each occupancy group to determine the weighted average project energy credits achieved.
2. Improved envelope efficiency (E01 through E06), HVAC performance (H01) and lighting reduction (L06) measure credits shall be determined for the building or permitted conditioned floor area as a whole. Credits for other measures shall be determined for each occupancy separately. Credits shall be taken from applicable tables or calculations for each occupancy and weighted by the building occupancy group floor area.

TABLE C406.2(1)
BASE ENERGY CREDITS FOR GROUP R-2, R-4 AND I-1 OCCUPANCIES[a]

ID	ENERGY CREDIT MEASURE	SECTION	CLIMATE ZONE		
			4	5	6
E01	Envelope performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1		
E02	UA reduction (15%)	C406.2.1.2	22	29	32
E03	Reduced air leakage	C406.2.1.3	7	65	73
E04	Add roof insulation	C406.2.1.4	5	6	7
E05	Add wall insulation	C406.2.1.5	8	11	14
E06	Improve fenestration	C406.2.1.6	22	27	41
H01	HVAC performance	C406.2.2.1	13	15	18
H02	Heating efficiency	C406.2.2.2	6	10	14
H03	Cooling efficiency	C406.2.2.3	1	1	x
H04	Residential HVAC control	C406.2.2.4	21	23	21
H05	DOAS/fan control	C406.2.2.5	42	56	73
W01	SHW preheat recovery	C406.2.3.1 a	103	102	93
W02	Heat pump water heater	C406.2.3.1 b	88	88	81
W03	Efficient gas water heater	C406.2.3.1 c	64	64	58
W04	SHW pipe insulation	C406.2.3.2	8	7	6
W05	Point of use water heaters	C406.2.3.3 a	x	x	x
W06	Thermostatic bal. valves	C406.2.3.3 b	3	3	3
W07	SHW heat trace system	C406.2.3.3 c	14	13	11
W08	SHW submeters	C406.2.3.4	19	19	17
W09	SHW flow reduction	C406.2.3.5	38	38	35
W10	Shower heat recovery	C406.2.3.6	27	27	25
P01	Energy monitoring	C406.2.4	2	2	3
L01	Lighting performance	C406.2.5.1	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	1	1	1
L03	Increase occupancy sensor	C406.2.5.3	2	1	1
L04	Increase daylight area	C406.2.5.4	x	x	x
L05	Residential light control	C406.2.5.5	6	4	3
L06	Light power reduction	C406.2.5.6	1	1	1
Q01	Efficient elevator	C406.2.6.1	4	4	4
Q02	Commercial kitchen equip.	C406.2.6.2	x	x	x
Q03	Residential kitchen equip.	C406.2.6.3	16	15	13
Q04	Fault detection	C406.2.6.4	2	1	3

DOAS = Dedicated Outside Air System; HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water; UA = U-factor × Area.

a. “x” indicates credit is not available in that climate zone for that measure.

TABLE C406.2(2)
BASE ENERGY CREDITS FOR GROUP I-2 OCCUPANCIES[a]

ID	ENERGY CREDIT MEASURE	SECTION	CLIMATE ZONE		
			4	5	6
E01	Envelope performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1		
E02	UA reduction (15%)	C406.2.1.2	1	27	3
E03	Reduced air leakage	C406.2.1.3	6	7	9
E04	Add roof insulation	C406.2.1.4	1	2	2
E05	Add wall insulation	C406.2.1.5	4	3	3
E06	Improve fenestration	C406.2.1.6	4	5	5
H01	HVAC performance	C406.2.2.1	x	x	x
H02	Heating efficiency	C406.2.2.2	6	8	11
H03	Cooling efficiency	C406.2.2.3	1	1	x
H04	Residential HVAC control	C406.2.2.4	x	x	x
H05	DOAS/fan control	C406.2.2.5	49	56	65
W01	SHW preheat recovery	C406.2.3.1 a	6	6	6
W02	Heat pump water heater	C406.2.3.1 b	3	3	3
W03	Efficient gas water heater	C406.2.3.1 c	3	3	3
W04	SHW pipe insulation	C406.2.3.2	1	1	1
W05	Point of use water heaters	C406.2.3.3 a	x	x	x
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1
W07	SHW heat trace system	C406.2.3.3 c	2	2	1
W08	SHW submeters	C406.2.3.4	x	x	x
W09	SHW flow reduction	C406.2.3.5	x	x	x
W10	Shower heat recovery	C406.2.3.6	1	1	1
P01	Energy monitoring	C406.2.4	3	3	3
L01	Lighting performance	C406.2.5.1	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	5	5	4
L03	Increase occupancy sensor	C406.2.5.3	5	5	4
L04	Increase daylight area	C406.2.5.4	x	x	x
L05	Residential light control	C406.2.5.5	x	x	x
L06	Light power reduction	C406.2.5.6	7	6	5
Q01	Efficient elevator	C406.2.6.1	2	2	2
Q02	Commercial kitchen equip.	C406.2.6.2	x	x	x
Q03	Residential kitchen equip.	C406.2.6.3	x	x	x
Q04	Fault detection	C406.2.6.4	3	3	3

DOAS = Dedicated Outside Air System; HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water; UA = U-Factor × Area.

a. “x” indicates credit is not available in that climate zone for that measure.

TABLE C406.2(3)
BASE ENERGY CREDITS FOR GROUP R-1 OCCUPANCIES[a]

ID	ENERGY CREDIT MEASURE	SECTION	CLIMATE ZONE		
			4	5	6
E01	Envelope performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1		
E02	UA reduction (15%)	C406.2.1.2	5	7	9
E03	Reduced air leakage	C406.2.1.3	14	19	28
E04	Add roof insulation	C406.2.1.4	2	2	3
E05	Add wall insulation	C406.2.1.5	6	7	8
E06	Improve fenestration	C406.2.1.6	6	9	13
H01	HVAC performance	C406.2.2.1	11	11	13
H02	Heating efficiency	C406.2.2.2	2	3	6
H03	Cooling efficiency	C406.2.2.3	1	1	x
H04	Residential HVAC control	C406.2.2.4	x	x	x
H05	DOAS/fan control	C406.2.2.5	26	30	41
W01	SHW preheat recovery	C406.2.3.1 a	34	37	36
W02	Heat pump water heater	C406.2.3.1 b	29	31	30
W03	Efficient gas water heater	C406.2.3.1 c	21	23	22
W04	SHW pipe insulation	C406.2.3.2	4	4	4
W05	Point of use water heaters	C406.2.3.3 a	x	x	x
W06	Thermostatic bal. valves	C406.2.3.3 b	2	2	2
W07	SHW heat trace system	C406.2.3.3 c	7	7	7
W08	SHW submeters	C406.2.3.4	x	x	x
W09	SHW flow reduction	C406.2.3.5	13	14	13
W10	Shower heat recovery	C406.2.3.6	9	10	9
P01	Energy monitoring	C406.2.4	2	2	2
L01	Lighting performance	C406.2.5.1	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	1	1	1
L03	Increase occupancy sensor	C406.2.5.3	4	2	2
L04	Increase daylight area	C406.2.5.4	x	x	x
L05	Residential light control	C406.2.5.5	x	x	x
L06	Light power reduction	C406.2.5.6	2	1	1
Q01	Efficient elevator	C406.2.6.1	3	3	2
Q02	Commercial kitchen equip.	C406.2.6.2	x	x	x
Q03	Residential kitchen equip.	C406.2.6.3	11	11	10
Q04	Fault detection	C406.2.6.4	2	2	2

DOAS = Dedicated Outside Air System; HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water; UA = U-Factor × Area.

a. “x” indicates credit is not available in that climate zone for that measure.

TABLE C406.2(4)
BASE ENERGY CREDITS FOR GROUP B OCCUPANCIES[a]

ID	ENERGY CREDIT MEASURE	SECTION	CLIMATE ZONE		
			4	5	6
E01	Envelope performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1		
E02	UA reduction (15%)	C406.2.1.2	13	21	13
E03	Reduced air leakage	C406.2.1.3	8	13	18
E04	Add roof insulation	C406.2.1.4	3	3	3
E05	Add wall insulation	C406.2.1.5	5	6	9
E06	Improve fenestration	C406.2.1.6	8	10	21
H01	HVAC performance	C406.2.2.1	15	16	19
H02	Heating efficiency	C406.2.2.2	3	5	9
H03	Cooling efficiency	C406.2.2.3	1	1	x
H04	Residential HVAC control	C406.2.2.4	x	x	x
H05	DOAS/fan control	C406.2.2.5	35	47	64
W01	SHW preheat recovery	C406.2.3.1 a	13	13	12
W02	Heat pump water heater	C406.2.3.1 b	5	5	5
W03	Efficient gas water heater	C406.2.3.1 c	8	8	8
W04	SHW pipe insulation	C406.2.3.2	4	4	4
W05	Point of use water heaters	C406.2.3.3 a	20	20	18
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1
W07	SHW heat trace system	C406.2.3.3 c	5	5	5
W08	SHW submeters	C406.2.3.4	x	x	x
W09	SHW flow reduction	C406.2.3.5	x	x	x
W10	Shower heat recovery	C406.2.3.6	x	x	x
P01	Energy monitoring	C406.2.4	3	3	3
L01	Lighting performance	C406.2.5.1	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	6	5	4
L03	Increase occupancy sensor	C406.2.5.3	6	5	4
L04	Increase daylight area	C406.2.5.4	6	6	6
L05	Residential light control	C406.2.5.5	x	x	x
L06	Light power reduction	C406.2.5.6	7	6	5
Q01	Efficient elevator	C406.2.6.1	5	5	4
Q02	Commercial kitchen equip.	C406.2.6.2	x	x	x
Q03	Residential kitchen equip.	C406.2.6.3	x	x	x
Q04	Fault detection	C406.2.6.4	2	2	3

DOAS = Dedicated Outside Air System; HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water; UA = U-Factor × Area.

a. “x” indicates credit is not available in that climate zone for that measure.

TABLE C406.2(5)
BASE ENERGY CREDITS FOR GROUP A-2 OCCUPANCIES[a]

ID	ENERGY CREDIT MEASURE	SECTION	CLIMATE ZONE		
			4	5	6
E01	Envelope performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1		
E02	UA reduction (15%)	C406.2.1.2	4	5	6
E03	Reduced air leakage	C406.2.1.3	24	33	42
E04	Add roof insulation	C406.2.1.4	1	2	2
E05	Add wall insulation	C406.2.1.5	2	2	2
E06	Improve fenestration	C406.2.1.6	1	3	4
H01	HVAC performance	C406.2.2.1	x	x	x
H02	Heating efficiency	C406.2.2.2	10	15	19
H03	Cooling efficiency	C406.2.2.3	1	1	x
H04	Residential HVAC control	C406.2.2.4	x	x	x
H05	DOAS/fan control	C406.2.2.5	51	67	84
W01	SHW preheat recovery	C406.2.3.1 a	38	37	34
W02	Heat pump water heater	C406.2.3.1 b	26	26	25
W03	Efficient gas water heater	C406.2.3.1 c	24	23	21
W04	SHW pipe insulation	C406.2.3.2	3	2	2
W05	Point of use water heaters	C406.2.3.3 a	x	x	x
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1
W07	SHW heat trace system	C406.2.3.3 c	4	3	3
W08	SHW submeters	C406.2.3.4	x	x	x
W09	SHW flow reduction	C406.2.3.5	x	x	x
W10	Shower heat recovery	C406.2.3.6	x	x	x
P01	Energy monitoring	C406.2.4	2	2	2
L01	Lighting performance	C406.2.5.1	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	2	1	1
L03	Increase occupancy sensor	C406.2.5.3	1	1	1
L04	Increase daylight area	C406.2.5.4	x	x	x
L05	Residential light control	C406.2.5.5	x	x	x
L06	Light power reduction	C406.2.5.6	2	2	1
Q01	Efficient elevator	C406.2.6.1	1	1	1
Q02	Commercial kitchen equip.	C406.2.6.2	26	24	21
Q03	Residential kitchen equip.	C406.2.6.3	x	x	x
Q04	Fault detection	C406.2.6.4	2	2	3

DOAS = Dedicated Outside Air System; HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water; UA = U-Factor × Area.

a. “x” indicates credit is not available in that climate zone for that measure.

TABLE C406.2(6)
BASE ENERGY CREDITS FOR GROUP M OCCUPANCIES[a]

ID	ENERGY CREDIT MEASURE	SECTION	CLIMATE ZONE		
			4	5	6
E01	Envelope performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1		
E02	UA reduction (15%)	C406.2.1.2	35	41	43
E03	Reduced air leakage	C406.2.1.3	44	56	64
E04	Add roof insulation	C406.2.1.4	19	21	24
E05	Add wall insulation	C406.2.1.5	27	25	23
E06	Improve fenestration	C406.2.1.6	7	7	10
H01	HVAC performance	C406.2.2.1	27	29	32
H02	Heating efficiency	C406.2.2.2	19	26	29
H03	Cooling efficiency	C406.2.2.3	1	1	x
H04	Residential HVAC control	C406.2.2.4	x	x	x
H05	DOAS/fan control	C406.2.2.5	98	120	134
W01	SHW preheat recovery	C406.2.3.1 a	17	16	13
W02	Heat pump water heater	C406.2.3.1 b	5	4	4
W03	Efficient gas water heater	C406.2.3.1 c	9	8	7
W04	SHW pipe insulation	C406.2.3.2	4	4	4
W05	Point of use water heaters	C406.2.3.3 a	x	x	x
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1
W07	SHW heat trace system	C406.2.3.3 c	5	5	5
W08	SHW submeters	C406.2.3.4	x	x	x
W09	SHW flow reduction	C406.2.3.5	x	x	x
W10	Shower heat recovery	C406.2.3.6	x	x	x
P01	Energy monitoring	C406.2.4	5	5	5
L01	Lighting performance	C406.2.5.1	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	9	7	5
L03	Increase occupancy sensor	C406.2.5.3	10	7	6
L04	Increase daylight area	C406.2.5.4	11	9	8
L05	Residential light control	C406.2.5.5	x	x	x
L06	Light power reduction	C406.2.5.6	8	6	6
Q01	Efficient elevator	C406.2.6.1	3	3	3
Q02	Commercial kitchen equip.	C406.2.6.2	x	x	x
Q03	Residential kitchen equip.	C406.2.6.3	x	x	x
Q04	Fault detection	C406.2.6.4	2	2	3

DOAS = Dedicated Outside Air System; HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water; UA = U-Factor × Area.

a. “x” indicates credit is not available in that climate zone for that measure.

TABLE C406.2(7)
BASE ENERGY CREDITS FOR GROUP E OCCUPANCIES[a]

ID	ENERGY CREDIT MEASURE	SECTION	CLIMATE ZONE		
			4A	5A	6A
E01	Envelope performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1		
E02	UA reduction (15%)	C406.2.1.2	24	33	40
E03	Reduced air leakage	C406.2.1.3	1	1	2
E04	Add roof insulation	C406.2.1.4	14	18	23
E05	Add wall insulation	C406.2.1.5	6	5	7
E06	Improve fenestration	C406.2.1.6	16	22	33
H01	HVAC performance	C406.2.2.1	19	19	23
H02	Heating efficiency	C406.2.2.2	5	9	15
H03	Cooling efficiency	C406.2.2.3	1	1	x
H04	Residential HVAC control	C406.2.2.4	x	x	x
H05	DOAS/fan control	C406.2.2.5	43	57	79
W01	SHW preheat recovery	C406.2.3.1 a	14	15	13
W02	Heat pump water heater	C406.2.3.1 b	10	11	10
W03	Efficient gas water heater	C406.2.3.1 c	9	9	8
W04	SHW pipe insulation	C406.2.3.2	5	5	4
W05	Point of use water heaters	C406.2.3.3 a	5	5	4
W06	Thermostatic bal. valves	C406.2.3.3 b	2	2	1
W07	SHW heat trace system	C406.2.3.3 c	6	6	5
W08	SHW submeters	C406.2.3.4	x	x	x
W09	SHW flow reduction	C406.2.3.5	x	x	x
W10	Shower heat recovery	C406.2.3.6	3	3	3
P01	Energy monitoring	C406.2.4	3	3	3
L01	Lighting performance	C406.2.5.1	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	6	5	4
L03	Increase occupancy sensor	C406.2.5.3	6	4	3
L04	Increase daylight area	C406.2.5.4	6	5	5
L05	Residential light control	C406.2.5.5	x	x	x
L06	Light power reduction	C406.2.5.6	7	6	5
Q01	Efficient elevator	C406.2.6.1	5	5	4
Q02	Commercial kitchen equip.	C406.2.6.2	x	x	x
Q03	Residential kitchen equip.	C406.2.6.3	x	x	x
Q04	Fault detection	C406.2.6.4	3	3	4

DOAS = Dedicated Outside Air System; HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water; UA = U-Factor × Area.

a. “x” indicates credit is not available in that climate zone for that measure.

TABLE C406.2(8)
BASE ENERGY CREDITS FOR GROUP S-1 AND S-2 OCCUPANCIES[a]

ID	ENERGY CREDIT MEASURE	SECTION	CLIMATE ZONE		
			4	5	6
E01	Envelope performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1		
E02	UA reduction (15%)	C406.2.1.2	37	44	43
E03	Reduced air leakage	C406.2.1.3	77	92	95
E04	Add roof insulation	C406.2.1.4	14	14	10
E05	Add wall insulation	C406.2.1.5	10	9	7
E06	Improve fenestration	C406.2.1.6	4	5	3
H01	HVAC performance	C406.2.2.1	x	x	x
H02	Heating efficiency	C406.2.2.2	33	41	44
H03	Cooling efficiency	C406.2.2.3	1	1	x
H04	Residential HVAC control	C406.2.2.4	x	x	x
H05	DOAS/fan control	C406.2.2.5	141	168	180
W01	SHW preheat recovery	C406.2.3.1 a	5	4	3
W02	Heat pump water heater	C406.2.3.1 b	1	1	1
W03	Efficient gas water heater	C406.2.3.1 c	3	2	2
W04	SHW pipe insulation	C406.2.3.2	2	1	1
W05	Point of use water heaters	C406.2.3.3 a	x	x	x
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1
W07	SHW heat trace system	C406.2.3.3 c	2	2	2
W08	SHW submeters	C406.2.3.4	x	x	x
W09	SHW flow reduction	C406.2.3.5	x	x	x
W10	Shower heat recovery	C406.2.3.6	x	x	x
P01	Energy monitoring	C406.2.4	5	5	5
L01	Lighting performance	C406.2.5.1	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	6	3	3
L03	Increase occupancy sensor	C406.2.5.3	7	5	4
L04	Increase daylight area	C406.2.5.4	7	5	4
L05	Residential light control	C406.2.5.5	x	x	x
L06	Light power reduction	C406.2.5.6	8	5	4
Q01	Efficient elevator	C406.2.6.1	9	7	5
Q02	Commercial kitchen equip.	C406.2.6.2	x	x	x
Q03	Residential kitchen equip.	C406.2.6.3	x	x	x
Q04	Fault detection	C406.2.6.4	5	5	6

DOAS = Dedicated Outside Air System; HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water; UA = U-Factor × Area.

a. “x” indicates credit is not available in that climate zone for that measure.

TABLE C406.2(9)
BASE ENERGY CREDITS FOR OTHER OCCUPANCIES[a, b]

ID	ENERGY CREDIT MEASURE	SECTION	CLIMATE ZONE		
			4A	5A	6A
E01	Envelope performance	C406.2.1.1	Determined in accordance with Section C406.2.1.1		
E02	UA reduction (15%)	C406.2.1.2	18	26	24
E03	Reduced air leakage	C406.2.1.3	28	36	41
E04	Add roof insulation	C406.2.1.4	7	9	9
E05	Add wall insulation	C406.2.1.5	9	9	9
E06	Improve fenestration	C406.2.1.6	9	11	16
H01	HVAC performance	C406.2.2.1	x	x	x
H02	Heating efficiency	C406.2.2.2	11	15	18
H03	Cooling efficiency	C406.2.2.3	x	x	x
H04	Residential HVAC control	C406.2.2.4	x	x	x
H05	DOAS/fan control	C406.2.2.5	61	75	90
W01	SHW preheat recovery	C406.2.3.1 a	29	29	26
W02	Heat pump water heater	C406.2.3.1 b	21	21	20
W03	Efficient gas water heater	C406.2.3.1 c	18	18	16
W04	SHW pipe insulation	C406.2.3.2	4	4	3
W05	Point of use water heaters	C406.2.3.3 a	13	13	11
W06	Thermostatic bal. valves	C406.2.3.3 b	1	1	1
W07	SHW heat trace system	C406.2.3.3 c	6	5	5
W08	SHW submeters	C406.2.3.4	x	x	x
W09	SHW flow reduction	C406.2.3.5	x	x	x
W10	Shower heat recovery	C406.2.3.6	10	10	10
P01	Energy monitoring	C406.2.4	3	3	3
L01	Lighting performance	C406.2.5.1	x	x	x
L02	Lighting dimming & tuning	C406.2.5.2	5	4	3
L03	Increase occupancy sensor	C406.2.5.3	5	4	3
L04	Increase daylight area	C406.2.5.4	x	x	x
L05	Residential light control	C406.2.5.5	x	x	x
L06	Light power reduction	C406.2.5.6	5	4	4
Q01	Efficient elevator	C406.2.6.1	4	4	3
Q02	Commercial kitchen equip.	C406.2.6.2	x	x	x
Q03	Residential kitchen equip.	C406.2.6.3	x	x	x
Q04	Fault detection	C406.2.6.4	3	3	4

DOAS = Dedicated Outside Air System; HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water; UA = U-Factor × Area.

a. “x” indicates credit is not available in that climate zone for that measure.

b. Other occupancy groups include all groups except Groups A-2, B, E, I, M, S and R.

C406.2.1 More efficient building thermal envelope. A project shall achieve credits for improved envelope performance by complying with one of the following measures:

1. Section C406.2.1.1: E01.
2. Section C406.2.1.2: E02.
3. Section C406.2.1.3: E03.
4. Both E02 and E03.
5. Any combination of:
   5.1. Section C406.2.1.3: E03.
   5.2. Section C406.2.1.4: E04.
   5.3. Section C406.2.1.5: E05.

C406.2.1.1 E01 Improved envelope performance ASHRAE 90.1 Appendix C. *Building thermal envelope* measures shall be installed to improve the energy performance of the project. The achieved energy credits shall be determined using Equation 4-13.

Equation 4-13 $EC_{ENV} = 1{,}000 \times (EPF_B - EPF_P)/EPF_B$

where:

EC_{ENV} = E01 measure energy credits.

EPF_B = base envelope performance factor calculated in accordance with ASHRAE 90.1 Appendix C.

EPF_P = proposed envelope performance factor calculated in accordance with ASHRAE 90.1 Appendix C.

C406.2.1.2 E02 Component performance envelope reduction. Energy credits shall be achieved where the component performance of the building thermal envelope as designed is not less than 15 percent below the component performance of the building thermal envelope in accordance with Section C402.1.4.

C406.2.1.3 E03 Reduced air leakage. Energy credits shall be achieved where tested building *air leakage* is not less than 10 percent of the maximum leakage permitted by Section C402.6.2, provided that the *building* is tested in accordance with the applicable method in Section C402.6.2. Energy credits achieved for measure E03 shall be determined as follows:

Equation 4-14 $EC_{E03} = EC_B \times EC_{adj}$

where:

EC_{E03} = Energy efficiency credits achieved for envelope leakage reduction.

EC_B = Section C406.2.1.3 credits from Tables C406.2(1) through C406.2(9).

$EC_{adj} = L_s / EC_a$

L_s = Leakage savings fraction: the lesser of $[(L_r - L_m)/L_r]$ or 0.8.

L_r = Maximum leakage permitted for tested buildings, by occupancy group, in accordance with Section C402.6.2.

L_m = Measured leakage in accordance with Section C402.6.2.1 or C402.6.2.2.

EC_a = Energy credit alignment factor: 0.37 for whole-building tests in accordance with Section C402.6.2.1 or 0.25 for dwelling and sleeping unit enclosure tests in accordance with Section C402.6.2.2.

C406.2.1.4 E04 Added roof insulation. Energy credits shall be achieved for insulation that is in addition to the required insulation in Table C402.1.3. All roof areas in the project shall have additional R-10 continuous insulation included in the roof assembly. For attics, this is permitted to be achieved with fill or batt insulation rated at R-10 that is continuous and not interrupted by ceiling or roof joists. Where interrupted by joists, the added insulation shall be not less than R-13. Alternatively, one- half of the base credits shall be achieved where the added R-value is one-half of the additional R-value required by this section.

C406.2.1.5 E05 Added wall insulation. Energy credits shall be achieved for insulation applied to not less than 90 percent of all opaque wall area in the project that is in addition to the required insulation in Table C402.1.3. Opaque walls shall have additional R-5 continuous insulation included in the wall assembly. Alternatively, one-half of the base credits shall be achieved where the added R-value is R-2.5.

C406.2.1.6 E06 Improve fenestration. Reserved

C406.2.2 More efficient HVAC equipment performance. All heating and cooling systems shall meet the minimum requirements of Section C403 and efficiency improvements shall be referenced to minimum efficiencies listed in tables referenced by Section C403.3.2. Where multiple efficiency requirements are listed, equipment shall meet the seasonal or part-load efficiencies including SEER, integrated energy efficiency ratio (IEER), integrated part load value (IPLV) or AFUE. Equipment that is larger than the maxi- mum capacity range indicated in tables referenced by Section C403.3.2 shall utilize the values listed for the largest capacity equipment for the associated equipment type shown in the table. Where multiple individual heating or cooling systems serve the project, the improvement shall be the weighted-average improvement based on individual system capacity. Systems are permit- ted to achieve HVAC energy credits by meeting the requirements of one of the following:

1. C406.2.2.1 H01.
2. C406.2.2.2 H02.
3. C406.2.2.3 H03.
4. C406.2.2.4 H04.
5. C406.2.2.5 H05.
6. Any combination of H02, H03, H04 and H05.
7. The combination of H01 and H04.

C406.2.2.1 H01 HVAC Total System Performance Ratio (TSPR). H01 energy credits shall be earned where systems are permitted to use Section C409 and where the savings ($TSPR_s$) based on the proposed TSPR ($TSPR_p$) compared to the target TSPR is 5 percent or more. If savings are greater than 5 percent, determine H01 earned credits using Equation 4-15. Energy credits for H01 shall not be combined with energy credits from HVAC measures H02, H03 or H05.

Equation 4-15 $$EC_{TSPR} = EC_{BASE} \times AREA_{TSPR} \times TSPR_S/0.05$$

EC_{TSPR} = Energy credits achieved for H01.

EC_{BASE} = H01 base energy credits from Tables C406.2(1) through C406.2(9).

$TSPR_s$ = The lesser of 0.20 and [1 – ($TSPR_t$ / $TSPR_p$)]. where:

$AREA_{TSPR}$ = (floor area served by systems included in TSPR)/(total building conditioned floor area)

$TSPR_p$ = HVAC TSPR of the proposed design calculated in accordance with Sections C409.4, C409.5 and C409.6.

$TSPR_t = TSPR_r / MPF$.

$TSPR_r$ = HVAC TSPR of the reference building design calculated in accordance with Sections C409.4, C409.5 and C409.6.

MPF = Mechanical performance factor from Table C409.4 based on *climate zone* and building use type. Where a building has multiple building use types, *MPF* shall be area weighted in accordance with Section C409.4.

C406.2.2.3 H03 More efficient HVAC cooling equipment and fan performance. In accordance with Section C406.1.1, not less than 90 percent of the total HVAC cooling capacity serving the total *conditioned floor area* of the entire *building* or tenant space shall comply with all of the requirements of this section.

1. Equipment installed shall be types that are listed in tables referenced by Section C403.3.2.
2. Equipment shall exceed the minimum cooling efficiency requirements listed in tables referenced by Section C403.3.2 by not less than 5 percent. For water-cooled chiller plants, heat-rejection equipment performance in Table C403.3.2(7) shall also be increased by at least the chiller efficiency improvement. Where equipment exceeds both the minimum annual cooling efficiency and heat-rejection efficiency requirements by more than 5 percent, energy efficiency credits for cooling shall be determined using Equation 4-17, rounded to the nearest whole number.

Where fan energy is not included in the packaged equipment rating or it is and the fan size has been increased from the as- rated equipment condition, fan power or horsepower shall be less than 95 percent of the allowed fan power in Section C403.8.1.

Equation 4-17 $EEC_{HEH} = EEC_{H5} \times (CEI/0.05)$

EEC_{HEC} = Energy efficiency credits for cooling efficiency improvement.

EEC_5 = Section C406.2.2.3 base energy credits from Tables C406.2(1) through C406.2(9).

CEI = The lesser of the improvement above minimum cooling efficiency and heat-rejection performance requirements, expressed as a fraction, or 20 percent (0.20). Where cooling equipment with different minimum efficiencies is included in the building, a cooling capacity weighted-average improvement shall be used. Where multiple cooling efficiency or performance requirements are provided, the equipment shall exceed the annualized energy or part-load requirement. Meeting both part-load and full-load efficiencies is not required.

For metrics that increase as efficiency increases, *CEI* shall be calculated as follows:

$CEI = (CM_{DES} / CM_{MIN}) - 1$.

For metrics that decrease as efficiency increases, CEI shall be calculated as follows:

$CEI = (CM_{MIN} / CM_{DES}) - 1$.

where:

CM_{DES} = Design cooling efficiency metric, part-load or annualized where available.

CM_{MIN} = Minimum required cooling efficiency metric, part-load or annualized where available from Section C403.3.2.

For data centers using ASHRAE Standard 90.4, *CEI* shall be calculated as follows:

$CEI = (AMLC_{MAX} / AMLC_{DES}) - 1$

where:

$AMLC_{DES}$ = As-designed annualized mechanical load component calculated in accordance with ASHRAE Standard 90.4, Section 6.5.

$AMLC_{MAX}$ = Maximum annualized mechanical load component from ASHRAE Standard 90.4, Table 6.5.

C406.2.2.4 H04 Residential HVAC control. HVAC systems serving dwelling units or sleeping units shall be controlled to automatically activate a setback at least 5°F (3°C) for both heating and cooling. The temperature controller shall be configured to provide setback during occupied sleep periods. The unoccupied setback mode shall be configured to operate in conjunction with one of the following:

1. A manual main control device by each dwelling unit main entrance that initiates setback and nonventilation mode for all HVAC units in the dwelling unit and is clearly identified as “Heating/Cooling Master Setback.”
2. Occupancy sensors in each room of the dwelling unit combined with a door switch to initiate setback and nonventilation mode for all HVAC units in the dwelling within 20 minutes of all spaces being vacant immediately after a door switch operation. Where separate room HVAC units are used, an individual occupancy sensor on each unit that is configured to provide setback shall meet this requirement.
3. An advanced learning thermostat or controller that recognizes occupant presence and automatically creates a sched- ule for occupancy and provides a dynamic setback schedule based on when the spaces are generally unoccupied.
4. An automated control and sensing system that uses geographic fencing connected to the dwelling unit occupants’ cell phones and initiates the setback condition when all occupants are away from the building.

C406.2.2.5 H05 Dedicated outdoor air system. Credits for this measure are allowed only where single-zone HVAC units are not required to have multispeed or variable-speed fan control in accordance with Section C403.8.6.1. HVAC controls and ventilation systems shall include all of the following:

1. Zone controls shall cycle the heating/cooling unit fans off when not providing required heating and cooling or shall limit fan power to 0.12 watts/cfm (0.056 w/l/s) of zone supply air.
2. Outdoor air shall be supplied by an independent ventilation system designed to provide not more than 130 percent of the minimum outdoor air to each individual occupied zone, as specified by the *New York City Mechanical Code*.

   Exception: Outdoor airflow is permitted to increase during emergency or economizer operation, implemented as described in Item 4.
3. The ventilation system shall have energy recovery with an enthalpy recovery ratio of 65 percent or more at heating design conditions and an enthalpy recovery ratio of 65 percent or more at cooling design conditions. Energy recovery shall include latent recovery. Where no humidification is provided, heating energy recovery effectiveness is permitted to be based on sensible energy recovery ratio. Where energy recovery effectiveness is less than the 65 percent required for full credit, adjust the credits from Section C406.2 by the factors in Table C406.2.2.5.

4. Where the ventilation system serves multiple zones and the system is not in a latent recovery outside air dehumidification mode, partial economizer cooling through an outdoor air bypass or wheel speed control shall automatically do one of the following:

   4.1. Set the energy recovery leaving-air temperature 55°F (13°C) or 100 percent outdoor air bypass when a majority of zones require cooling and outdoor air temperature is below 70°F (21°C).

   4.2. The HVAC ventilation system shall include supply-air temperature controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperatures. The controls shall reset the supply-air temperature not less than 25 percent of the difference between the design supply-air temperature and the design room-air temperature.

5. Ventilation systems providing mechanical dehumidification shall use recovered energy for reheat within the limits of Item 4. This shall not limit the use of latent energy recovery for dehumidification.

Where only a portion of the building is permitted to be served by constant air volume units or the enthalpy recovery ratio or sensible energy recovery ratio is less than 65 percent, the base energy credits shown in Section C406.2 shall be prorated as follows:

Equation 4-18 $EC_{DOAS} = EC_{BASE} \times FLOOR_{CAV} \times ERE_{ADJ}$

where:

EC_{DOAS} = Energy credits achieved for H05.

EC_{BASE} = H05 base energy credits in Section C406.2.

$FLOOR_{CAV}$ = Fraction of whole-project gross conditioned floor area not required to have variable-speed or multi-speed fan airflow control in accordance with Section C403.8.6.

ERE_{adj} = The energy recovery adjustment from Table C406.2.2.5 based on the lower of actual cooling or heating enthalpy recovery ratio or sensible energy recovery ratio where required for the *climate zone*. Where recovery ratios vary, use a weighted average by supply airflow.

TABLE C406.2.2.5
DOAS ENERGY RECOVERY ADJUSTMENTS

ERE_{adj} **BASED ON LOWER OF ACTUAL HEATING OR COOLING ENERGY RECOVERY EFFECTIVENESS WHERE REQUIRED**		
Cooling *Err* Is at Least	**Heating Enthalpy Recovery Ratio or Sensible Energy Recovery Ratio Is at Least**	**Energy Recovery Effectiveness Adjustment (ERE_{adj})**
65%	65%	1.00
60%	60%	0.67
55%	55%[a]	0.33
50%	50%[a]	0.25

a. In climate zones where heating recovery is required in Section C403, a heating recovery effectiveness below 60 percent is not allowed for dwelling units.

C406.2.3 Reduced energy use in service water heating. For projects with service water heating equipment that serves the whole building, a building addition or a tenant space shall achieve credits through compliance with the requirements of this section. Systems are permitted to achieve energy credits by meeting the requirements of one of the following:

1. Section C406.2.3.1 by selecting one allowed measure W01, W02, or a combination in accordance with Section C406.2.3.1.4.
2. Section C406.2.3.2 W04.
3. Section C406.2.3.3 by selecting one allowed measure: W05, W06 or W07.
4. Section C406.2.3.4 W08.
5. Section C406.2.3.5 W09.
6. Section C406.2.3.6 W10.
7. Any combination of measures in Sections C406.2.3.1 through C406.2.3.6 as long as not more than one allowed measure from Sections C406.2.3.1 and C406.2.3.3 are selected.

C406.2.3.1 Service water heating system efficiency. A project is allowed to achieve energy credits from only one of Sections C406.2.3.1.1 through C406.2.3.1.4.

C406.2.3.1.1 W01 Recovered or renewable water heating. The building service water-heating system shall have one or more of the following that are sized to provide not less than 30 percent of the building's annual hot water requirements, or sized to provide not less than 70 percent of the building's annual hot water requirements if the building is required to comply with Section C403.11.5:

1. Waste heat recovery from service hot water, heat recovery chillers, building equipment or process equipment.
2. A water-to-water heat pump that precools chilled water return for building cooling while heating SHW.
3. On-site renewable energy water-heating systems.

C406.2.3.1.2 W02 Heat pump water heater. Air-source heat pump water heaters shall be installed according to the manufacturer's instructions and at least 30 percent of design end-use service water heating requirements shall be met using only heat pump heating at an ambient condition of 67.5°F (19.7°C), db without supplemental electric resistance or fossil fuel heating. For a heat pump water heater with supplemental electric resistance heating, the heat pump-only capacity shall be deemed at 40 percent of first-hour draw. Where the heat pump-only capacity exceeds 50 percent of the design end-use load, excluding recirculating system losses, the credits from the Section C406.2 tables shall be prorated as follows:

Equation 4-19 $ECH_{PWH} = (EC_{BASE}/0.5) \times \{(CAP_{HPWH})/(\text{Endload})[\text{not greater than 2}]\}$ where:

ECH_{PWH} = Energy credits achieved for W02.
EC_{BASE} = W02 base energy credits from Tables C406.2(1) through C406.2(9).
Endload = End-use peak hot water load, excluding load for heat trace or recirculation, Btu/h or kW.
CAP_{HPWH} = The heat pump-only capacity at 50°F (10°C) entering air and 70°F (21°C) entering potable water without supplemental electric resistance or fossil fuel heat, Btu/h or kW.

The heat pump service water heating system shall comply with the following requirements

1. For systems with an installed total output capacity of more than 100,000 Btu/h (29 kW) at an ambient condition of 67.5°F (19.7°C) db, a preheat storage tank with greater than or equal to 0.75 gallons per 1,000 Btu/h (≥ 9.7 L/kW) of design end-use service water-heating requirements shall be heated only with a heat pump heating when the ambient temperature is greater than 45°F (7.2°C).
2. For systems with piping temperature maintenance, either a heat trace system or a separate water heater in series for recirculating system and final heating shall be installed.
3. Heat pump water heater efficiency shall meet or exceed one of the following:
   3.1. Output-capacity-weighted-average UEF of 3.0 in accordance with 10 CFR 430 Appendix E.
   3.2. Output-capacity-weighted-average COP of not less than 4.0 tested at 50°F (10°C) entering air and 70°F (21°C) entering potable water in accordance with ANSI/AHRI 1300.

C406.2.3.1.3 W03 Efficient fossil fuel water heater. Reserved.

C406.2.3.1.4 Combination service water heating systems. Where service water heating employs both energy recovery and heat pump water heating, W01 may be combined with W02 and receive the sum of both credits.

C406.2.3.2 W04 Service hot water piping insulation increase. Where service hot water is provided by a central water heating system, the hot water pipe insulation thickness shall be at least 1.5 times the thickness required in Section C404.4. All service hot water piping shall be insulated from the hot water source to the fixture shutoff. Where 50 percent or more of hotwater piping does not have increased insulation due to installation in partitions, the credit shall be prorated as a percentage of lineal feet of piping with increased insulation.

C406.2.3.3 Service water-heating distribution temperature maintenance. A project is allowed to claim energy credits from only one of the following SHW distribution temperature maintenance measures.

1. **W05 Point of use water heaters.** Credits are available for Group B or E buildings larger than 5,000 square feet (465 m^2) where service water heating systems meet the following requirements:
   1.1. Fixtures requiring hot water shall be supplied from a local water heater with no recirculating system or heat trace piping.

   Exception: Commercial kitchens or showers in locker rooms shall be permitted to have a local recirculating system or heat trace piping where water heaters are located not more than 50 lineal feet (15 m) from the farthest fixture served.

   1.2. Supply piping from the water heater to the termination of the fixture supply pipe shall be insulated to the levels shown in Table C404.4.1.

   Exceptions:

   1. Piping at locations where a vertical support of the piping is installed.

2. Where piping passes through a framing member and insulation requires increasing the size of the framing member.

1.3. The water volume in the piping from the water heater to the termination of any individual fixture shall be limited as follows:

1.3.1. Nonresidential public lavatory faucets that are available for use by members of the general public: not more than 2 ounces (59 mL).

1.3.2. Commercial kitchens or showers in locker rooms with recirculating systems or heat trace piping: not more than 24 ounces (710 mL) from the recirculating system or heat trace piping.

1.3.3. All other plumbing fixtures or appliances: not more than 16 ounces (473 mL).

2. **W06 Thermostatic balancing valves.** Credits are available where service water heating is provided centrally and distributed throughout the building with a recirculating system. Each recirculating system branch return connection to the main SHW supply piping shall have an automatic thermostatic balancing valve set to a minimal return water flow when the branch return temperature is greater than 120°F (49°C).

3. **W07 Heat trace system.** Credits are available for projects with gross floor area greater than 10,000 square feet (929 m^2) and a central water heating system. The energy credits achieved shall be from Tables C406.2(1) through C406.2(9). This system shall include self-regulating electric heat cables, connection kits and electronic controls. The cable shall be installed directly on the hot water supply pipes underneath the insulation to replace standby losses.

C406.2.3.4 W08 Water-heating system submeters. Each individual *dwelling unit* in a Group R-2 occupancy served by a central service water heating system shall be provided with a service hot water meter connected to a reporting system that provides individual *dwelling unit* reporting of actual domestic hot water use. Preheated water serving the cold water inlet to showers need not be metered.

C406.2.3.5 W09 Service hot water flow reduction. *Dwelling unit*, *sleeping unit* and guestroom plumbing fixtures that are connected to the service water-heating system shall have a flow or consumption rating less than or equal to the values shown in Table C406.2.3.5.

TABLE C406.2.3.5
MAXIMUM FLOW RATING FOR RESIDENTIAL PLUMBING FIXTURES WITH HEATED WATER

PLUMBING FIXTURE	MAXIMUM FLOW RATE
Faucet for private lavatory,[a] hand sinks, or bar sinks	1.2 gpm at 60 psi
Faucet for residential kitchen sink[a, b, c]	1.8 gpm at 60 psi
Shower head (including hand-held shower spray) [a, b, d]	1.8 gpm at 80 psi

For SI: 1 gallon per minute = 3.785 L/min, 1 pound per square inch = 6.89 kPa.

a. Showerheads, lavatory faucets and kitchen faucets are subject to US federal requirements listed in 10 CFR 430.32(o)–(p).
b. Maximum flow allowed is less than required by flow rates listed in 10 CFR 430.32(o)–(p) for showerheads and kitchen faucets.
c. Residential kitchen faucets may temporarily increase the flow above the maximum rate, but not above 2.2 gallons per minute at 60 psi (8.3 L/min at 414 kPa), and must default to the maximum flow rate listed.
d. Where a shower is served by multiple shower heads, the combined flow rate of all shower heads controlled by a single valve shall not exceed the maximum flow rate listed or the shower shall be designed to allow only one shower head to operate at a time.

C406.2.3.6 W10 Shower drain heat recovery. Cold water serving building showers shall be preheated by shower drain heat recovery units that comply with Section C404.7. The efficiency of drain heat recovery units shall be 54 percent or greater measured in accordance with CSA B55.1. Full credits are applicable to the following building uses: I-2, I-4, R-1, R-2 and also Group E where there are more than eight showers. Partial credits are applicable to buildings where all but ground floor showers are served where the base energy credit from Section C406.2 is adjusted by Equation 4-21.

Equation 4-21

W10 credit = W10 base energy credit × (showers with drain heat recovery/total showers in building)

C406.2.4 P01 Energy monitoring. A project not required to comply with Section C405.13 can achieve energy credits for installing an energy monitoring system that complies with all the requirements of Sections C405.13.1 through C405.13.5.

C406.2.5 Energy savings in lighting systems. Projects are permitted to achieve energy credits for increased lighting system performance by meeting the requirements of one of the following:

1. Section C406.2.5.2 L02.
2. Section C406.2.5.3 L03.
3. Section C406.2.5.4 L04.
4. Section C406.2.5.5 L05.
5. Section C406.2.5.6 L06.
6. Any combination of L03, L04, L05 and L06.
7. Any combination of L02, L03 and L04.

C406.2.5.1 L01 Lighting system performance (reserved). Reserved for future use.

C406.2.5.2 L02 High-end trim lighting controls. Measure credits shall be achieved where qualifying spaces are not less than 50 percent of the project interior floor area exclusive of *dwelling* and *sleeping units*. Qualifying spaces are those where *general lighting* is controlled by *high-end trim* lighting controls complying with the following:

1. The calibration adjustment equipment is located for ready access only by authorized personnel.
2. Lighting controls with ready access for users cannot increase the lighting power above the maximum level established by the high-end trim controls.
3. Construction documents shall state that maximum light output or power of general lighting in spaces contributing to the qualifying floor area shall be not greater than 85 percent of full power or light output.
4. High-end trim lighting controls shall be tested in accordance with Section C408.3.1.5.

The base credits from Tables C406.2(1) through C406.2(9) shall be prorated as follows:

HET × [Base energy credits for C406.2.5.2]/50%

where:

HET = Floor area of qualifying spaces where *general lighting* is provided with high-end trim lighting controls complying with this section, expressed as a percentage of total interior floor area, excluding *dwelling* and *sleeping units*.

C406.2.5.3 L03 Increase occupancy sensor. Lighting controls shall comply with Sections C406.2.5.3.1, C406.2.5.3.2 and C406.2.5.3.3.

C406.2.5.3.1 Occupant sensor controls. Occupant sensor controls shall be installed to control lights in the following space types:

1. Food preparation area.
2. Laboratory.
3. Elevator lobby.
4. Pharmacy area.
5. Vehicular maintenance area.
6. Workshop.
7. Recreation room in a facility for the visually impaired.
8. Exercise area in a fitness center.
9. Playing area in a fitness center.
10. Exam/treatment room in a health care facility.
11. Imaging room in a health care facility.
12. Physical therapy room in a health care facility.
13. Library reading area.
14. Library stacks.
15. Detailed manufacturing area.
16. Equipment room in a manufacturing facility.
17. Low-bay area in a manufacturing facility.
18. Post office sorting area.
19. Religious fellowship hall.
20. Hair salon.
21. Nail salon.
22. Banking activity area.
23. Museum restoration room.

C406.2.5.3.2 Occupant sensor control function. Occupant sensors in library stacks and laboratories shall comply with Section C405.2.1.2. Occupant sensors in elevator lobbies shall comply with Section C405.2.1.4. All other occupant sensors required by Section C406.2.5.3.1 shall comply with Section C405.2.1.1.

Exception: In spaces where an *automatic* shutoff could endanger occupant safety or security, *occupant sensor controls* shall uniformly reduce lighting power to not more than 20 percent of full power within 10 minutes after all occupants have left the space. Time-switch controls complying with Section C405.2.2.1 shall automatically turn off lights.

C406.2.5.3.3 Occupant sensor time delay and setpoint. *Occupant sensor controls* installed in accordance with Sections C405.2.1.1, C405.2.1.2, C405.2.1.3 and C405.2.1.4 shall automatically turn off lights or reduce lighting power within 10 minutes after all occupants have left the space. *Occupant sensor controls* installed in accordance with Section C405.2.1.2 shall have an unoccupied setpoint of not greater than 20 percent of full power.

C406.2.5.4 L04 Increased daylight area. The total daylight area of the *building* (DLA_{BLDG}) determined by Equation 4-22 shall be at least 5 percent greater than the typical daylight area (DLA_{TYP}) from Table C406.2.5.4. Credits for measure L04 shall be deter- mined by Equation 4-23 or Equation 4-24, whichever is less:

Equation 4-22 $DLA_{BLDG} = DLZ/LFA$

where:

DLZ = The total building floor area located within sidelit and toplit daylight zones complying with Section C405.2.4.2 or C405.2.4.3 and provided with daylight responsive controls complying with Section C405.2.4.1, ft^2 or m^2.

LFA = The total building floor area used to determine the lighting power allowance in Section C405.3.2, ft^2 or m^2.

Equation 4-23 $EC_{DL} = EC_{DL5} \times 20 \times (DLA_{BLDG} - DLA_{TYP})$

where:

EC_{DL} = The lesser of actual area of daylight zones in the *building* with continuous daylight dimming, ft^2 or m^2 and ($GLFA \times DLA$); see Table C406.2.5.4. Daylight zones shall meet the criteria in Sections C405.2.4.2 and C405.2.4.3 for primary sidelit daylight zones, secondary sidelit daylight zones and toplit daylight zones.

DLA_{TYP} = Typical percent of building area with daylight control (as a fraction) from Table C406.2.5.4.

EC_{DL5} = Section C406.2.5.4 L04 base energy credits from Section C406.2.

Equation 4-24 $EC_{DL} = EC_{DL5} \times 20 \times (DLA_{MAX} - DLA_{TYP})$

where:

EC_{DL} = The number of credits achieved by this measure.

EC_{DL5} = Section C406.2.5.4 L04 base energy credits from Section C406.2 and Tables C406.2(4), C406.2(6), C406.2(7) and C406.2(8).

DLA_{TYP} = Typical percent of building floor area with daylight control (as a fraction) from Table C406.2.5.4.

DLA_{MAX} = Maximum percent of building floor area with daylight control that can be counted for compliance with this measure, from Table C406.2.5.4.

TABLE C406.2.5.4
ADDED DAYLIGHTING PARAMETERS

BUILDING-USE TYPE	DLA_{TYP}	DLA_{MAX}
Group B; ≤ 5,000 ft^2 (460 m^2)	10%	20%
Group B; > 5,000 ft^2 (460 m^2)	21%	31%
Group M; with ≤ 1,000 ft^2 (900 m^2) roof area	0%	20%
Group M; with > 1,000 ft^2 (900 m^2) roof area	60%	80%
Group E; education	42%	52%
Groups S-1 and S-2; warehouse	50%	70%
Groups S-1 and S-2; other than warehouse	NA	NA

NA = Not Available.

C406.2.5.5 L05 Residential light control. In *buildings* with Group R-2 occupancy spaces, interior lighting systems shall comply with the following:

1. In *common areas*, the following space types shall have *occupant sensor controls* that comply with the requirements of Section C405.2.1.1:
   1.1. Laundry/washing areas.
   1.2. Dining areas.
   1.3. Food preparation areas.
   1.4. Seating areas.
   1.5. Exercise areas.
   1.6. Massage spaces.
2. In *dwelling units*, not less than one receptacle in each living room and each sleeping room shall be controlled by a switch in that room.
3. Lights and switched receptacles in bathrooms and kitchens shall be controlled by an occupant sensor complying with Section C405.2.1.1. All other lights and switched receptacles in each *dwelling unit* shall be controlled by a switch at the main entrance. The switch shall be marked to indicate its function.

   Exception: Lighting and switched receptacles controlled by an occupant sensor complying with Section C405.2.1.1 are not required to be controlled by the switch at the main entrance.

C406.2.5.6 L06 Reduced lighting power. Interior lighting within all building areas shall comply with this section.

1. The connected interior lighting power (LP) determined in accordance with Section C405.3.1 shall be 95 percent or less than the interior lighting power allowance (LPA) determined in accordance with Section C405.3.2 using the same method used to comply with Section C405.3. Energy credits shall not be greater than four times the L06 base credit from Section C406.2 and shall be determined using Equation 4-25.
2. All permanently installed lighting serving dwelling units and sleeping units, including ceiling fan light kits and lighting integrated into range hoods and exhaust fans shall be provided by lamps with an efficacy of not less than 90 lumens per watt or by luminaires that have an efficacy of not less than 65 lumens per watt.

Exceptions:

1. Lighting integral to other appliances.
2. Antimicrobial lighting used for the sole purpose of disinfecting.

Equation 4-25 $ECLPA = EC5 \times 20 \times (LPA - LP)/LPA$

where:

EC_{LPA} = Additional energy credit for lighting power reduction.
LP = Connected interior lighting power calculated in accordance with Section C405.3.1, watts.
LPA = Interior lighting power allowance calculated in accordance with the requirements of Section C405.3.2, watts.
EC_5 = L06 base credit from Section C406.2.

C406.2.6 Efficient equipment credits. Projects are permitted to achieve energy credits using any combination of Efficient Equipment Credits Q01 through Q04.

C406.2.6.1 Q01 Efficient elevator equipment. Reserved.

C406.2.6.2 Q02 Efficient commercial kitchen equipment. Reserved.

C406.2.6.3 Q03 Efficient residential kitchen equipment. For projects with Group R-1 and R-2 occupancies, energy cred- its shall be achieved where all dishwashers, refrigerators and freezers comply with all of the following:

1. Achieve the Energy Star Most Efficient 2021 label in accordance with the specifications current as of:
   1.1. Refrigerators and freezers 5.0, 9/15/2014.
   1.2. Dishwashers 6.0, 1/29/2016.
2. Be installed before the issuance of the certificate of occupancy.

For Group R-1 where only some sleeping units are equipped with both refrigerators and dishwashers, the table credits shall be prorated as follows:

Equation 4-27

[Section C406.2 base credits] × [floor area of sleeping units with kitchens]/[total sleeping unit floor area]

C406.2.6.4 Q04 Fault detection and diagnostics system. A project not required to comply with Section C403.2.3 can achieve energy credits for installing a fault detection and diagnostics system to monitor the HVAC system's performance and automatically identify faults. The installed system shall comply with Items 1 through 6 in Section C403.2.3.

C406.3 Renewable and load management credits achieved. Renewable energy and load management measures shall achieve credits as follows:

1. General measure requirements. Credits are achieved for measures installed in the building that comply with Sections C406.3.1 through C406.3.8.
2. Achieved credits are determined as follows:
   2.1. Measure credits achieved shall be determined in one of two ways, depending on the measure:
      2.1.1. The measure credit shall be the base credit listed by occupancy group and climate zone for the measure in Tables C406.3(1) through C406.3(9) where no adjustment factor or formula is shown in the description of the measure in Section C406.3.
      2.1.2. The measure credit shall be the base energy credit for the measure adjusted by a factor or formula as stated in the description of the measure in Section C406.3. Where adjustments are applied, each energy credit shall be rounded to the nearest whole number.
   2.2. Load management and renewable credits achieved for the project shall be the sum of credits for individual measures included in the project. Credits are available for the measures listed in this section.
   2.3. Where a project contains multiple building use groups, credits achieved for each building use group shall be summed and then weighted by the gross floor area of each building use group to determine the weighted-average project energy credits achieved.

3. Load management control requirements. The load management measures in Sections C406.3.2 (G01) through C406.3.7 (G06) require load management control sequences that are capable of and configured to automatically provide the load management operation specified based on indication of a peak period related to high short-term electric prices, grid condition or peak building load. Such a peak period shall, where possible, be initiated by a demand response signal from the controlling entity, such as a utility or service operator. Where communications are disabled or unavailable, all demand- responsive controls shall continue backup demand response based on a local schedule or building-demand monitoring.

   The local building schedule shall be adjustable without programming and reflect the electric rate peak period dates and times. The load management control sequences shall be activated for peak period control by one of the following:

   3.1. A certified OpenADR 2.0a or OpenADR 2.0b Virtual End Node (VEN), as specified under Clause 11, Conformance, in the applicable OpenADR 2.0 Specification.

   3.2. A device 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.

   3.3. The physical configuration and communication protocol of ANSI/CTA-2045-A or ANSI/CTA-2045-B.

   3.4. For air conditioners and heat pumps with two or more stages of control and cooling capacity of less than 65,000 Btu/h (19 kW), thermostats with a demand responsive control that complies with the communication and performance requirements of AHRI 1380.

   3.5. A device that complies with IEC 62746-10-1, an international standard for the open automated demand response system interface between the appliance, system, or energy management system and the controlling entity.

   3.6. An interface that complies with the communication protocol required by a controlling entity to participate in an automated demand response program.

   3.7. Where the controlling entity does not have a demand response signal available for the building type and size, local load management control shall be provided based on either:

      3.7.1. Building demand management controls that monitor building electrical demand and initiate controls to minimize monthly or peak time period demand charges.

      3.7.2. A local building schedule that reflects the electric rate peak period dates and times where buildings are less than 25,000 gross square feet (2322 m^2).

      In this case, a binary input to the control system shall be provided that activates the demand response sequence.

TABLE C406.3(1)
RENEWABLE AND LOAD MANAGEMENT CREDITS FOR GROUP R-2, R-4 AND I-1 OCCUPANCIES

ID	ENERGY CREDIT ABBREVIATED TITLE	SECTION	CLIMATE ZONE		
			4	5	6
R01	Renewable energy	C406.3.1	10	9	9
G01	Lighting load management	C406.3.2	11	8	5
G02	HVAC load management	C406.3.3	17	20	10
G03	Automated shading	C406.3.4	2	10	1
G04	Electric energy storage	C406.3.5	16	14	14
G05	Cooling energy storage	C406.3.6	12	9	7
G06	SHW energy storage	C406.3.7	19	19	18
G07	Building thermal mass	C406.3.8	19	32	27

HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water.
x = Credits excluded from this building use type and climate zone.

TABLE C406.3(2)
RENEWABLE AND LOAD MANAGEMENT CREDITS FOR GROUP I-2 OCCUPANCIES

ID	ENERGY CREDIT ABBREVIATED TITLE	SECTION	CLIMATE ZONE		
			4	5	6
R01	Renewable energy	C406.3.1	6	6	6
G01	Lighting load management	C406.3.2	13	13	14
G02	HVAC load management	C406.3.3	11	12	12
G03	Automated shading	C406.3.4	x	x	x
G04	Electric energy storage	C406.3.5	14	14	13
G05	Cooling energy storage	C406.3.6	16	14	11
G06	SHW energy storage	C406.3.7	4	4	4
G07	Building thermal mass	C406.3.8	18	31	25

HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water.
x = Credits excluded from this building use type and climate zone.

TABLE C406.3(3)
RENEWABLE AND LOAD MANAGEMENT CREDITS FOR GROUP R-1 OCCUPANCIES

ID	ENERGY CREDIT ABBREVIATED TITLE	SECTION	CLIMATE ZONE		
			4	5	6
R01	Renewable energy	C406.3.1	9	9	8
G01	Lighting load management	C406.3.2	14	10	9
G02	HVAC load management	C406.3.3	x	x	x
G03	Automated shading	C406.3.4	3	1	1
G04	Electric energy storage	C406.3.5	14	14	13
G05	Cooling energy storage	C406.3.6	18	15	12
G06	SHW energy storage	C406.3.7	29	28	26
G07	Building thermal mass	C406.3.8	17	30	26

HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water.
x = Credits excluded from this building use type and climate zone.

TABLE C406.3(4)
RENEWABLE AND LOAD MANAGEMENT CREDITS FOR GROUP B OCCUPANCIES

ID	ENERGY CREDIT ABBREVIATED TITLE	SECTION	CLIMATE ZONE		
			4	5	6
R01	Renewable energy	C406.3.1	17	14	14
G01	Lighting load management	C406.3.2	10	10	10
G02	HVAC load management	C406.3.3	12	9	8
G03	Automated shading	C406.3.4	4	4	5
G04	Electric energy storage	C406.3.5	17	17	16
G05	Cooling energy storage	C406.3.6	17	15	12
G06	SHW energy storage	C406.3.7	7	7	6
G07	Building thermal mass	C406.3.8	4	9	8

HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water.
x = Credits excluded from this building use type and climate zone.

TABLE C406.3(5)
RENEWABLE AND LOAD MANAGEMENT CREDITS FOR A-2 OCCUPANCIES

ID	ENERGY CREDIT ABBREVIATED TITLE	SECTION	CLIMATE ZONE		
			4	5	6
R01	Renewable energy	C406.3.1	2	2	2
G01	Lighting load management	C406.3.2	4	4	4
G02	HVAC load management	C406.3.3	20	19	16
G03	Automated shading	C406.3.4	x	x	x
G04	Electric energy storage	C406.3.5	4	3	4
G05	Cooling energy storage	C406.3.6	5	3	2
G06	SHW energy storage	C406.3.7	16	16	15
G07	Building thermal mass	C406.3.8	6	8	6

HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water.
x = Credits excluded from this building use type and climate zone.

TABLE C406.3(6)
RENEWABLE AND LOAD MANAGEMENT CREDITS FOR GROUP M OCCUPANCIES

ID	ENERGY CREDIT ABBREVIATED TITLE	SECTION	CLIMATE ZONE		
			4	5	6
R01	Renewable energy	C406.3.1	11	10	9
G01	Lighting load management	C406.3.2	18	18	18
G02	HVAC load management	C406.3.3	23	17	14
G03	Automated shading	C406.3.4	7	8	8
G04	Electric energy storage	C406.3.5	11	10	11
G05	Cooling energy storage	C406.3.6	17	11	9
G06	SHW energy storage	C406.3.7	4	4	4
G07	Building thermal mass	C406.3.8	7	14	13

HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water.
x = Credits excluded from this building use type and climate zone.

TABLE C406.3(7)
RENEWABLE AND LOAD MANAGEMENT CREDITS FOR GROUP E OCCUPANCIES

ID	ENERGY CREDIT ABBREVIATED TITLE	SECTION	CLIMATE ZONE		
			4	5	6
R01	Renewable energy	C406.3.1	15	14	13
G01	Lighting load management	C406.3.2	12	10	16
G02	HVAC load management	C406.3.3	23	20	18
G03	Automated shading	C406.3.4	12	10	14
G04	Electric energy storage	C406.3.5	22	23	20
G05	Cooling energy storage	C406.3.6	24	20	16
G06	SHW energy storage	C406.3.7	7	7	7
G07	Building thermal mass	C406.3.8	21	37	31

HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water.
x = Credits excluded from this building use type and climate zone.

TABLE C406.3(8)
RENEWABLE AND LOAD MANAGMENT CREDITS FOR GROUP S-1 AND S-2 OCCUPANCIES

ID	ENERGY CREDIT ABBREVIATED TITLE	SECTION	CLIMATE ZONE		
			4	5	6
R01	Renewable energy	C406.3.1	36	29	24
G01	Lighting load management	C406.3.2	31	32	36
G02	HVAC load management	C406.3.3	23	16	14
G03	Automated shading	C406.3.4	x	x	x
G04	Electric energy storage	C406.3.5	30	21	24
G05	Cooling energy storage	C406.3.6	5	2	1
G06	SHW energy storage	C406.3.7	3	3	2
G07	Building thermal mass	C406.3.8	18	28	20

HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water.
x indicates measure is not available for building occupancy in that climate zone.

TABLE C406.3(9)
RENEWABLE AND LOAD MANAGEMENT CREDITS FOR OTHER[a] OCCUPANCIES

ID	ENERGY CREDIT ABBREVIATED TITLE	SECTION	CLIMATE ZONE		
			4	5	6
R01	Renewable energy	C406.3.1	13	12	11
G01	Lighting load management	C406.3.2	14	13	14
G02	HVAC load management	C406.3.3	18	16	13
G03	Automated shading	C406.3.4	5	5	5
G04	Electric energy storage	C406.3.5	16	15	14
G05	Cooling energy storage	C406.3.6	14	11	9
G06	SHW energy storage	C406.3.7	11	11	10
G07	Building thermal mass	C406.3.8	14	24	20

HVAC = Heating, Ventilation and Air Conditioning; SHW = Service Hot Water.
a. Other occupancy groups include all Groups except for Groups A-2, B, E, I, M and R.

C406.3.1 R01 Renewable energy. Projects installing on-site renewable energy systems with a capacity of at least 0.1 watts per gross square foot (1.08 W/m2) of building area or securing off-site renewable energy shall achieve energy credits for this measure calculated as follows:

Equation 4-28 $EC_R = EC_{0.1} \times (R_t + R_{off} - R_{ex})/(0.1 \times PGFA)$

where:

EC_R = Section C406.3.1 R01 energy credits achieved for this project.

$EC_{0.1}$ = Section C406.3.1 R01 base credits from Tables C406.3(1) through C406.3(9).

R_t = Actual total rating of on-site renewable energy systems (W).

R_{off} = Actual total equivalent rating of off-site renewable energy contracts (W), calculated as follows:

$R_{off} = TRE/(REN \times 20)$

where:

TRE = Total off-site renewable electrical energy in kilowatt-hours (kWh) that is procured in accordance with Sections C405.15.2.1 through C405.15.4.

REN = Annual off-site renewable electrical energy of 1.35 kilowatt-hours per watt of array capacity.

R_{ex} = Rating (W) of renewable energy resources capacity excluded from credit calculated as follows:

$R_{ex} = RR_r + RR_x + RR_c$

where:

RR_r = Rating of on-site renewable energy systems required by Section C405.15.1, without exception (W).

RR_x = Rating of renewable energy resources used to meet any exceptions of this code (W).

RR_c = Rating of renewable energy resources used to achieve other energy credits in Section C406 (W).

PGFA = Project gross floor area, ft2. Where renewable requirements, exceptions or credits are expressed in annual kWh or Btu rather than watts of output capacity, they shall be converted as 3413 Btu = 1 kWh and converted to W equivalent capacity as follows:

RR_w = Actual total equivalent rating of renewable energy capacity (W), calculated as follows:

$RR_w = TREx /(REN \times PGFA)$

where:

TRE_x = Total renewable energy in kilowatt-hours (kWh) that is excluded from R01 energy credits.

C406.3.2 G01 Lighting load management. A project not required to comply with Section C405.2.8 can achieve energy credits for installing demand-responsive lighting controls for interior general lighting that comply with Section C405.2.8.1. The demand responsive lighting controls shall automatically reduce the light output or power of controlled lighting to not more than 80 percent of full output, or 80 percent of the high-end trim setpoint, whichever is less. Energy credits can be earned where demand responsive lighting controls are installed for the following:

1. Not less than 10 percent of the interior floor area in Group R or I occupancies.
2. Not less than 50 percent of the interior floor area in all other occupancies.

G01 credits shall be prorated using Equation 4-29 with not more than 75 percent of the interior floor area being counted.

Equation 4-29

[interior floor area with lighting load management, %] × [table credits for Section C406.3.2]/75%

C406.3.3 G02 HVAC load management. Automatic load management controls shall be configured as follows:

1. Cooling temperature shift: Where electric cooling is in use, controls shall gradually increase the cooling setpoint by at least 3°F (1.7°C) over a minimum of 3 hours or reduce effective cooling capacity to 60 percent of installed capacity during the peak period or adjust the cooling temperature setpoint as described in Section C403.6.1.
2. Heating temperature shift: Where electric heating is in use, controls shall gradually decrease the heating setpoint by at least 3°F (1.7°C) over a minimum of 3 hours or reduce effective heating capacity to 60 percent of installed capacity during the peak period or adjust the heating temperature setpoint as described in Section C403.6.1.
3. Ventilation shift: Where HVAC systems serve multiple zones and have less than 70 percent outdoor air required, include controls that provide excess outdoor air preceding the peak period and reduce outdoor air by at least 30 percent during the peak period, in accordance with ASHRAE Standard 62.1 Section 6.2.5.2 or provisions for approved engineering analysis in Section 403.3.1.1 of the New York City Mechanical Code.

Credits achieved for measure G02 shall be calculated as follows:

Equation 4-30 $EC_{G02\_ach} = EC_{G02\_base} \times EC_{G02\_adj}$

where:

EC_{G02_ach} = Demand responsive control credit achieved for project.
EC_{G02_base} = G02 Base energy credit from Section C406.3.
EC_{G02_adj} = Energy credit adjustment factor from Table C406.3.3.

TABLE C406.3.3
ENERGY CREDIT ADJUSTMENT BASED ON USE OF VENTILATION SHIFT OR DEMAND RESPONSE

DEMAND RESPONSE SIGNAL AVAILABLE[a]	DEMAND RESPONSE REQUIRED BY SECTION C403.4.6[b]	INCLUDES VENTILATION SHIFT[c]	EC_{G02_adj}
No	No	Yes	100%
No	Yes	Yes	80%
Yes	No	Yes	80%
Yes	Yes	Yes	40%
No	No	No	70%
No	Yes	No	50%
Yes	No	No	50%
Yes	Yes	No	0%

a. "Demand Response Signal Available" is "Yes" where a controlling entity other than the owner makes a demand response signal available to the building.
b. Where the exception is invoked in Section C403.4.6 for buildings that comply with Load Management measure G02, then "Demand Response Required" is "Yes."
c. Ventilation shift controls in accordance with Section C406.3.3, Item 3.

C406.3.4 G03 Automated shading load management. Where fenestration on east, south and west exposures is greater than 20 percent of the wall area, load management credits shall be achieved as follows:

1. Automatic exterior shading devices or dynamic glazing that is capable of reducing solar gain through sunlit fenestration by not less than 50 percent when fully closed shall receive the full credits in Tables C406.3(1) through C406.3(9). The exterior shades shall have fully open and fully closed solar heat gain coefficient (SHGC) determined in accordance with AERC 1.
2. Automatic interior shading devices with a solar reflectance of not less than 0.50 for the surface facing the fenestration

shall receive 40 percent of the credits in Tables C406.3(1) through C406.3(9).

3. All shading devices, dynamic glazing or shading attachments shall:

3.1. Provide not less than 90 percent coverage of the total fenestration on east, south and west exposures in the building to achieve the credits determined in Item 1 or 2. Alternatively, provide not less than 70 percent cover- age of the total fenestration on the south and west exposures in the building to achieve 50 percent of the credits determined in Item 1 or 2.

3.2. Be automatically controlled and shall modulate in multiple steps or continuously the amount of solar gain and light transmitted into the space in response to peak periods and either daylight levels or solar intensity.

3.3. Include a manual override located in the same enclosed space as the shaded vertical fenestration that shall override operation of automatic controls for not longer than 4 hours. Such override shall be locked out during peak periods.

For this section, directional exposures shall exclude fenestration that has an orientation deviating by more than 45 degrees of facing the cardinal direction. In the southern hemisphere, where the south exposure is referred to, it shall be replaced by the north exposure.

C406.3.5 G04 Electric energy storage. Electric storage devices shall be charged and discharged by automatic load management controls to store energy during nonpeak periods and use stored energy during peak periods to reduce building demand. Electric storage devices shall have a minimum capacity of 1.5 watt-hours per square foot (Wh/ft^2) (16 Wh/m^2) of gross building area. Base credits in Tables C406.3(1) through C406.3(9) are based on installed electric storage of 5 Wh/ft^2 (54 Wh/m^2) and shall be prorated for actual installed storage capacity between 1.5 and 15 Wh/ft^2 (16 to 161 Wh/m^2), as follows:

Equation 4-31

[installed electric storage capacity, Wh/ft^2 (Wh/m^2)]/5(54) × [table credits for Section C406.3.5]

Larger energy storage shall be permitted; however, credits are limited to the range of 1.5 to 15 Wh/ft^2 (16 to 161 Wh/m^2).

C406.3.6 G05 Cooling energy storage. Automatic load management controls shall be capable of activating ice or chilled water storage equipment to reduce demand during summer peak periods. Storage tank standby loss shall be demonstrated through analysis to be not more than 2 percent of storage capacity over a 24-hour period for the cooling design day. Base credits in Section C406.3 are based on storage capacity of the design peak hour cooling load with a 1.15 sizing factor. Credits shall be prorated for installed storage systems sized between 0.5 and 4.0 times the design day peak hour cooling load, rounded to the nearest whole credit. Larger storage shall be permitted but the associated credits are limited to the range provided in this section. Energy credits shall be determined as follows:

Equation 4-32 $ECS = EC1.0 \times (1.44 \times SR + 0.71)/2.15$

where:

EC_s = Cooling storage credit achieved for project.

$EC_{1.0}$ = G05 base energy credit for building use type and climate zone based on 1.0 ton-hours storage per design day ton (kWh/kW) of cooling load.

SR = Storage ratio in ton-hours storage per design day ton (kWh/kW) of cooling load where $0.5 \le SR \le 4.0$.

C406.3.7 G06 Service hot water energy storage. Where service hot water (SHW) is heated by electricity, automatic load management controls complying with ANSI/CTA-2045-B shall preheat stored SHW before the peak period and suspend electric water heating during the peak period. Storage capacity shall be provided by either:

1. Preheating water above 140°F (60°C) delivery temperature with at least 1.34 kWh of energy storage per kW of water-heating capacity. Tempering valves shall be provided at the water heater delivery location.
2. Providing additional heated water tank storage capacity above peak SHW demand with equivalent peak storage capacity to Item 1.

Credits earned for measure G06 shall be calculated using Equation 4-33:

Equation 4-33 $EC_{G06\_ach} = EC_{G06\_base} \times EC_{G06\_adj}$

where:

EC_{G06_ach} = *SWH energy storage credit achieved for project.*
EC_{G06_base} = *G06 Base energy credit from Section C406.3.*
EC_{G06_adj} = Energy credit adjustment factor from Table C406.3.7.

TABLE C406.3.7
ENERGY CREDIT ADJUSTMENT BASED ON USE OF HEAT PUMP WATER HEATER OR DEMAND RESPONSE

DEMAND RESPONSE READY PER SECTION C404.10	DEMAND RESPONSE SIGNAL AVAILABLE[a]	HAS HPWH	EC_{GO6_adj}[b]
No	NA	No	100%
No	NA	Yes	33%
Yes	No	No	50%
Yes	No	Yes	17%
Yes	Yes	NA	0%

HPWH = Heat Pump Water Heater, NA = Not available.

a. "Demand Response Signal Available" is "Yes" where a controlling entity currently makes a demand response signal available to the building.

b. The lower values of ECG06_adj in this column apply where not less than 67 percent of the whole-building design end use service water heating requirements are met using only heat pump heating at the conditions described in Section C406.2.3.1.2.

C406.3.8 G07 Building thermal mass. The project shall have additional passive interior mass and a night flush control of the HVAC system. The credit is available to projects that have at least 80 percent of gross floor area unoccupied between midnight and 6:00 a.m. The project shall meet the following requirements:

1. Interior to the building thermal envelope insulation, provide 10 pounds per foot (15 kg/m) of project conditioned floor area of passive thermal mass in the building interior wall, the inside of the exterior wall or the interior floor construction. Mass construction shall have mass surfaces directly contacting the air in conditioned spaces with directly attached gypsum panels allowed. Mass with carpet or furred gypsum panels or exterior wall mass that is on the exterior of the insulation layer [e.g., the portion of concrete masonry unit (CMU) block on the exterior of insulation-filled cell cavities] shall not be included toward the building mass required.
2. HVAC units for 80 percent or more of the supply airflow in the project shall be equipped with outdoor air economizers and fans that have variable or low speed capable of operating at 66 percent or lower airflow and be included in the night flush control sequence.
3. Night flush controls shall be configured with the following sequence or another night flush strategy shall be permitted where demonstrated to be effective, avoids added morning heating and is approved by the authority having jurisdiction.
   3.1. Summer mode shall be activated when outdoor air temperature exceeds 70°F (21°C) and shall continue uninterrupted until deactivated when outdoor air temperature falls below 45°F (7°C). During summer mode, the occupied cooling setpoint shall be set 1°F (0.6°C) higher than normal and the occupied heating setpoint shall be reset 2°F (1.1°C) lower than normal.

3.2. Where all the following conditions exist, night flush shall be activated:

3.2.1. Summer mode is active in accordance with Item 3.1.

3.2.2. Outdoor air temperature is 5°F (2.8°C) or more below indoor average zone temperature.

3.2.3. Indoor average zone temperature is greater than morning occupied heating setpoint.

3.2.4. Local time is between 10:00 p.m. and 6:00 a.m.

3.3. When night flush is active, automatic night flush controls shall operate outdoor air economizers at low fan speed not exceeding 66 percent during the unoccupied period with mechanical cooling and heating locked out.

SECTION ECC C407
RESERVED

SECTION ECC C408
MAINTENANCE INFORMATION AND SYSTEM COMMISSIONING

C408.1 General. This section covers the provision of maintenance information and the commissioning of, and the functional testing requirements for, building systems.

C408.1.1 Building operations and maintenance information. The building operations and maintenance documents shall be provided to the owner and shall consist of manufacturers' information, specifications and recommendations; programming procedures and data points; narratives; and other means of illustrating to the owner how the building, equipment and systems are intended to be installed, maintained and operated. Required regular maintenance actions for equipment and systems shall be clearly stated on a readily visible label. The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product.

C408.2 Mechanical systems, renewable energy, and service water-heating systems commissioning and completion requirements. Prior to the final mechanical and plumbing inspections, the approved agency shall provide evidence of mechanical systems commissioning and completion in accordance with the provisions of this section.

Construction document notes shall clearly indicate provisions for commissioning and completion requirements in accordance with this section and are permitted to refer to specifications for further requirements. Copies of all documentation shall be given to the owner or owner's authorized agent and made available to the building official upon request in accordance with Sections C408.2.4 and C408.2.5.

Mechanical systems, renewable energy, and service water heating systems shall include but are not limited to, at a minimum, the following heating, ventilating, air conditioning, service water heating, indoor air quality and refrigeration systems (mechanical and/or passive) and associated controls:

1. Heating, cooling, air handling and distribution, ventilation, and exhaust systems, and their related air quality monitoring systems.
2. Air, water, and other energy recovery systems.
3. Manual or automatic controls, whether local or remote, on energy using systems including but not limited to temperature controls, setback sequences, and occupancy-based control, including energy management functions of the building management system.
4. Plumbing, including insulation of piping and associated valves, domestic and process water pumping, and mixing systems.
5. Mechanical heating systems and service water heating systems.
6. Refrigeration systems.
7. Renewable energy and energy storage systems.
8. Other systems, equipment and components that are used for heating, cooling or ventilation and that affect energy use.

Exceptions: The following systems are exempt:

1. Buildings with less than 10,000 square feet (929 m^2) gross conditioned floor area and combined heating, cooling and service water heating capacity of less than 960,000 Btu/h (281 kW).

2. Components within dwelling units and sleeping units served by one of the following systems:
    2.1. Simple unitary or packaged HVAC equipment listed in Table C403.3.2(1), C403.3.2(2), C403.3.2(4) or C403.3.2(5), each serving one zone and controlled by a single thermostat in the zone served.
    2.2. Two-pipe heating systems installed in the dwelling, serving one or more zones.
3. Renewable energy systems being installed with a generating capacity of less than 25 kW.

C408.2.1 Commissioning plan. A *commissioning plan* shall be developed by a registered design professional or approved agency and shall include the following items:

1. A narrative description of the activities that will be accomplished during each phase of commissioning, including the personnel intended to accomplish each of the activities.
2. A listing of the specific equipment, appliances or systems to be tested their full sequences of operation, and a description of the tests to be performed, including prerequisite activities and reference to specific checklists or worksheets which are necessary or required by the department.
3. Functions to be tested including, but not limited to, calibrations and economizer controls.
4. Conditions under which the test will be performed. Testing shall affirm winter and summer design conditions and full outside air conditions.
5. Measurable criteria for performance.

C408.2.2 Systems adjusting and balancing. HVAC systems shall be balanced in accordance with ASHRAE 111, “Testing, Adjusting, and Balancing of Building HVAC Systems” or other accepted engineering standards. Air and water flow rates shall be measured and adjusted to deliver final flow rates within the tolerances provided in the product specifications. Test and balance activities shall include air system and hydronic system balancing.

C408.2.2.1 Air systems balancing. Each supply air outlet and zone terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the *New York City Mechanical Code*. Discharge dampers used for air-system balancing are prohibited on constant-volume fans and variable volume fans with motors 10 hp (18.6 kW) and larger. Air systems shall be balanced in a manner to first minimize throttling losses then, for fans with system power of greater than 1 hp (0.746 kW), fan speed shall be adjusted to meet design flow conditions.

C408.2.2.2 Hydronic systems balancing. Individual hydronic heating and cooling coils shall be equipped with means for balancing and measuring flow. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses, then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions. Each hydronic system shall have either the capability to measure pressure across the pump, or test ports at each side of each pump.

Exception: The following equipment is not required to be equipped with a means for balancing or measuring flow:

1. Pumps with pump motors of 5 hp (3.7 kW) or less.
2. Where throttling results in not greater than 5 percent of the nameplate horsepower draw above that required if the impeller were trimmed.

C408.2.3 Functional performance testing. Functional performance testing specified in Sections C408.2.3.1 through C408.2.3.3 shall be conducted in accordance with ASHRAE Standard 202 or other approved methods.

C408.2.3.1 Equipment. Equipment functional performance testing shall demonstrate the installation and operation of components, systems and system-to-system interfacing relationships in accordance with approved plans and specifications such that operation, function and maintenance serviceability for each of the commissioned systems are confirmed. Testing shall include all modes and sequence of operation, including under full-load, part-load and the following emergency conditions:

1. All modes as described in the sequence of operation.
2. Redundant or automatic back-up mode.
3. Performance of alarms.
4. Mode of operation upon a loss of power and restoration of power.

Exception: Unitary or packaged HVAC equipment listed in the tables in Section C403.3.2 that do not require supply air economizers shall only be required to demonstrate functioning under full-load and part-load conditions.

C408.2.3.2 Controls. HVAC and service water-heating control systems shall be tested to document that control devices, components, equipment and systems are calibrated and adjusted and operate in accordance with approved plans and specifications. Sequences of operation shall be functionally tested to document they operate in accordance with approved plans and specifications.

C408.2.3.3 Economizers. Air economizers shall undergo a functional test to determine that they operate in accordance with manufacturer's specifications.

C408.2.4 Preliminary commissioning report. A preliminary report of commissioning test procedures and results shall be completed and certified by the approved agency and provided to the building owner or owner's authorized agent. The report shall be organized with mechanical and service hot water findings in separate sections to allow independent review. The report shall be identified as "Preliminary Commissioning Report," shall include the completed Commissioning Compliance Checklist, Figure C408.2.4, and shall identify:

1. Itemization of deficiencies found during testing required by this section that have not been corrected at the time of report preparation.
2. Deferred tests that cannot be performed at the time of report preparation because of climatic conditions.
3. Climatic conditions required for performance of the deferred tests.
4. Results of functional performance tests.
5. Functional performance test procedures used during the commissioning process, including measurable criteria for test acceptance.

Project Information: _____ Project Name:_____

Project Address: _____

Commissioning Authority: _____

Commissioning Plan (Section C408.2.1)

☐ Commissioning Plan was used during construction and includes all items required by Section C408.2.1

☐ Systems Adjusting and Balancing has been completed.

☐ HVAC Equipment Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:_____

☐ HVAC Controls Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:_____

☐ Economizer Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:_____

☐ Lighting Controls Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:_____

☐ Service Water Heating System Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on:_____

☐ Manual, record documents and training have been completed or scheduled

☐ Preliminary Commissioning Report submitted to owner and includes all items required by Section C408.2.4

I hereby certify that the commissioning provider has provided me with evidence of mechanical, service water heating and lighting systems commissioning in accordance with the 2021 IECC.

Signature of Building Owner or Owner's Representative _____ Date_____

FIGURE C408.2.4
COMMISSIONING COMPLIANCE CHECKLIST

C408.2.4.1 Acceptance of report. *Buildings*, or portions thereof, shall not be considered as acceptable for a final inspection pursuant to Chapter 1 of this code until the building official has received a letter of transmittal from the *building owner* acknowledging that the building owner or owner's authorized agent has received the Preliminary Commissioning Report.

C408.2.4.2 Copy of report. The *building official* shall be permitted to require that a copy of the Preliminary Commissioning Report be made available for review by the *building official*.

C408.2.5 Documentation requirements. The *construction documents* shall specify that the documents described in Sections C408.2.5.1 through C408.2.5.3 be provided to the building owner or owner's authorized agent within 90 days of the date of receipt of the certificate of occupancy or letter of completion. The construction documents shall also specify that the Final Commissioning Report be provided to the building owner or owner's authorized agent in accordance with the requirements of Section C408.2.5.4.

C408.2.5.1 Drawings. Construction documents shall include the location and performance data on each piece of equipment.

C408.2.5.2 Manuals. An operating and maintenance manual shall be provided and include all of the following:

1. Submittal data stating equipment size and selected options for each piece of equipment requiring maintenance.
2. Manufacturer's operation manuals and maintenance manuals for each piece of equipment requiring maintenance, except equipment not furnished as part of the project. Required routine maintenance actions shall be clearly identified.
3. Name and address of at least one service agency.
4. HVAC and service hot water controls system maintenance and calibration information, including wiring diagrams, schematics and control sequence descriptions. Desired or field-determined set points shall be permanently recorded on control drawings at control devices or, for digital control systems, in system programming instructions.
5. Submittal data indicating all selected options for each piece of lighting equipment and lighting controls.
6. Operation and maintenance manuals for each piece of lighting equipment. Required routine maintenance actions, cleaning and recommended relamping shall be clearly identified.
7. A schedule for inspecting and recalibrating all lighting controls.
8. A narrative of how each system is intended to operate, including recommended set points.

C408.2.5.3 System balancing report. A written report describing the activities and measurements completed in accordance with Section C408.2.2.

C408.2.5.4 Final commissioning report. Within 30 months for new buildings 500,000 gross square feet (46 452 m²) or greater, excluding R-2 occupancies, or within 18 months for R-2 occupancies and all other buildings, of the issuance of the certificate of occupancy or letter of completion, an approved agency shall prepare a report of test procedures and results, including test procedures and results performed

after occupancy, identified as the "Final Commissioning Report," provide such report to the building owner, and submit a certification to the department with applicable fees in accordance with department rules. The owner of a building 500,000 gross square feet (46 452 m²) or greater may apply for an extension of time to the building official based on good cause, in accordance with department rules. Such report shall include the following:

1. Results of functional performance tests.
2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.
3. Functional performance test procedures used during the commissioning process including measurable criteria for test acceptance, provided herein for repeatability.

Exception: Deferred tests that cannot be performed at the time of report preparation due to climatic conditions.

C408.3 Functional testing of lighting and receptacle controls. *Automatic lighting* and receptacle controls required by this code shall comply with this section.

C408.3.1 Functional testing. Prior to passing final inspection, the approved agency shall provide evidence that the lighting and receptable control systems have been tested to ensure that control hardware and software are calibrated, adjusted, programmed and in proper working condition in accordance with the construction documents and manufacturer's instructions. Functional testing shall be in accordance with Sections C408.3.1.1 through C408.3.1.3 for the applicable control type.

C408.3.1.1 Occupant sensor controls. Where occupant sensor controls are provided, the following procedures shall be performed:

1. Certify that the occupant sensor has been located and aimed in accordance with manufacturer recommendations.
2. For projects with seven or fewer occupant sensors, each sensor shall be tested.
3. For projects with more than seven occupant sensors, testing shall be done for each unique combination of sensor type and space geometry. Where multiples of each unique combination of sensor type and space geometry are provided, not less than 10 percent and in no case fewer than one, of each combination shall be tested unless the building official or design professional requires a higher percentage to be tested. Where 30 percent or more of the tested controls fail, all remaining identical combinations shall be tested.

   For occupant sensor controls to be tested, verify the following:

   3.1. Where occupant sensor controls include status indicators, verify correct operation.
   3.2. The lights and receptacles controlled by occupant sensor controls turn off or down to the permitted level within the required time upon vacancy of the space.
   3.3. For auto-on occupant sensor controls, the lights and receptacles controlled by occupant sensor controls turn on to the permitted level when an occupant enters the space.
   3.4. For manual-on occupant sensor controls, the lights and receptacles controlled by occupant sensor controls turn on only when manually activated.
   3.5. The lights are not incorrectly turned on by movement in adjacent areas or by HVAC operation.

C408.3.1.2 Time-switch controls. Where time-switch controls are provided, Items 1 through 5 shall be performed for all time- switch controls. For projects with more than seven spaces where lighting or receptacles are controlled by time-switch controls, not less than 10 percent of spaces and in no case fewer than one space shall be tested according to Items 6 and 7 unless the building official or registered design professional requires a higher percentage to be tested. Where 30 percent or more of the tested spaces fail any of the requirements in Items 6 and 7, all remaining spaces shall be tested.

1. Confirm that the time-switch control is programmed with accurate weekday, weekend and holiday schedules.
2. Provide documentation to the owner of time-switch controls programming including weekday, weekend, holiday schedules, and set-up and preference program settings.
3. Verify the correct time and date in the time switch.
4. Verify that any battery back-up is installed and energized.
5. Verify that the override time limit is set to not more than 2 hours.
6. Simulate occupied condition. Verify and document the following:
    6.1. All lights can be turned on and off by their respective area control switch.
    6.2. The switch only operates lighting in the enclosed space in which the switch is located.
    6.3. Receptacles in the space controlled by the time-switch controls turn on.
7. Simulate unoccupied condition. Verify and document the following:
    7.1. Nonexempt lighting turns off.
    7.2. Manual override switch allows only the lights and receptacles controlled by the time-switch controls in the enclosed space where the override switch is located to turn on controlled lighting and receptacles for more than 2 hours.
    7.3. Receptacles controlled by the time-switch controls turn off.
8. Additional testing as specified by the registered design professional.

C408.3.1.3 Daylight responsive controls. Where daylight responsive controls are provided, the following shall be verified:

1. Control devices have been properly located, field calibrated and set for accurate setpoints and threshold light levels.
2. Daylight controlled lighting loads adjust to light level setpoints in response to available daylight.
3. The calibration adjustment equipment is located for ready access only by authorized personnel.

C408.3.1.4 High-end trim controls. Where lighting controls are configured for high-end trim, verify the following:

1. High-end trim maximum level has been set.
2. The calibration adjustment equipment is located for ready access only by authorized personnel.
3. Lighting controls with ready access for users cannot increase the lighting power above the maximum level established by the high-end trim controls.

C408.3.1.5 High-end trim lighting control verification for L02 Additional Efficiency Credit. For the qualifying spaces associated with the project receiving the additional efficiency credits in Section C406.2.5.2, the following shall be documented while daylight responsive controls are not reducing lighting power:

1. The maximum setting for power or light output for each control group of general lighting luminaires.
2. The high-end trim setting for power or light output for each control group of general lighting luminaires.
3. For projects with seven or fewer claimed qualifying spaces, the reduction in light output or reduction in power due to high-end trim shall be tested in all spaces and shown to reduce the general lighting power or light output to not greater than 85 percent of full power or light output. For projects with more than seven claimed qualifying spaces, the reduction in light output or reduction in power due to high-end trim shall be tested in not less than 10 percent of spaces, and not less than seven spaces, and be shown to reduce general lighting power or light output to not greater than 85 percent of full power or light output. Where more than 30 percent of the tested spaces fail, the remaining qualifying spaces shall be tested.
4. Summarize the reduction in general lighting power or light output resulting from the high-end trim setting for each qualifying space and the floor area of each qualifying space.
5. Summarize the fraction of total floor area for spaces where high-end trim reduces general lighting power or light output to not greater than 85 percent of full power or light output.

C408.3.1.6 Demand responsive lighting controls G01. For spaces associated with the project receiving renewable and load management credits in Section C406.3.2, the following procedures shall be performed:

1. Confirm the maximum setpoint upon receipt of the demand response signal has been established for each space.
2. For projects with seven or fewer spaces with controls, each space shall be tested.
3. For projects with more than seven spaces with controls, testing shall be done for each unique space type. Where multiple spaces of each space type exist, not less than 10 percent of each space type, and in no case fewer than one space, shall be tested unless the building official requires a higher percentage to be tested. Where 30 percent or more of the tested controls fail in a space type, all remaining identical space types shall be tested.
4. For demand responsive controls to be tested, verify the following:
    4.1. Where high-end trim controls are used, the high-end trim shall be set before testing.
    4.2. Turn off all nongeneral lighting in the space.
    4.3. Set general lighting to its maximum illumination level. Where high-end trim is set, this will be the maximum illumination level at the high-end trim setpoint.
    4.4. An illumination measurement shall be taken in an area of the space not controlled by daylight responsive controlled lighting. If there is not an area without daylight responsive controls, the daylight responsive controls shall be overridden from reducing the lighting level during the test.
    4.5. Measure and document the maximum illumination level of the space.

5. Simulate a demand response signal and measure the illumination level at the same location as for the measurement in Section C408.3.1.6, Item 4.5. Verify the illumination level has been reduced to not greater than 80 percent of the maximum illumination level documented in Section C408.3.1.6, Item 4.5.
6. Simulate the end of a demand event by turning off the demand response signal; confirm controls automatically return to their normal operational settings at the end of the demand response event.

C408.3.2 Documentation requirements. The construction documents shall specify that the documents described in this section be provided to the building owner or owner's authorized agent within 90 days of the date of receipt of the certificate of occupancy.

C408.3.2.1 Drawings. Construction documents shall include the location and catalogue number of each piece of equipment.

C408.3.2.2 Manuals. An operating and maintenance manual shall be provided and include the following:

1. Name and address of not less than one service agency for installed equipment.
2. A narrative of how each system is intended to operate, including recommended setpoints.
3. Submittal data indicating all selected options for each piece of lighting equipment and lighting controls.
4. Operation and maintenance manuals for each piece of lighting equipment. Required routine maintenance actions, cleaning and recommended relamping shall be clearly identified.
5. A schedule for inspecting and recalibrating all lighting controls.

C408.3.2.3 Report. A report of test results shall be provided and include the following:

1. Results of functional performance tests.
2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.

C408.4 Air barrier commissioning. For new buildings or additions that are 10,000 gross square feet (929 m^2) and greater, prior to passing final inspection, the approved agency shall provide evidence of air barrier commissioning and substantial completion in accordance with the provisions of Sections C408.4.1 through C408.4.3.

C408.4.1 Documentation. Construction documents shall include documentation of the continuous air barrier components included in the design and a field inspection checklist that includes all requirements necessary for maintaining air barrier continuity and durability in accordance with Section C402.6.

C408.4.2 Field inspections. Reports from field inspections during project construction showing compliance with continuous air barrier requirements including proper material handling and storage, use of approved materials and material substitutes, proper material and surface preparation, and air barrier continuity shall be provided to the owner and, upon request, to the building official. Air barrier continuity shall be determined by testing or inspecting each type of unique air barrier joint or seam in the building envelope for continuity and defects.

C408.4.3 Report. A Final Commissioning Report indicating compliance with the continuous air barrier requirements shall be provided to the building owner and, upon request, to the building official.

SECTION ECC C409
CALCULATION OF THE HVAC TOTAL SYSTEM PERFORMANCE RATIO

C409.1 Applicability. Use of the HVAC total system performance ratio (TSPR) method shall comply with this section.

C409.2 Permitted uses. Only HVAC systems that serve building occupancies and uses in Table C409.4 and are not excluded by Section C409.2.1 shall be permitted to use the TSPR method.

C409.2.1 Systems not permitted. The following HVAC systems are not permitted to use Section C403.1, Item 3:

1. HVAC systems using:
   - 1.1. District heating water, chilled water or steam.
   - 1.2. Small-duct high-velocity air-cooled, space-constrained air-cooled, or single-package vertical air conditioner; single-package vertical heat pump; or double-duct air conditioner or double-duct heat pump, as defined in subpart F to 10 CFR Part 431.
   - 1.3. Packaged terminal air conditioners and packaged terminal heat pumps that have a cooling capacity greater than 12,000 Btu/h (3.5 kW).
   - 1.4. A common heating source serving both HVAC and service water heating equipment.
2. HVAC systems that provide recovered heat for service water heating.
3. HVAC systems not specified in Table C409.6.1.10.1.
4. HVAC systems specified in Table C409.6.1.10.1 with characteristics or parameters in Table C409.6.1.10.2(1), not identified as applicable to that HVAC system type.
5. HVAC systems with chilled water supplied by absorption chillers, heat recovery chillers, water-to-water heat pumps, air- to-water heat pumps, or a combination of air- and water-cooled chillers on the same chilled water loop.
6. HVAC systems served by heating water systems that include air-to-water or water-to-water heat pumps.
7. Underfloor air distribution and displacement ventilation HVAC systems.
8. Space-conditioning systems that do not include mechanical cooling.
9. HVAC systems serving laundry rooms, elevator rooms, mechanical rooms, electrical rooms, data centers and computer rooms.
10. Buildings or areas of medical office buildings required to use ASHRAE Standard 170.
11. Buildings or areas that are required by regulation to have continuous air-handling unit operation.
12. HVAC systems serving laboratories with fume hoods.
13. Locker rooms with more than two showers.
14. Natatoriums and rooms with saunas.

15. Restaurants and commercial kitchens with a total cooking capacity greater than 100,000 Btu/h (29 kW).
16. Areas of buildings with commercial refrigeration equipment exceeding 100 kW of power input.
17. Cafeterias and dining rooms

C409.3 HVAC TSPR compliance. HVAC systems permitted to use TSPR shall comply with Section C409.4 and the following:

1. HVAC systems shall comply with applicable requirements of Section C403 as follows:
   1.1. Air economizers shall meet the requirements of Sections C403.5.3.4 and C403.5.5.
   1.2. Variable-air-volume systems shall meet the requirements of Sections C403.6.5, C403.6.6 and C403.6.9.
   1.3. Hydronic systems shall meet the requirements of Section C403.4.4.
   1.4. Plants with multiple chillers or boilers shall meet the requirements of Section C403.4.5.
   1.5. Hydronic (water loop) heat pumps and water-cooled unitary air conditioners shall meet the requirements of Section C403.4.3.3.
   1.6. Cooling tower turndown shall meet the requirements of Section C403.11.4.
   1.7. Heating of unenclosed spaces shall meet the requirements of Section C403.14.1.
   1.8. Hot-gas bypass shall meet the requirements of Section C403.3.3.
   1.9. Systems shall meet the operable openings interlock requirements of Section C403.4.7. Refrigeration systems shall meet the requirements of Section C403.12.
2. Systems shall comply with the applicable provisions of Section C403 required by Table C407.2.

C409.4 Performance target. For HVAC systems serving uses or portions of uses listed in Section C409.2 that are not served by systems listed in Section C409.2.1, the HVAC TSPR of the proposed design shall be greater than or equal to the HVAC TSPR of the standard reference design divided by the mechanical performance factor (MPF) using Equation 4-35.

Equation 4-35 $TSPR_p > TSPR_r/MPF$

where:

$TSPR_p$ = HVAC TSPR of the proposed design calculated in accordance with Sections C409.4, C409.5 and C409.6.

$TSPR_r$ = HVAC TSPR of the reference building design calculated in accordance with Sections C409.4, C409.5 and C409.6.

MPF = Mechanical performance factor from Table C409.4 based on *climate zone* and building use type.

Equation 4-36 $MPF = (A_1 \times MPF_1 + A_2 \times MPF_2 + \ldots A_n \times MPF_n)/(A_1 + A_2 + \ldots A_n)$

where:

MPF_1, MPF_2 through MPF_n = Mechanical performance factors from Table C409.4 based on *climate zone* and building use types 1, 2 through n.

A_1, A_2 through A_n = Conditioned floor areas for building use types 1, 2 through n.

TABLE C409.4
MECHANICAL PERFORMANCE FACTORS

BUILDING USE	OCCUPANCY GROUP	CLIMATE ZONE		
		4	5	6
Office (all others)[a]	B	0.805	0.845	0.865
Office (large)[a]	B	0.67	0.71	0.73
Retail	M	0.45	0.46	0.50
Hotel/motel	R-1	0.45	0.38	0.35
Multi-family/dormitory	R-2	0.53	0.54	0.55
School/education and libraries	E (A-3)	0.73	0.82	0.89

a. Large-office conditioned floor area greater than 150,000 square feet or more than five stories.

C409.4.1 HVAC TSPR. HVAC TSPR is calculated according to Equation 4-37.

Equation 4-37 HVAC TSPR = heating and cooling load/building HVAC system energy

where:

Building HVAC system energy = Sum of the annual site energy consumption for heating, cooling, fans, energy recovery, pumps and heat rejection in thousands of Btu (kWh).

Heating and cooling load = Sum of the annual heating and cooling loads met by the building HVAC system in thousands of Btu (kWh).

C409.5 General. Projects shall use the procedures of this section when calculating compliance using HVAC total system performance ratio.

C409.5.1 Simulation program. Simulation tools used to calculate the HVAC TSPR of the standard reference design shall comply with the following:

1. The simulation program shall calculate the HVAC TSPR based only on the input for the proposed design and the requirements of Section C409. The calculation procedure shall not allow the user to directly modify the building component characteristics of the standard reference design.
2. Performance analysis tools shall meet the applicable subsections of Section C409 and be tested in accordance with ASHRAE Standard 140, except for Sections 7 and 8. The required tests shall include the building thermal envelope and fabric load test (Sections 5.2.1, 5.2.2 and 5.2.3), ground-coupled slab-on-grade analytical verification tests (Section 5.2.4), space-cooling equipment performance tests (Section 5.3), space-heating equipment performance tests (Section 5.4), and air-side HVAC equipment analytical verification test (Section 5.5), along with the associated reporting (Section 6).
3. The test results and modeler reports shall be publicly available and shall include the test results of the simulation programs and input files used for generating the results along with the results of the other simulation programs included in ASHRAE Standard 140, Annexes B8 and B16. The modeler report in ASHRAE Standard 140 Annex A2 Attachment A2.7 shall be completed for results exceeding the maximum or falling below the minimum of the reference values and for omitted results.

4. The simulation program shall have the ability to model part-load performance curves or other part-load adjustment methods based on manufacturer's part-load performance data for mechanical equipment.
5. The building official shall be permitted to approve specific software deemed to meet these requirements in accordance with Section C101.5.1.1.

C409.5.2 Climatic data. The simulation program shall perform the simulation using hourly values of climatic data for a full calendar year (8,760 hours) and shall reflect approved coincident hourly data for temperature, solar radiation, humidity and wind speed for the building location.

C409.5.3 Documentation. Documentation or web links to documentation conforming to the provisions of this section shall be provided to the building official.

C409.5.3.1 Compliance report. Building permit submittals shall include:

1. A report produced by the simulation software that includes the following:
   1.1. Address of the building.
   1.2. Name of the individual completing the compliance report.
   1.3. Name and version of the compliance software tool.
   1.4. The dimensions, floor heights and number of floors for each thermal block.
   1.5. By thermal block, the U-factor, C-factor or F-factor for each simulated opaque envelope component and the U-factor and SHGC for each fenestration component.
   1.6. By thermal block or by surface for each thermal block, the fenestration area.
   1.7. By thermal block, a list of the HVAC equipment simulated in the proposed design, including the equipment type, fuel type, equipment efficiencies and system controls.
   1.8. Annual site HVAC energy use by end use for the proposed and baseline building.
   1.9. Annual sum of heating and cooling loads for the baseline building.
   1.10. The HVAC TSPR for both the standard reference design and the proposed design.
2. A mapping of the actual building HVAC component characteristics and those simulated in the proposed design showing how individual pieces of HVAC equipment identified in Item 1 have been combined into average inputs as required by Section C409.6.1.10, including:
   2.1. Fans.
   2.2. Hydronic pumps.
   2.3. Air handlers.
   2.4. Packaged cooling equipment.
   2.5. Furnaces.
   2.6. Heat pumps.
   2.7. Boilers.
   2.8. Chillers.
   2.9. Heat rejection equipment (open- and closed-circuit cooling towers, dry coolers).
   2.10. Electric resistance coils.
   2.11. Condensing units.
   2.12. Motors for fans and pumps.
   2.13. Energy recovery devices.

3. For each piece of equipment identified in Item 2, include the following, as applicable:
    3.1. Equipment name or tag consistent with that found on the design documents.
    3.2. Rated efficiency level.
    3.3. Rated capacity.
    3.4. Where not provided by the simulation program report in Item 1, documentation of the calculation of any weighted equipment efficiencies input into the program.
    3.5. Electrical input power for fans and pumps (before any speed or frequency control device) at design condition and calculation of input value (W/cfm or W/gpm) or W/gpm (W/Lps).
4. Floor plan of the building, identifying:
    4.1. How portions of the buildings are assigned to the simulated thermal blocks.
    4.2. Areas of the building that are not covered under the requirements of Section C403.1.1.

C409.6 Calculation procedures. Except as specified by this section, the standard reference design and proposed design shall be configured and analyzed using identical methods and techniques.

C409.6.1 Simulation of the proposed building design. The proposed design shall be configured and analyzed as specified in this section.

C409.6.1.1 Thermal block geometry. The geometry of buildings shall be configured using one or more thermal blocks. Each thermal block shall define attributes, including thermal block dimensions, number of floors, floor-to-floor height and floor-to- ceiling height. Simulation software may allow the use of simplified shapes (such as rectangle, L-shaped, H-shaped, U-shaped or T-shaped) to represent thermal blocks. Where actual building shape does not match these predefined shapes, simplifications are permitted, provided that the following requirements are met:

1. The conditioned floor area and volume of each thermal block shall match the proposed design within 10 percent.
2. The area of each exterior envelope component from Table C402.1.4 is accounted for within 10 percent of the actual design.
3. The area of vertical fenestration and skylights is accounted for within 10 percent of the actual design.
4. The orientation of each component in Items 2 and 3 is accounted for within 45 degrees of the actual design.

The creation of additional thermal blocks may be necessary to meet these requirements. A more complex zoning of the building shall be allowed where all thermal zones in the reference and proposed models are the same, and rules related to thermal block geometry and HVAC system assignment to thermal blocks are met with appropriate assignment to thermal zones.

Exception: Portions of the building that are unconditioned or served by systems not covered by the requirements of Section C403.1.1 shall be omitted.

C409.6.1.1.1 Number of thermal blocks. One or more thermal blocks may be required per building based on the following restrictions:

1. Each thermal block shall have not more than one building use.
2. Each thermal block shall be served by not more than one type of HVAC system. A single block shall be created for each unique HVAC system and building use combination, and multiple HVAC units or components of the same type shall be combined in accordance with Section C409.6.1.10.2.
3. Each thermal block shall have not more than a single defined floor-to-floor or floor-to-ceiling height. Where floor heights differ by more than 2 feet, separate thermal blocks shall be created.
4. Each block shall include either above-grade or below-grade stories. For buildings with both above-grade and below-grade stories, separate blocks shall be created for each. Where blocks have exterior walls partially below grade, if greater than 50 percent of the exterior wall surface is below grade, then simulate the block as below grade; otherwise, simulate as above grade.
5. Where a block includes multiple stories, separate blocks shall be created, if needed, to comply with both the following fenestration modeling requirements:
    5.1. The product of the proposed design U-factor times the area of windows (U × A) on a given story of each facade shall not differ by more than 15 percent of the average U × A for that modeled facade in each block.
    5.2. The product of the proposed design SHGC times the area of windows (SHGC × A) on a given story of each facade shall not differ by more than 15 percent of the average SHGC × A for that modeled facade in each block.
6. For a building model with multiple blocks, the blocks shall be configured together to have the same adjacencies as the actual building design.

C409.6.1.2 Thermal zoning. Each story in a thermal block shall be modeled as follows:

1. Below-grade stories shall be modeled as a single thermal zone.
2. Where any facade in the block is less than 45 feet (13.7 m) in length, it shall be modeled as a single thermal zone per story.
3. For stories not covered by Item 1 or Item 2, each story shall be modeled with five thermal zones. A perimeter zone shall be created, extending from each facade to a depth of 15 feet (4572 mm). Where facades intersect, the zone boundary shall be formed by a 45-degree angle with the two facades. The remaining area of each story shall be modeled as a core zone with no exterior walls.

C409.6.1.2.1 Core and shell, build-out and future system construction analysis. Where the building permit applies to only a portion of the HVAC system in a building and the remaining components will be designed under a future building permit or were previously installed, such components shall be modeled as follows:

1. Blocks including existing or future HVAC zone served by independent systems and not part of the construction project shall not be modeled.

2. Where the HVAC zones that do not include complete HVAC systems in the permit are intended to receive HVAC services from systems that are part of the construction project, their proposed zonal systems shall be modeled with equipment that meets, but does not exceed, the requirements of Section C403.
3. Where existing HVAC systems serve permitted zone equipment, the existing systems shall be modeled with equipment matching the manufacturer's stated efficiency for the installed equipment or equipment that meets, but does not exceed, the requirements of Section C403.
4. Where the central plant heating and cooling equipment is completely replaced and HVAC zones with existing systems receive HVAC services from systems in the permit, their proposed zonal systems shall be modeled with equipment that meets, but does not exceed, the requirements of Section C403.

C409.6.1.3 Occupancy. Building occupancies modeled in the standard reference design and the proposed design shall comply with the following requirements.

C409.6.1.3.1 Occupancy type. The occupancy type for each thermal block shall be consistent with the building occupancy and uses specified in Table C409.4. Portions of the building occupancy and uses other than those specified in Table C409.4 shall not be included in the simulation. Surfaces adjacent to such excluded building portions shall be modeled as adiabatic in the simulation program.

C409.6.1.3.2 Occupancy schedule, density and heat gain. The occupant density, heat gain and schedule shall be for multi- family, offices, retail spaces, libraries, hotels/motels or schools as specified by ANSI/ASHRAE/IES 90.1, Normative Appendix C.

C409.6.1.4 Building thermal envelope components. Building thermal envelope components modeled in the standard reference design and the proposed design shall comply with the requirements of this section.

C409.6.1.4.1 Roofs. The roof U-factor and area shall be modeled as in the proposed design. If different roof thermal properties are present in a single thermal block, an area-weighted U-factor shall be used. Roofs shall be modeled with insulation above a steel roof deck, with a solar reflectance of 0.25 and an emittance of 0.90.

C409.6.1.4.2 Above-grade walls. The U-factor and area of above-grade walls shall be modeled as in the proposed design. If different wall constructions exist on the facade of a thermal block, an area-weighted U-factor shall be used. Walls will be modeled as steel-frame construction.

C409.6.1.4.3 Below-grade walls. The C-factor and area of below-grade walls shall be modeled as in the proposed design. If different below-grade wall constructions exist in a thermal block, an area-weighted C-factor shall be used.

C409.6.1.4.4 Above-grade exterior floors. The U-factor and area of floors shall be modeled as in the proposed design. If different floor constructions exist in the thermal block, an area-weighted U-factor shall be used. Exterior floors shall be modeled as steel frame.

C409.6.1.4.5 Slab-on-grade floors. The F-factor and perimeter of slab-on-grade floors shall be modeled as in the proposed design. If different slab-on-grade floor constructions exist in a thermal block, a perimeter-weighted F-factor shall be used.

C409.6.1.4.6 Vertical fenestration. The window area and area-weighted U-factor and SHGC shall be modeled for each facade based on the proposed design. Each exterior surface in a thermal block must comply with Section C409.6.1.1.1, Item 5. Windows shall be combined into a single window centered on each facade based on the area and sill height input by the user. Where different U-values, SHGC or sill heights exist on a single facade in a block, the area-weighted average for each shall be input by the user.

C409.6.1.4.7 Skylights. The skylight area and area-weighted U-factor and SHGC shall be modeled for each roof based on the proposed design. Skylights shall be combined into a single skylight centered on the roof of each zone based on the area input by the user.

C409.6.1.4.8 Exterior shading. Permanent window overhangs shall be modeled. Where windows with and without over- hangs or windows with different overhang projection factors exist on a facade, window width-weighted projection factors shall be input by the user as follows:

Equation 4-38 $P_{avg} = (A_1 \times L_{o1} + A_2 \times L_{o2} \ldots A_n \times L_{on})/(L_{w1} + L_{w2} \ldots L_{wn})$

where:

P_{avg} = Average overhang projection modeled in the simulation tool.

A = Distance measured horizontally from the farthest continuous extremity of any overhang, eave or permanently attached shading device to the vertical surface of the glazing.

L_o = Length off the overhang.

L_w = Length of the window.

C409.6.1.5 Lighting. Interior lighting power density shall be equal to the allowance in Table C405.3.2(1) for multifamily buildings, offices, retail spaces, libraries or schools. The lighting schedule shall be for multifamily buildings, offices, retail spaces, libraries or schools as specified by ANSI/ASHRAE/IES 90.1, Normative Appendix C. The impact of lighting controls is assumed to be captured by the lighting schedule and no explicit controls shall be modeled. Exterior lighting shall not be modeled.

C409.6.1.6 Miscellaneous equipment. The miscellaneous equipment schedule and power shall be for multifamily buildings, offices, retail spaces, libraries or schools as specified by ANSI/ASHRAE/IES 90.1, Normative Appendix C. The impact of miscellaneous equipment controls is assumed to be captured by the equipment schedule and no explicit controls shall be modeled.

Exceptions:

1. Multiple-family dwelling units shall have a miscellaneous load density of 0.42 watts per square foot.
2. Multiple-family common areas shall have a miscellaneous load density of 0 watts per square foot.

C409.6.1.7 Elevators. Elevators shall not be modeled.

C409.6.1.8 Service water heating equipment. Service water heating shall not be modeled.

C409.6.1.9 On-site renewable energy systems. On-site renewable energy systems shall not be modeled.

C409.6.1.10 HVAC equipment. Where proposed or where reference system parameters are not specified in Section C409, HVAC systems shall be modeled to meet the minimum requirements of Section C403.

C409.6.1.10.1 Supported HVAC systems. At a minimum, the HVAC systems shown in Table C409.6.1.10.1 shall be supported by the simulation program.

TABLE C409.6.1.10.1
PROPOSED BUILDING HVAC SYSTEMS SUPPORTED BY HVAC TSPR SIMULATION SOFTWARE

SYSTEM NO.	SYSTEM NAME
1	Packaged terminal air conditioner (with electric or hydronic heat)
2	Packaged terminal air heat pump
3	Packaged single-zone gas furnace[a] and/or air-cooled air conditioner (includes split systems)[b]
4	Packaged single-zone heat pump (air to air only)(includes split systems[b] and electric or gas supplemental heat)
5	Variable refrigerant flow (air cooled only)
6	Four pipe fan coil
7	Water-source heat pump (water loop), water-source v*ariable refrigerant flow system* or water-source air conditioner
8	Ground source heat pump
9	Packaged variable air volume (DX cooling)[a]
10	Variable air volume (hydronic cooling)[a]
11	Variable air volume with fan-powered terminal units
12	Dedicated outdoor air system (in conjunction with systems 1–8)

a. Reheat or primary heat may be electric, hydronic or gas furnace.
b. Condensing units with DX air handlers are modeled as package furnaces with air conditioners or heat pumps.

C409.6.1.10.2 Proposed building HVAC system simulation. The HVAC systems shall be modeled as in the proposed design at design conditions unless otherwise stated, with clarifications and simplifications as described in Tables C409.6.1.10.2(1) and C409.6.1.10.2(2). System parameters not described in the following sections shall be simulated to meet the minimum requirements of Section C403. All zones within a thermal block shall be served by the same HVAC system type as described in Section C409.6.1.1.1, Item 2. Heat loss from ducts and pipes shall not be modeled. The proposed building system parameters in Table C409.6.1.10.2(1) are based on input of full-load equipment efficiencies with adjustments using part-load curves integrated into the simulation program. Where other approaches to part-load adjustments are used, it is permitted for specific input parameters to vary. The simulation program shall model part-load HVAC equipment performance using one of the following:

1. Full-load efficiency adjusted for fan power input that is modeled separately and typical part-load performance adjustments for the proposed equipment.
2. Part-load adjustments based on input of both full-load and part-load metrics.
3. Equipment-specific adjustments based on performance data provided by the equipment manufacturer for the proposed equipment.

Where multiple system components serve a thermal block, average values weighted by the appropriate metric as described in this section shall be used.

1. Where multiple fan systems serve a single thermal block, fan power shall be based on a weighted average using the design supply air (cfm).
2. Where multiple cooling systems serve a single thermal block, the coefficient of performance (COP) shall be based on a weighted average using cooling capacity. Direct expansion (DX) coils shall be entered as multistage if more than 50 percent of coil capacity serving the thermal block is multistage with staged controls.
3. Where multiple heating systems serve a single thermal block, thermal efficiency or heating COP shall be based on a weighted average using heating capacity.
4. Where multiple boilers or chillers serve a heating water or chilled water loop, efficiency shall be based on a weighted average for using heating or cooling capacity.
5. Where multiple cooling towers serving a condenser water loop are combined, the cooling tower efficiency, cooling tower design approach and design range are based on a weighted average of the design water flow rate through each cooling tower.
6. Where multiple pumps serve a heating water, chilled water or condenser water loop, pump power shall be based on a weighted average for using design water flow rate.
7. Where multiple system types with and without economizers are combined, the economizer maximum outside air fraction of the combined system shall be based on the weighted average of 100 percent supply air for systems with economizers and design outdoor air for systems without economizers.
8. Multiple systems with and without ERVs cannot be combined.
9. Systems with and without supply-air temperature reset controls cannot be combined.
10. Systems with different fan controls (constant volume, multispeed or VAV) for supply fans cannot be combined.

TABLE C409.6.1.10.2(1)
PROPOSED BUILDING SYSTEM PARAMETERS

CATEGORY	PARAMETER	FIXED OR USER DEFINED	REQUIRED	APPLICABLE SYSTEMS
HVAC system type	System type	User defined	Selected from Table C409.6.1.10.1	All
System sizing	Design day information	Fixed	99.6% heating design and 1% dry-bulb and 1% wet-bulb cooling design	All
	Zone coil capacity	Fixed	Sizing factors used are 1.25 for heating equipment and 1.15 for cooling equipment	All
	Supply airflow	Fixed	Based on a supply-air-to-room-air temperature setpoint difference of 20°F (11.2°C)	1–11
		Fixed	Equal to required outdoor air ventilation	12
Outdoor ventilation air	Portion of supply air with proposed filter ≥ MERV 13	User defined	Percentage of supply airflow subject to higher filtration (adjusts baseline fan power higher; prorated)	All
	Outdoor ventilation airflow rate	Fixed	As specified in ANSI/ASHRAE/IES 90.1, Normative Appendix C; adjusted for proposed DCV control	All
	Outdoor ventilation supply airflow rate adjustments	Fixed	Based on ASHRAE 62.1 Section 6.2.4.3, system ventilation efficiency (E_v) is 0.75	9–11
		Fixed	System ventilation efficiency (E_v) is 1.0	1–8, 12
		Fixed	Basis is 1.0 zone air distribution effectiveness	All
System operation	Space temperature setpoints	Fixed	As specified in ANSI/ASHRAE/IES 90.1, Normative Appendix C, except: • Multiple-family, which shall use 68°F heating and 76°F cooling setpoints. • Hotel/motel setpoints, which shall be 70°F heating and 72°F cooling.	1–11
	Fan operation—occupied	User defined	Runs continuously during occupied hours or cycles to meet load. Multispeed fans reduce airflow related to thermal loads.	1–11
	Fan operation—occupied	Fixed	Fan runs continuously during occupied hours	12
	Fan operation—night cycle	Fixed	Fan cycles on to meet setback temperatures	1–11
Packaged equipment efficiency	DX cooling efficiency	User defined	Cooling COP without fan energy calculated in accordance with Section C409.6.1.10.2	1, 2, 3, 4, 5,7, 8, 9, 11,12
	DX coil number of stages	User defined	Single stage or multistage	3, 4, 9, 10, 11, 12
	Heat pump efficiency	User defined	Heating COP without fan energy calculated in accordance with Section C409.6.1.10.2	2, 4, 5, 7, 8, 12
	Furnace efficiency	User defined	Furnace thermal efficiency	3, 9, 11, 12
Heat pump supple- mental heat	Heat source	User defined	Electric resistance or gas furnace	2, 4, 7, 8, 12
	Control	Fixed	Supplemental electric heat locked out above 40°F OAT. Runs as needed in conjunction with compressor between 40°F and 0°F. Gas heat operates in place of the heat pump when the heat pump cannot meet load.	2, 4, 7, 8, 12
System fan power and controls	Part-load fan controls[a]: • Constant volume. • Two speed or three speed. • VAV.	User defined	Static pressure reset included for VAV	1–8 (CAV, two or three speed), 9, 10, 11 (VAV), 12 (CAV and VAV)
	Design fan power (W/cfm)	User defined	Input electric power for all fans required to operate at fan system design conditions divided by the supply airflow rate. This is a wire-to-air value, including all drive, motor efficiency and other losses.	All

TABLE C409.6.1.10.2(1)
PROPOSED BUILDING SYSTEM PARAMETERS—continued

CATEGORY	PARAMETER	FIXED OR USER DEFINED	REQUIRED	APPLICABLE SYSTEMS
System fan power and controls—continued	Low-speed and medium- speed fan power	User defined	Low-speed input electric power for all fans required to operate at low-speed conditions divided by the low-speed supply airflow rate. This is a wire-to-air value, including all drive, motor efficiency and other losses. Also provide medium-speed values for three-speed fans.	1-8
Variable air volume systems	Supply air temperature (SAT) controls	User defined	If not SAT reset, then constant at 55°F. Options for reset based on OAT or warmest zone. If warmest zone, then the user can specify the minimum and maximum temperatures. If OAT reset, SAT is reset higher to 60°F at an outdoor low of 50°F. SAT is 55°F at an outdoor high of 70°F.	9, 10, 11
	Minimum terminal unit airflow percentage	User defined	Average minimum terminal unit airflow percent- age for thermal block weighted by cfm or minimum required for outdoor air ventilation, whichever is higher.	9, 10, 11
	Terminal unit heating source	User defined	Electric or hydronic	9, 10, 11
	Dual setpoint minimum VAV damper position	User defined	Heating maximum airflow fraction	9, 10
	Fan-powered terminal unit (FPTU) type	User defined	Series or parallel FPTU	11
	Parallel FPTU fan	Fixed	Sized for 50% peak primary air at 0.35 W/cfm	11
	Series FPTU fan	Fixed	Sized for 50% peak primary air at 0.35 W/cfm	11
Economizer	Economizer presence	User defined	Yes or no	3, 4, 5, 6, 9, 10, 11
	Economizer control type	Fixed	Lockout on differential db temperature (OAT > RAT) in *Climate Zones* 5A, 6A, all B & C; fixed enthalpy > 28 Btu/lb (47kJ/kg) or fixed db OAT > 75°F (24°C) in *Climate Zones* 0A through 4A	3, 4, 5, 6, 9, 10, 11
Energy recovery	Sensible effectiveness	User defined	Heat exchanger sensible effectiveness at design heating and cooling conditions	3, 4, 9, 10, 11, 12
	Latent effectiveness	User defined	Heat exchanger latent effectiveness at design heating and cooling conditions	3, 4, 9, 10, 11, 12
	Economizer bypass	User defined	If ERV is bypassed or wheel rotation is slowed during economizer conditions (yes/no)	3, 4, 9, 10, 11, 12
	Economizer bypass active	Fixed	If there is a bypass, it will be active between 45°F and 75°F outside air temperature	3, 4, 9, 10, 11, 12
	Bypass SAT setpoint	User defined	If bypass, target SAT	3, 4, 9, 10, 11, 12
	Fan power reduction during bypass (W/cfm)	User defined	If ERV system includes bypass, static pressure setpoint and variable speed fan, fan power can be reduced during economizer conditions	3, 4, 9, 10, 11, 12
Demand control ventilation (DCV)	DCV application on/off	User defined	Percent of thermal block floor area under occupied standby controls, on/off only with occupancy sensor and no variable control	3, 4, 9, 10, 11, 12
	DCV application CO_2	User defined	Percentage of thermal block floor area under variable DCV control (CO_2); may include both variable and on/off controls	3, 4, 9, 10, 11, 12
DOAS	DOAS fan power W/cfm	User defined	Fan electrical input power in W/cfm of supply airflow	12
	DOAS supplemental heating and cooling	User defined	Heating source, cooling source, energy recovery and respective efficiencies	12
	Maximum SAT setpoint (cooling)	User defined	SAT setpoint if DOAS includes supplemental cooling	12
	Minimum SAT setpoint (heating)	User defined	SAT setpoint if DOAS includes supplemental heating	12

TABLE C409.6.1.10.2(1)
PROPOSED BUILDING SYSTEM PARAMETERS—continued

CATEGORY	PARAMETER	FIXED OR USER DEFINED	REQUIRED	APPLICABLE SYSTEMS
Heating plant	Boiler efficiency	User defined	Boiler thermal efficiency	1, 6, 7, 9, 10, 11, 12
	Heating water loop configuration	User defined	Constant flow primary only; variable flow primary only; constant flow primary/variable flow secondary; variable flow primary and secondary	1, 6, 7, 9, 10, 11, 12
	Heating water primary pump power (W/gpm)	User defined	Heating water primary pump input W/gpm heat- ing water flow	1, 6, 7, 9, 10, 11, 12
	Heating water secondary pump power (W/gpm)	User defined	Heating water secondary pump input W/gpm heating water flow (if primary/secondary)	1, 6, 7, 9, 10, 11, 12
	Heating water loop temperature	User defined	Heating water supply and return temperatures, °F	1, 6, 9, 10,11
	Heating water loop supply temperature reset	Fixed	Reset HWS by 27.3% of design delta-T (HWS-70°F space heating temperature setpoint) between 20°F and 50°F OAT	1, 6, 7, 9, 10, 11, 12
	Boiler type	Fixed	Noncondensing boiler where input thermal effi- ciency is less than 86%; condensing boiler otherwise	1, 6, 7, 9, 10, 11, 12
Chilled water plant	Chiller compressor type	User defined	Screw/scroll, centrifugal or reciprocating	6, 10, 11, 12
	Chiller condenser type	User defined	Air cooled or water cooled	6, 10, 11, 12
	Chiller full-load efficiency	User defined	Chiller COP	6, 10, 11, 12
	Chilled water loop configuration	User defined	Variable flow primary only, constant flow primary/variable flow secondary, variable flow primary and secondary	6, 10, 11,12
	Chilled water primary pump power (W/gpm)	User defined	Primary pump input W/gpm chilled water flow	6, 10, 11,12
	Chilled water secondary pump power (W/gpm)	User defined	Secondary pump input W/gpm chilled water flow (if primary/secondary)	6, 10, 11,12
	Chilled water temperature reset included	User defined	Yes/no	6, 10, 11,12
	Chilled water temperature reset schedule (if included)	Fixed	Outdoor air reset: CHW supply temperature of 44°F at 80°F (26.7°C) outdoor air db temperature and above, CHW supply temperature of 54°F at 60°F outdoor air db temperature and below, ramped linearly between	6, 10, 11,12
	Condenser water pump power (W/gpm)	User defined	Pump input W/gpm condenser water flow	6, 7, 8, 10, 11, 12
	Condenser water pump control	User defined	Constant speed or variable speed	6, 7, 8, 10, 11,12
	Heat rejection equipment efficiency	User defined	Gpm/hp tower fan	6, 7, 10, 11, 12
	Heat rejection fan control	User defined	Constant or variable speed	6, 7, 10, 11, 12
	Heat rejection approach and range	User defined	Design cooling tower approach and range temperature	6, 7, 10, 11, 12

TABLE C409.6.1.10.2(1)
PROPOSED BUILDING SYSTEM PARAMETERS—continued

CATEGORY	PARAMETER	FIXED OR USER DEFINED	REQUIRED	APPLICABLE SYSTEMS
Heat pump loop	Loop flow and heat pump control valve	Fixed	Two-position valve with VFD on pump; loop flow at 3 gpm/ton	7, 8
	Heat pump loop minimum and maximum temperature control	User defined	User input: restrict to minimum 20°F and maximum 40°F temperature difference	7
GLHP well field	—	Fixed	Bore depth = 250 ft Bore length 200 ft/ton for the greater of cooling or heating load Bore spacing = 15 ft Bore diameter = 5 in ¾″ (19 mm) polyethylene pipe Ground and grout conductivity = 4.8 Btu × in/h × ft^2 × °F	8

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, °C = (°F – 32)/1.8, 1 British thermal unit per hour = 0.2931 W, 1 British thermal unit per pound = 2.33 kJ/kg, 1 cubic foot per minute = 0.4719 L/s, 1 cubic foot per minute/foot = 47.82 W, COP = (Btu/h × hp)/(2,550.7), 1 gallon per minute = 3.79 L/m.
CHW =Chilled Water, db = dry bulb, DOAS = Dedicated Outdoor Air System, GLHP = Ground Loop Heat Pump, HWS = Hot Water Supply, OAT = Outdoor Air Temperature, SAT = Supply Air Temperature, VFD = Variable Frequency Drive, wb = wet bulb.
a. Part-load fan power and pump power modified in accordance with Table C409.6.1.10.2(2).

TABLE C409.6.1.10.2(2)
FAN AND PUMP POWER CURVE COEFFICIENTS

EQUATION TERM	FAN POWER COEFFICIENTS	PUMP POWER COEFFICIENTS	
	VSD + SP Reset	Ride Pump Curve	VSD + DP/Valve Reset
b	0.0408	0	0
x	0.088	3.2485	0.0205
x^2	-0.0729	-4.7443	0.4101
x^3	0.9437	2.5295	0.5753

C409.6.1.10.3 Demand control ventilation. Demand control ventilation (DCV) shall be modeled using a simplified approach that adjusts the design outdoor supply airflow rate based on the floor area of the building that is covered by DCV. The simplified method shall accommodate both variable DCV and on/off DCV, giving on/off DCV one third of the effective floor control area of the variable DCV. Outdoor air reduction coefficients shall be as stated in Table C409.6.1.10.3.

Exception: On/off DCV shall receive full effective area adjustment for R-1 and R-2 occupancies.

TABLE C409.6.1.10.3
DCV OUTDOOR AIR REDUCTION CURVE COEFFICIENTS

EQUATION TERM	DCV OSA REDUCTION (*y*) AS A FUNCTION OF EFFECTIVE DCV CONTROL FLOOR AREA (*x*)			
	Office	School	Hotel, Motel, Multiple- Family, Dormitory	Retail
b	0	0	0	0
x	0.4053	0.2676	0.5882	0.4623
x^2	-0.8489	0.7753	-1.0712	-0.848
x^3	1.0092	-1.5165	1.3565	1.1925
X^4	-0.4168	0.7136	-0.6379	-0.5895

OSA = Outside Air.

C409.6.2 Simulation of the standard reference design. The standard reference design shall be configured and analyzed as specified in this section.

C409.6.2.1 Utility rates. Same as the proposed design.

C409.6.2.2 Thermal blocks. Same as the proposed design.

C409.6.2.3 Thermal zoning. Same as the proposed design.

C409.6.2.4 Occupancy type, schedule, density and heat gain. Same as the proposed design.

C409.6.2.5 Envelope components. Same as the proposed design

C409.6.2.6 Lighting. Same as the proposed design.

C409.6.2.7 Miscellaneous equipment. Same as the proposed design.

C409.6.2.8 Elevators. Not modeled. Same as the proposed design.

C409.6.2.9 Service water heating equipment. Not modeled. Same as the proposed design.

C409.6.2.10 On-site renewable energy systems. Not modeled. Same as the proposed design.

C409.6.2.11 HVAC equipment. The reference building design HVAC equipment consists of separate space conditioning systems as described in Tables C409.6.2.11(1) through C409.6.2.11(3) for the appropriate building use types.

TABLE C409.6.2.11(1)
REFERENCE BUILDING DESIGN HVAC COMPLEX SYSTEMS

BUILDING TYPE PARAMETER	BUILDING TYPE	
	Large Office	School
System type	VAV/RH Water-cooled chiller	VAV/RH
	Gas boiler	Water-cooled chiller Gas boiler
Fan control	VSD (no SP reset)	VSD (no SP reset)
Main fan power [W/cfm (W × s/L)] proposed ≥ MERV 13	1.165 (2.468)	1.165 (2.468)
Main fan power [W/cfm (W × s/L)] proposed < MERV 13	1.066 (2.259)	1.066 (2.259)
Zonal fan power [W/cfm (W × s/L)]	NA	NA
Minimum zone airflow fraction	1.5 × Voz	1.2 × Voz
Heat/cool sizing factor	1.25/1.15	1.25/1.15
Outdoor air economizer	Yes except 4A	Yes except 4A
Occupied OSA (= proposed)	Sum(Voz)/0.75	Sum(Voz)/0.65
Energy recovery ventilator efficiency ERR; ERV bypass SAT setpoint	NA	50% 60°F except 4A
DCV	No	No
Cooling source	(2) Water-cooled centrifugal chillers	(2) Water-cooled screw chillers
Cooling COP (net of fan)	Path B for profile	Path B for profile
Heating source (reheat)	Gas boiler	Gas boiler
Furnace or boiler efficiency	75% E_t	80% E_t
Condenser heat rejection	Axial Fan Open Circuit Cooling Tower	
Cooling tower efficiency [gpm/fan hp (L/s × fan kW)]	38.2	38.2
Tower turndown [> 300 ton (1060 kW)]	50%	50%
Pump (constant flow/variable flow)	Constant flow; 10°F (5.6°C) range	Constant flow; 10°F (5.6°C) range
Tower approach	25.72 - (0.24 x WB), where WB is the 0.4% evaporation design wetbulb temperature (°F)	
Cooling condenser pump power [W/gpm (W × s/L)]	19 (300)	19 (300)
Cooling primary pump power [W/gpm (W × s/L)]	9 (142)	9 (142)
Cooling secondary pump power [W/gpm (W × s/L)]	13 (205)	13 (205)
Cooling coil chilled water delta-T, °F (°C)	12 (6.7)	12 (6.7)
Design chilled water supply temperature, °F (°C)	44 (6.7)	44 (6.7)
Chilled water supply temperature (CHWST) reset setpoint vs. outside air temperature (OAT), °F (°C)	CHWST: 44-54/ OAT 80-60 (6.7-12.2/26.7-15.6)	CHWST: 44-54/ OAT 80-60 (6.7-12.2/26.7-15.6)
CHW cooling loop pumping control	2-way valves & pump VSD	2-way valves & pump VSD
Heating pump power [W/gpm (W × s/L)]	16.1 (254)	19 (300)

TABLE C409.6.2.11(1)
REFERENCE BUILDING DESIGN HVAC COMPLEX SYSTEMS—continued

BUILDING TYPE PARAMETER	BUILDING TYPE	
	Large Office (cold)	School (cold)
HWST reset setpoint vs. OAT, °F (°C)	HWST: 180-150/ OAT 20-50 (82-65.6/-6.7-10)	HWST: 180-150/ OAT 20-50 (82-65.6/-6.7-10)
Heat loop pumping control	2-way valves & pump VSD	2-way valves & pump VSD

For SI: °C = (°F – 32)/1.8, 1 hp = 0.746 kW, 1 ton = 3.517 kW.
CHW = Chilled Water, ERR = Enthalpy Recovery Ratio, NA = Not Applicable, OSA = Outside Air, PIU = Parallel Powered Induction Unit, RH = Relative Humidity, SP = Static Pressure, Voz = Outdoor airflow to the zone, VSD = Variable Speed Drive.

TABLE C409.6.2.11(2)
TSPR REFERENCE BUILDING DESIGN HVAC SIMPLE SYSTEMS

BUILDING TYPE PARAMETER	BUILDING TYPE		
	Medium Office	Small Office	Retail
System type	ckage VAV—hydronic reheat	PSZ-AC	PSZ-AC
Fan control	VSD (no SP reset)	Constant volume	Constant volume
Main fan power [W/cfm (W × s/L)] proposed ≥ MERV 13	1.285 (2.723)	0.916 (1.941)	0.899 (1.905)
Main fan power [W/cfm (W × s/L)] proposed < MERV 13	1.176 (2.492)	0.850 (1.808)	0.835 (1.801)
Zonal fan power [W/cfm (W × s/L)]	NA	NA	NA
Minimum zone airflow fraction	30%	NA	NA
Heat/cool sizing factor	1.25/1.15	1.25/1.15	1.25/1.15
Supplemental heating availability	NA	NA	NA
Outdoor air economizer	Yes except 4A	Yes except 4A	Yes except 4A
Occupied OSA source	Packaged unit, occupied damper, all building use types		
Energy recovery ventilator	No	No	No
DCV	No	No	No
Cooling source	DX, multistage	DX, single stage	DX, single stage
Cooling COP (net of fan)	3.40	3.00	3.50
Heating source	Gas boiler	Furnace	Furnace
Heating COP (net of fan)/furnace or boiler efficiency	75% E_t	80% E_t	80% E_t

For SI: °C = (°F – 32)/1.8.
NA = Not Applicable, OSA = Outside Air, RH = Relative Humidity, SP = Static Pressure, VSD = Variable Speed Drive.

TABLE C409.6.2.11(3)
TSPR REFERENCE BUILDING DESIGN HVAC SIMPLE SYSTEMS

BUILDING TYPE PARAMETER	BUILDING TYPE	
	Hotel	Multifamily
System type	PTAC	PTAC
Fan control	Constant volume	Constant volume
Main fan power [W/cfm (W × s/L)]	0.300 (0.636)	0.300 (0.636)
Heat/cool sizing factor	1.25/1.15	1.25/1.15
Supplemental heating availability	NA	NA
Outdoor air economizer	No	No
Occupied OSA source	Packaged unit, occupied damper	Packaged unit, occupied damper
Energy recovery ventilator	No	No
DCV	No	No
Cooling source	DX, 1 stage	DX, 1 stage
Cooling COP (net of fan)	3.20	3.20
Heating source	(2) Hydronic boiler	(2) Hydronic boiler
Heating COP (net of fan)/furnace or boiler efficiency	75% E_t	75% E_t
Heating pump power [W/gpm (W × s/L)]	19 (300)	19 (300)
Heating coil heating water delta-T, °F (°C)	50 (27.8)	50 (27.8)
Design HWST, °F (°C)	180 (82.2)	180 (82.2)
HWST reset setpoint vs. OAT, °F (°C)	HWST: 180-150/ OAT 20-50 (82-65.6/-6.7-10)	HWST: 180-150/ OAT 20-50 (82-65.6/-6.7-10)
Heat loop pumping control	2-way valves & ride pump curve	2-way valves & ride pump curve

For SI: °C = (°F – 32)/1.8.
HWST = Hot Water Supply Temperature, NA = Not Applicable, OAT = Outdoor Air Temperature, OSA = Outside Air.

C409.7 Target design HVAC systems. Target system descriptions in Tables C409.7(1) through C409.7(3) are provided as reference. The target systems are used for developing mechanical performance factors and do not need to be programmed into TSPR software.

TABLE C409.7(1)
TARGET BUILDING DESIGN CRITERIA HVAC COMPLEX SYSTEMS

BUILDING TYPE PARAMETER	BUILDING TYPE	
	Large Office	School
System type	VAV/RH	VAV/RH
	Water-cooled chiller	Water-cooled chiller
	Gas boiler	Gas boiler
Fan control	VSD (no SP reset)	VSD (no SP reset)
Main fan power [W/cfm (W × s/L] Proposed ≥ MERV 13	1.127 (2.388)	1.127 (2.388)
Zonal fan power [W/CFM (W × s/L)]	NA	NA
Minimum zone airflow fraction	1.5 × Voz	1.2 × Voz
Heat/cool sizing factor	1.25/1.15	1.25/1.15
Outdoor air economizer	Yes	Yes

TABLE C409.7(1)
TARGET BUILDING DESIGN CRITERIA HVAC COMPLEX SYSTEMS-continued

BUILDING TYPE PARAMETER	BUILDING TYPE	
	Large Office	School
Occupied OSA (= proposed)	Sum(Voz)/0.75	Sum(Voz)/0.65
Energy recovery ventilator efficiency ERR	NA	50%
ERV bypass SAT setpoint	NA	60°F (15.6°C) except 4A
DCV	Yes	Yes
% Area variable control	15%	70%
% Area on/off control	65%	20%
Cooling source	(2) Water-cooled centrifugal chillers	(2) Water-cooled screw chillers
Cooling COP (net of fan)	ASHRAE 90.1 Appendix G, Table G3.5.3	ASHRAE 90.1 Appendix G, Table G3.5.3
Heating source (reheat)	Gas boiler	Gas boiler
Furnace or boiler efficiency	90% E_t	90% E_t
Condenser heat rejection	Cooling tower	Cooling tower
Cooling tower efficiency [gpm/hp (L/s × kW)]—See ASHRAE 90.1 Appendix G, Section G3.1.3.11	40.2 (3.40)	40.2 (3.40)
Tower turndown (> 300 ton (1060 kW))	50%	50%
Pump (constant flow/variable flow)	Constant flow; 10°F (5.6°C) range	Constant flow; 10°F (5.6°C) range
Tower approach	ASHRAE 90.1 Appendix G, Table G3.1.3.11	ASHRAE 90.1 Appendix G, Table G3.1.3.11
Cooling condenser pump power [W/gpm (W·s/L)]	19 (300)	19 (300)
Cooling primary pump power [W/gpm (W·s/L)]	9 (142)	9 (142)
Cooling secondary pump power [W/gpm (W·s/L)]	13 (205)	13 (205)
Cooling coil chilled water delta-T, °F (°C)	18 (10)	18 (10)
Design chilled water supply temperature, °F (°C)	42 (5.56)	42 (5.56)
Chilled water supply temperature (CHWST) reset setpoint vs. OAT, °F (°C)	CHWST 44-54/OAT 80-60 (6.7- 12.2)/26.7-15.6)	CHWST 44-54/OAT 80-60 (6.7-12.2)/26.7-15.6)
CHW cooling loop pumping control	2-way valves & pump VSD	2-way valves & pump VSD
Heating pump power [W/gpm (W·s/L)]	16.1 (254)	19 (254)
Heating HW delta-T, °F (°C)	20 (11.11)	20 (11.11)
Design hot water supply temperature (HWST), °F (°C)	140 (60)	140 (60)
Hot water supply temperature (HWST) range vs. outside air temperature (OAT) range	HWST: 180-150/OAT 20-50 (82-65.6/- 6.7-10)	HWST: 180-150/OAT 20-50 (82-65.6/-6.7-10)
Heat loop pumping control	2-way valves & pump VSD	2-way valves & pump VSD

For SI: °C = (°F – 32)/1.8.
CHW = Chilled Water, ERR = Enthalpy Recovery Ratio, NA = Not Applicable, OSA = Outside Air, PIU = Parallel Powered Induction Unit, RH = Relative Humidity, SP = Static Pressure, Voz = Outdoor airflow to the zone, VSD = Variable Speed Drive.

TABLE C409.7(2)
TARGET BUILDING DESIGN CRITERIA HVAC SIMPLE SYSTEMS

BUILDING TYPE PARAMETER	BUILDING TYPE		
	Medium Office	**Small Office**	**Retail**
System type	Package VAV—hydronic reheat	PSZ-AC	PSZ-AC
Fan control	VSD (with SP reset)	Constant volume	2-speed
Main fan power [W/cfm(W × s/L)] proposed ≥ MERV 13	0.634 (1.343)	0.486 (1.03)	0.585 (1.245)
Zonal fan power [W/CFM (W × s/L)]	NA	NA	NA
Minimum zone airflow fraction	1.5 × Voz	NA	NA
Heat/cool sizing factor	1.25/1.15	1.25/1.15	1.25/1.15
Supplemental heating availability	NA	NA	NA
Outdoor air economizer	Yes	Yes	Yes
Occupied OSA source	Packaged unit, occupied damper, all building use types		
Energy recovery ventilator	No	No	Yes
ERR			50%
DCV	Yes	No	Yes
% Area variable control	15%		80%
% Area on/off control	65%		0%
Cooling source	DX, multistage	DX, single stage	DX, 2 stage
Cooling COP (net of fan)	3.83	3.8248	3.765
Heating source	Gas boiler	Furnace	Furnace
Heating COP (net of fan)/ furnace or boiler efficiency	81% E_t	81% E_t	81% E_t
Heating coil HW delta-T, °F (°C)	20 (11.11)	NA	NA
Design HWST, °F (°C)	140 (60)	NA	NA
HWST reset setpoint vs OAT, °F (°C)	HWST: 180-150/OAT 20-50 (82-65.6/- 6.7-10)	NA	NA
Heat loop pumping control	2-way valves & ride pump curve	NA	NA
Heating pump power [W/gpm (W·s/L)]	16.1	NA	NA

For SI: °C = (°F – 32)/1.8.
CHW = Chilled Water, ERR = Enthalpy Recovery Ratio, HWST = Hot Water Supply Temperature, NA = Not Applicable, OAT = Outside Air Temperature, OSA = Outside Air, SP = Static Pressure, Voz = Outdoor airflow to the zone, VSD = Variable Speed Drive.

TABLE C409.7(3)
TARGET BUILDING DESIGN CRITERIA HVAC SIMPLE SYSTEMS

BUILDING TYPE PARAMETER	BUILDING TYPE	
	Hotel	Multifamily
System type	PTAC with hydronic boiler	Split AC
Fan control	Cycling	Cycling
Main fan power [W/cfm (W × s/L)]	0.300 (0.638)	0.271 (0.576)
Heat/cool sizing factor	1.25/1.15	1.25/1.15
Supplemental heating availability	NA	NA
Outdoor air economizer	No	No
Occupied OSA source	DOAS	DOAS
Energy recovery ventilator	NA	Yes
ERR	NA	60%
DCV	Yes	No
% Area variable control	70%	
% Area variable control	0%	
Cooling source	DX, 1 stage	DX, 1 stage
Cooling COP (net of fan)	3.83	3.6504
Heating source	(2) Hydronic boiler	Furnace
Heating COP (net of fan)/furnace or boiler efficiency	81% E_t	80% AFUE
Heating pump power (W/gpm (W·s/L))	16.1	NA
Heating coil heating water delta-T, °F (°C)	20 (11.11)	NA
Design HWST, °F (°C)	140 (60)	NA
HWST reset setpoint vs. OAT, °F (°C)	HWST: 180-150/ OAT 20-50 (82-65.6/ -6.7-10)	NA
Heat loop pumping control	2-way valves & ride pump curve	NA

For SI: °C = (°F – 32)/1.8.
DOAS = Dedicated Outdoor Air System, ERR = Enthalpy Recovery Ratio, HWST = Hot Water Supply Temperature, NA = Not Applicable, OAT = Outdoor Air Temperature, OSA = Outside Air.