

CHAPTER 3 [CE]

GENERAL REQUIREMENTS

SECTION C301 CLIMATE ZONES

C301.1 General. The State of Vermont, in its entirety, is classified as *Climate Zone 6A*.

SECTION C302 DESIGN CONDITIONS

C302.1 Interior design conditions. The interior design temperatures used for heating and cooling load calculations shall be a maximum of 72°F (22°C) for heating and minimum of 75°F (24°C) for cooling.

C302.2 Climatic data.

- Heating Design Temperature, 99.6%: -9°F (ASHRAE Standard 169)
- Cooling Design Temperature Dry-Bulb, 1.0%: 84°F (ASHRAE Standard 169)
- Cooling Design Temperature Wet-Bulb, 1.0%: 69°F (ASHRAE Standard 169)
- Heating Degree Days, 65° Base: 7,626 (ASHRAE Standard 169)
- Cooling Degree Days, 50° Base: 2,183 (ASHRAE Standard 169)

Adjustments may be made only in the following cases:

1. Winter heating design temperatures for projects either:
 - 1.1 Located at an elevation of 1,500 feet or higher, or
 - 1.2. Located in Caledonia, Essex or Orleans counties.
 - 1.3. Adjustments shall be made as listed in the National Climate Data Center for the specific weather station: <http://www.ncdc.noaa.gov/cdo-web/>.
2. As approved by the *code official or authority having jurisdiction*.

SECTION C303 MATERIALS, SYSTEMS AND EQUIPMENT

C303.1 Identification. Materials, systems and equipment shall be identified in a manner that will allow a determination of compliance with the applicable provisions of this code.

C303.1.1 Building thermal envelope insulation. An *R*-value identification mark shall be applied by the manufacturer to each piece of *building thermal envelope* insulation 12 inches (305 mm) or greater in width. Alternatively, the insulation installers shall provide a certification listing the type, manufacturer and *R*-value of insulation installed in each element of the *building thermal envelope*. For blown-

in or sprayed fiberglass and cellulose insulation, the initial installed thickness, settled thickness, settled *R*-value, installed density, coverage area and number of bags installed shall be *listed* on the certification. For sprayed polyurethane foam (SPF) insulation, the installed thickness of the areas covered and *R*-value of installed thickness shall be *listed* on the certification. For insulated siding, the *R*-value shall be labeled on the product's package and shall be *listed* on the certification. The insulation installer shall sign, date and post the certification in a conspicuous location on the job site.

Exception: For roof insulation installed above the deck, the *R*-value shall be labeled as required by the material standards specified in Table 1508.2 of the *International Building Code*.

C303.1.1.1 Blown-in or sprayed roof/ceiling insulation. The thickness of blown-in or sprayed fiberglass and cellulose roof/ceiling insulation shall be written in inches (mm) on markers and one or more of such markers shall be installed for every 300 square feet (28 m²) of attic area throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers not less than 1 inch (25 mm) in height. Each marker shall face the attic *access* opening. Spray polyurethane foam thickness and installed *R*-value shall be *listed* on certification provided by the insulation installer.

C303.1.2 Insulation mark installation. Insulating materials shall be installed such that the manufacturer's *R*-value mark is readily observable upon inspection.

C303.1.3 Fenestration product rating. *U*-factors of fenestration products shall be determined as follows:

1. For windows, doors and skylights, *U*-factor ratings shall be determined in accordance with NFRC 100.
2. Where required for garage doors and rolling doors, *U*-factor ratings shall be determined in accordance with either NFRC 100 or ANSI/DASMA 105.

U-factors shall be determined by an accredited, independent laboratory, and *labeled* and certified by the manufacturer.

Products lacking such a *labeled U*-factor shall be assigned a default *U*-factor from Table C303.1.3(1) or C303.1.3(2). The solar heat gain coefficient (SHGC) and *visible transmittance* (VT) of glazed fenestration products (windows, glazed doors and skylights) shall be determined in accordance with NFRC 200 by an accredited, independent laboratory, and *labeled* and certified by the manufacturer. Products lacking such a *labeled* SHGC or VT shall be assigned a default SHGC or VT from Table C303.1.3(3).

C303.1.4 Insulation product rating. The thermal resistance (*R*-value) of insulation shall be determined in accor-

GENERAL REQUIREMENTS

**TABLE C303.1.3(1)
DEFAULT GLAZED WINDOW,
GLASS DOOR AND SKYLIGHT U-FACTORS**

FRAME TYPE	WINDOW AND GLASS DOOR		SKYLIGHT	
	Single	Double	Single	Double
Metal	1.20	0.80	2.00	1.30
Metal with Thermal Break	1.10	0.65	1.90	1.10
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05
Glazed Block	0.60			

Metal Thermal Break = A metal thermal break framed window shall incorporate the following minimum design characteristics:

1. The thermal conductivity of the thermal break material shall be not more than 3.6 Btu-in/h/ft²/°F.
2. The thermal break material must produce a gap in the frame material of not less than 0.210 inches.
3. All metal framing members of the products exposed to interior and exterior air shall incorporate a thermal break meeting the criteria in Items 1 and 2, above.

**TABLE C303.1.3(2)
DEFAULT OPAQUE DOOR U-FACTORS**

DOOR TYPE	OPAQUE U-FACTOR
Uninsulated Metal	1.20
Insulated Metal (Rolling)	0.90
Insulated Metal (Other)	0.60
Wood	0.50
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	0.35

**TABLE C303.1.3(3)
DEFAULT GLAZED FENESTRATION SHGC AND VT**

	SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
	Clear	Tinted	Clear	Tinted	
SHGC	0.8	0.7	0.7	0.6	0.6
VT	0.6	0.3	0.6	0.3	0.6

dance with the U.S. Federal Trade Commission *R*-value rule (CFR Title 16, Part 460) in units of h • ft² • °F/Btu at a mean temperature of 75°F (24°C).

C303.1.4.1 Insulated siding. The thermal resistance (*R*-value) of insulated siding shall be determined in accordance with ASTM C1363. Installation for testing shall be in accordance with the manufacturer’s instructions.

C303.2 Installation. Materials, systems and equipment shall be installed in accordance with the manufacturer’s instructions and the *International Building Code*.

C303.2.1 Protection of exposed foundation insulation. Insulation applied to the exterior of basement walls, crawl space walls and the perimeter of slab-on-grade floors shall have a rigid, opaque and weather-resistant protective covering to prevent the degradation of the insulation’s thermal performance. The protective covering shall cover the exposed exterior insulation and extend not less than 6 inches (153 mm) below grade.

C303.2.2 Multiple layers of continuous insulation board. Where two or more layers of continuous insulation board are used in a construction assembly, the continuous insulation boards shall be installed in accordance with Section C303.2. Where the continuous insulation board manufacturer’s instructions do not address installation of two or more layers, the edge joints between each layer of continuous insulation boards shall be staggered.

CHAPTER 4 [CE]

COMMERCIAL ENERGY EFFICIENCY

SECTION 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 one of the following:

1. The requirements of Sections C402 through C405 and C407. In addition, commercial buildings shall comply with Section C406 and tenant spaces shall comply with Section C406.1.1.
2. The requirements of ANSI/ASHRAE/IESNA 90.1-2016. New buildings using ANSI/ASHRAE/IESNA 90.1-2016 compliance paths (a) or (b) (see ANSI/ASHRAE/IESNA 90.1-2016 section 4.2.1.1 *New Buildings*) shall comply with Section C406 in the 2020 CBES and tenant spaces shall comply with Section C406.1.1 in the 2020 CBES. Commercial building projects utilizing the alternative compliance path of ANSI/ASHRAE/IESNA 90.1-2016 must follow all applicable provisions listed in Section 401.2.1.

C401.2.1 Applicable provisions to Standard 90.1-2016.

1. All instances of the term building official in ASHRAE/IESNA 90.1-2016 shall be replaced with the terms *code official or authority having jurisdiction*.
2. ASHRAE/IESNA 90.1-2016 *Section 4.2.1.1 New Buildings*. Delete the equation for Performance Cost Index Target (PCI) and replace with:

$$PCI = [BPF \times (BBUEC + BBREC)]/BBP.$$

Delete Table 4.2.1.1 *Building Performance Factor* (BPF) and replace with:

**TABLE 4.2.1.1
BUILDING PERFORMANCE FACTOR (BPF)**

BUILDING AREA TYPE ^a	VERMONT BPF
Multifamily	0.62
Healthcare/hospital	0.46
Hotel/motel	0.48
Office	0.43
Restaurant	0.50
Retail	0.44
School	0.39
Warehouse	0.53
All Others	0.45

a. In cases where both a general *building* area type and a specific *building* area type are listed, the specific *building* area type shall apply.

3. ASHRAE/IESNA 90.1-2016 *Section 5.1.4.1 United States Locations*. Delete the exception clause and replace with the following:
 - a. Adjustments may be made only in the following cases:
 - a. Winter heating design temperatures for projects either:
 - i. Located at an elevation of 1,500 feet or higher.
 - ii. Located in Caledonia, Essex or Orleans counties.
 - iii. Adjustments shall be made as listed in the National Climate Data Center for the specific weather station: <http://www.ncdc.noaa.gov/cdo-web/>.
 - b. As approved by the *code official or authority having jurisdiction*.
4. ASHRAE/IESNA 90.1-2016 *Section 5 Building Envelope*. All envelope requirements shall comply with the following tables in the 2020 *Vermont Commercial Building Energy Standards* (CBES):
 - i. *Table C402.1(1), Building Envelope Requirements—Opaque Assemblies and Elements*. Any spaces that qualify as *Semiheated* in ASHRAE/IESNA 90.1-2016 need only comply with the *Semiconditioned* requirement in Table C402.1(1).
 - ii. *Table C402.1(2), Building Envelope Requirements—Metal Building Assembly Descriptions*.
 - iii. *Table C402.3, Building Envelope Fenestration Maximum U-Factor and SHGC Requirements*.
5. ASHRAE/IESNA 90.1-2016 *Section 5.4.3 Air Leakage*. Delete section in its entirety and replace with *Section C402.4 Air leakage—thermal envelope of the 2020 Vermont CBES*.
6. ASHRAE/IESNA 90.1-2016 *Section 5.5.3.1 Roof Insulation*. Delete section in its entirety and replace with *Section C402.2.1 Roof assembly of the 2020 Vermont CBES*.
7. ASHRAE/IESNA 90.1-2016 *Section 5.5.3.3 Below-Grade Wall Insulation*. Delete section in its entirety and replace with *Section C402.2.3 Below-grade walls of the 2020 Vermont CBES*.
8. ASHRAE/IESNA 90.1-2016 *Section 5.5.3.5 Slab-on-Grade Floor Insulation*. Add to the end of this section the requirements of section C402.2.6 *Slabs-on-grade perimeter insulation of the 2020 Vermont CBES*.

9. ASHRAE/IESNA 90.1-2016 *Section 6.2 Compliance Path(s)*. Add new section as follows:

- a. *Section 6.2.3 Electric Resistance Space Heating*. Building heating with electrical resistance units, including baseboard radiation, heat pump reheat coils, duct coils, boilers, domestic hot water heaters, and coils in terminal units and air systems is prohibited.

Exceptions to 6.2.3:

- a. Areas, such as stairways, that are not permitted to be penetrated with piping or duct and no other method of heating is possible.
- b. Replacement of existing electrical resistance unit.
- c. Special conditions of occupancy or use that require electrical resistance heat to maintain health, safety or environmental conditions.
- d. Limited areas where a practical application of resistance electrical heat is demonstrated (e.g., small interior space, such as a rest room, which is distant from the distribution system, hazardous material storerooms, stairwell or other means of emergency egress).
- e. Domestic hot water heaters less than or equal to 7.5 kW in total unit input capacity.
- f. Multifamily buildings with heating loads less than or equal to 6.0 Btu/hour/square foot at design temperature.*
- g. *Cold-Climate Heat Pump* where:*
 - a. the full heating demand can be met with the heat pump at an outside air temperature of 5°F (-15°C).
 - b. the building *thermal envelope* shall be tested in accordance with ASTM E779 at a pressure differential of 0.3 inch water gauge (75 Pa) and deemed to comply with the provisions of Section C402.4.1 when the tested air leakage rate of the building thermal envelope is not greater than 0.20 cfm/ft² (including the areas of the slab and below grade walls).

*Buildings served by the City of Burlington Electric (BED) must also receive approval from BED before installing electric resistance heating equipment.

10. ASHRAE/IESNA 90.1-2016 *Section 6.3.2(e) Criteria*. Delete “an electric resistance heater.”

11. ASHRAE/IESNA 90.1-2016 *Section 6.4.3.5 Heat Pump Auxiliary Heat Control*. Delete section in its entirety and replace with *Section C403.4.1.1 Heat pump supplementary heat of the 2020 Vermont CBES*.

12. ASHRAE/IESNA 90.1-2016 *Section 6.4.3.8 Ventilation Controls for High-Occupancy Areas*. Add *exception (6)*: Ventilation needs for process loads.

13. ASHRAE/IESNA 90.1-2016 *Section 6.4.3.9 Heated or Cooled Vestibules*. Delete section in its entirety and replace with *Section C403.4.1.4 Duct and plenum insulation and sealing of the 2020 Vermont CBES*.

14. ASHRAE/IESNA 90.1-2016 *Section 6.4.4.1.2 Duct and Plenum Insulation*. Delete section in its entirety and replace with *Section C403.11.1 Duct and plenum insulation and sealing of the 2020 Vermont CBES*.

15. Add new Section 6.4.7 to ASHRAE/IESNA 90.1-2016, titled *Economizer Fault Detection and Diagnostics (FDD)*. Insert *Section C403.5.5 Economizer fault detection and diagnostics (FDD) of the 2020 Vermont CBES*.

16. ASHRAE/IESNA 90.1-2016 *Section 6.5.1 Economizers*. Delete section in its entirety and replace with *Section C403.5 Economizers of the 2020 Vermont CBES*.

17. ASHRAE/IESNA 90.1-2016 *Tables 6.5.6.1-1 and 6.5.6.1-2 Exhaust Air Energy Recovery Requirements for Ventilation Systems*. Both tables shall be greater than or equal to 3,000 hours per year rather than 8,000 hours.

18. ASHRAE/IESNA 90.1-2016 *Tables 6.5.6.1-1 and Table 6.5.6.1-2 Exhaust Air Energy Recovery Requirements*, delete requirement for systems with $\geq 10\%$ and $< 20\%$ outdoor air (second column of tables).

19. ASHRAE/IESNA 90.1-2016 *Section 6.5.6.2 Heat Recovery for Service Water Heating*. Add *exception (3)*: If compliance with Section 6.5.6.2 will be detrimental to chiller operating efficiency due to conflicts with optimized chiller head pressure control.

20. ASHRAE/IESNA 90.1-2016 *Section 6.7.2.4 System Commissioning*. Delete section in its entirety and replace with *Section C407 System Commissioning of the 2020 Vermont CBES*.

21. ASHRAE/IESNA 90.1-2016 *Section 7.1 General*. Add new section as follows:

- a. *Section 7.1.1.4 Electrical Water Heating Limitation*. Individual electric service water heating units shall be limited to a maximum of 7.5 kW total power input.

Exception: Instantaneous electric water heaters used to serve emergency showers and emergency eye wash stations.

22. ASHRAE/IESNA 90.1-2016 *Table 7.8 Performance Requirements for Water Heating Equipment*.

- a. Change first row (Electric tabletop water heaters) size category to < 7.5 kW.
- b. Change second row (Electric water heaters) size category to < 7.5 kW.

- c. Delete entire third row for electric water heaters > 12 kW.
23. ASHRAE/IESNA 90.1-2016 *Section 9 Lighting*. All lighting power density (LPD) requirements shall comply with the following tables in the 2020 *Vermont Commercial Building Energy Standards (CBES)*:
- i. *Table C405.3.2(1), Interior Lighting Power Allowances: Building Area Method.*
 - ii. *Table C405.3.2(2), Interior Lighting Power Allowances: Space-by-Space Method.*
 - iii. *Table C405.4.2(2), Individual Lighting Power Allowances for Building Exteriors.* Note that Vermont does not have any exterior lighting zone 4 areas.
- Exception:** *Exterior lighting zone 0 shall follow LPD requirements given by ASHRAE/IESNA 90.1-2016 Table 9.4.4-2.*
24. ASHRAE/IESNA 90.1-2016 *Section 9.4.1.3 Special Applications*. At the end of the section add the following wording:
- d. Luminaires providing means of egress illumination where the means of egress shall be illuminated at all times the room or space is occupied shall be controlled by occupancy sensors, or a signal from another building control system, that automatically reduces the lighting power by at least 50% when unoccupied for a period longer than 15 minutes.
- Exceptions:**
- 1. Means of egress illumination that does not exceed 0.02 watts per square foot of building area is exempt from this requirement.
 - 2. Emergency lighting designated to meet Section 1008.3 of the *International Building Code*.
25. ASHRAE/IESNA 90.1-2016 *Section 9.4.1.4 Exterior Lighting Control*. Add the following requirement:
- e. Exterior lighting shall be *full cut off* fixtures, limiting the light output to less than 10% at and below 10 degrees below the horizontal. Fixtures shall be independently certified by manufacturer as full cut off or meet the definition of a *fully shielded* light fixture.
26. ASHRAE/IESNA 90.1-2016 *Section 9.4.4 Dwelling Units*. Delete section in its entirety and replace with: Not less than 90% of the *permanently installed* lighting fixtures shall use lamps with an *efficacy* of at least 65 lm/W or have a total *luminaire efficacy* of at least 55 lm/W.
27. ASHRAE/IESNA 90.1-2016 *Section 9.6.2 Additional Interior Lighting Power*. Amend the exception in part (a) to read that the power shall not exceed 0.6 W/ft² of such *spaces* instead of 0.75 W/ft². In part (b), delete the equation for Additional

Interior Lighting Power Allowance and replace with:

Additional interior lighting power allowance = 250 W + (Retail Area 1 × 0.20 W/ft²) + (Retail Area 2 × 0.20 W/ft²) + (Retail Area 3 × 0.50 W/ft²) + (Retail Area 4 × 0.90 W/ft²)

28. ASHRAE/IESNA 90.1-2016 *Section 10.4 Mandatory Provisions*. Add the following sections:
- i. *10.4.6, Renewable energy systems*, which will meet the requirements of *Section C405.10 Renewable energy systems* in the 2020 Vermont CBES.
 - ii. *10.4.7 Electric Vehicle Charging Stations*, which will meet the requirements of *Section C405.11 Electric Vehicle Charging Stations* in the 2020 Vermont CBES.

C401.2.2 Application to replacement fenestration products. Where some or all of an existing *fenestration* unit is replaced with a new *fenestration* product, including sash and glazing, the replacement *fenestration* unit shall meet the applicable requirements for *U-factor* and *SHGC* in Table C402.3.

Exception: An area-weighted average of the *U-factor* of replacement fenestration products being installed in the building for each fenestration product category listed in Table C402.3 shall be permitted to satisfy the *U-factor* requirements for each fenestration product category listed in Table C402.3. Individual fenestration products from different product categories listed in Table C402.3 shall not be combined in calculating the area-weighted average *U-factor*.

C401.3 Certificate of compliance. 30 V.S.A. §53 requires certification that both the design and the construction of a commercial building is in compliance with the CBES.

Certification shall be issued by completing and signing a certificate permanently and affixing it to the outside of the heating or cooling equipment, to the electrical service panel and located inside the building, or in a visible location in the immediate vicinity of one of these three areas. Copies of the signed certification documents shall be sent to the local town clerk and to the Vermont Public Service Department.

SECTION C402 BUILDING ENVELOPE REQUIREMENTS

C402.1 General (Prescriptive). In addition to the envelope requirements of Section C402, envelope enhancements may be needed to meet the requirements of Section C406, Additional Efficiency Package Options. See Section C406.

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, 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 either the *R-value-based* method of Section C402.1.1; the *U-, C- and F-factor-based* method of Section C402.1.2; the component performance alternative of Section

C402.1.3; or the building above-grade performance alternative of Section C402.1.4. Building assemblies between conditioned and semi-conditioned spaces shall comply with the semi-conditioned requirements.

2. Fenestration in building envelope assemblies shall comply with Section C402.3.

Exception: Semi-conditioned spaces do not have fenestration requirements.

3. Air leakage of building envelope assemblies shall comply with Section C402.4. Buildings with both conditioned and semi-conditioned spaces shall independently comply with the requirements of Section C402.4.

Alternatively, where buildings have a vertical fenestration area or skylight area exceeding that allowed in Section C402.3, the building and building thermal envelope shall comply with Section C401.2, Item 2.

Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.10.1.

C402.1.1 Insulation component R-value-based method.

Building thermal envelope opaque assemblies shall comply with the requirements of Sections C402.2 and C402.3. For opaque portions of the *building thermal envelope* intended to comply on an insulation component *R-value* basis, the *R-values* for insulation shall be not less than that specified in the “Minimum *R-values*” columns of Table C402.1(1). Commercial buildings or portions of commercial buildings enclosing *conditioned spaces* shall use the *R-values* from the “Conditioned Space” column of Table C402.1(1). Commercial buildings or portions of commercial buildings enclosing semi-conditioned spaces shall use the *R-values* from the “Semi-conditioned Space” column of Table C402.1(1). Walls between conditioned and semi-conditioned spaces shall use the *R-values* from the “Semi-conditioned Space” column of Table C402.1(1).

C402.1.2 Assembly U-factor, C-factor or F-factor-based method. Building thermal envelope opaque assemblies shall meet the requirements of Sections C402.2 and C402.3. Building thermal envelope opaque assemblies intended to comply on an assembly *U-, C- or F-factor* basis shall have a *U-, C- or F-factor* not greater than that specified in the “Maximum Overall *U-factor*” columns of Table C402.1(1). Commercial buildings or portions of commercial buildings enclosing *conditioned spaces* shall use the *U-, C- or F-factor* from the “Conditioned Space” column of Table C402.1(1). Commercial buildings or portions of commercial buildings enclosing semi-conditioned spaces shall use the *U-, C- or F-factor* from the “Semi-conditioned Space” column of Table C402.1(1). Walls between conditioned and semi-conditioned spaces shall use the *R-values* from the “Semi-conditioned Space” column of Table C402.1(1).

C402.1.3 Component performance alternative. Building envelope values and fenestration areas determined in accordance with Equation 4-1 shall be an alternative to compliance with the *U-, F- and C-factors* in Tables C402.1(1) and C402.3 and the maximum allowable fenestration areas in Section C402.3.1. *Fenestration* shall meet the applicable SHGC requirements of Section C402.3.3.

$$A + B + C + D + E \leq \text{Zero} \quad \text{(Equation 4-1)}$$

where:

- A = Sum of the (UA Dif) values for each distinct assembly type of the building thermal envelope, other than slabs on grade and below-grade walls.
 - UA Dif = UA Proposed - UA Table.
 - UA Proposed = Proposed *U-value* × Area.
 - UA Table = (*U-factor* from Table C402.1(1) or C402.3) × Area.
 - B = Sum of the (FL Dif) values for each distinct slab on-grade perimeter condition of the building thermal envelope.
 - FL Dif = FL Proposed - FL Table.
 - FL Proposed = Proposed *F-value* × Perimeter length.
 - FL Table = [*F-factor* specified in Table C402.1(1)] × Perimeter length.
 - C = Sum of the (CA Dif) values for each distinct below-grade wall assembly type of the building thermal envelope.
 - CA Dif = CA Proposed - CA Table.
 - CA Proposed = Proposed *C-value* × Area.
 - CA Table = [Maximum allowable *C-factor* specified in Table C402.1(1)] × Area.
- Where the proposed vertical glazing area is less than or equal to the maximum vertical glazing area allowed by Section C402.3.1, the value of D (Excess Vertical Glazing Value) shall be zero. Otherwise:
- D = (DA × UV) - (DA × U Wall), but not less than zero.
 - DA = (Proposed Vertical Glazing Area) - (Vertical Glazing Area allowed by Section C402.3.1).
 - UA Wall = Sum of the (UA Proposed) values for each opaque assembly of the exterior wall.
 - U Wall = Area-weighted average *U-value* of all above-grade wall assemblies.
 - UAV = Sum of the (UA Proposed) values for each vertical glazing assembly.
 - UV = UAV/total vertical glazing area.
- Where the proposed skylight area is less than or equal to the skylight area allowed by Section C402.3.1, the value of E (Excess Skylight Value) shall be zero. Otherwise:
- E = (EA × US) - (EA × U Roof), but not less than zero.
 - EA = (Proposed Skylight Area) - (Allowable Skylight Area as specified in Section C402.3.1).
 - U Roof = Area-weighted average *U-value* of all roof assemblies.
 - UAS = Sum of the (UA Proposed) values for each skylight assembly.
 - US = UAS/total skylight area.

**TABLE C402.1(1)
BUILDING ENVELOPE REQUIREMENTS—OPAQUE ASSEMBLIES AND ELEMENTS^{a,b}**

COMPONENT	MAXIMUM OVERALL U-FACTOR ^a		MINIMUM R-VALUES ^{a,b}	
	Conditioned Space	Semi-conditioned Space	Conditioned Space	Semi-conditioned Space
Roofs				
Insulation entirely above deck	U-0.025	U-0.039	R-40ci	R-25ci
Metal buildings ^a	U-0.026	U-0.037	R-25 + R-11 + R-11 LS	R-19 + R-11 LS or R-25 + R-8 LS
Attic and Other	U-0.021	U-0.034	R-49	R-30
Walls, Above grade				
Mass	U-0.048	U-0.104	R-19ci	R-9.5ci
Metal Building ^a	U-0.044	U-0.060	R-13 + R-17ci or R-22.1ci	R-15.8ci
Metal-framed	U-0.044	U-0.064	R-13 + R-15ci or R-20ci	R-13 + R-7.5ci
Wood-framed and other	U-0.042	U-0.064	R-13 + R-12ci or R-19 + R-8ci or R-20ci	R-13 + R-3.8ci
Walls, Below Grade^c				
Below-grade wall	C-0.063	C-0.119	R-15ci	R-7.5ci
Floors				
Mass ^d	U-0.051	U-0.087	R-16.7ci	R-8.3ci
Joist/Framing—Metal	U-0.032	U-0.052	R-38	R-19
Joist/Framing—Wood and Other	U-0.033	U-0.051	R-30	R-19
Slab-on-Grade Floors				
Unheated slabs	F-0.036	F-0.54	R-10 for entire slab and around perimeter	R-10 for 24 in.
Heated slabs ^e	F-0.373	F-0.55	R-20 for entire slab and around perimeter	R-10 for entire slab and around perimeter
Opaque Doors				
Swinging	U-0.37		N/A	
Non-Swinging	N/A		R-4.75	
Upward-acting, Sectional	N/A		R-10	
Garage door <14% glazing	U-0.31		N/A	

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m², 1 pound per cubic foot = 16 kg/m³.

ci = Continuous insulation, NR = No Requirement, LS = Liner System.

- a. For all envelope categories the use of opaque assembly *U*-factors, *C*-factors, and *F*-factors from ANSI/ASHRAE/IESNA 90.1-2016 Appendix A shall be permitted, provided the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/IESNA 90.1-2016 Appendix A. Alternatively, Table C402.1(2) for metal building assembly descriptions, Table C402.1(3) for metal building roof assembly *U*-factors, Table C402.1(4) for attic roofs with wood joists *U*-factors, Table C402.1(5) for metal building wall assembly *U*-factors, Table C402.1(6) for metal-framed wall assembly *U*-factors, and Table C402.1(7) for wood-framed wall assembly *U*-factors may be used in lieu of ANSI/ASHRAE/IESNA 90.1-2016 Appendix A.
- b. Opaque assembly *U*-factors based on designs tested in accordance with ASTM C1363 shall be permitted. 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 *F*-factor requirements for heated slabs.
- d. “Mass floors” shall include floors weighing not less than:
 1. 35 pounds per square foot of floor surface area; or
 2. 25 pounds per square foot of floor surface area where the material weight is not more than 120 pounds per cubic foot.
- e. Evidence of compliance with the *F*-factors indicated in the table for heated slabs shall be demonstrated by the application of the unheated slab *F*-factors and *R*-values derived from ASHRAE 90.1-2016 Appendix A.

**TABLE C402.1(2)
BUILDING ENVELOPE REQUIREMENTS—METAL BUILDING ASSEMBLY DESCRIPTIONS**

BUILDING ENVELOPE REQUIREMENTS—METAL BUILDING ASSEMBLY DESCRIPTIONS	DESCRIPTION	REFERENCE
ROOFS		
Liner system	A continuous membrane installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins. For multilayer installations, the last rated <i>R</i> -value of insulation is for unfaced insulation draped over purlins and then compressed when the metal roof panels are attached. A minimum R-5 thermal spacer block between the purlins and the metal roof panels is required unless compliance is shown by the overall assembly <i>U</i> -factor.	ANSI/ASHRAE/IESNA 90.1-2016
Filled Cavity (Fc)	The first <i>rated R-value of insulation</i> represents faced or unfaced insulation installed between the purlins. The second <i>rated R-value of insulation</i> represents unfaced insulation installed above the first layer, perpendicular to the purlins and compressed when the metal <i>roof</i> panels are attached. A supporting structure retains the bottom of the first layer at the prescribed depth required for the full thickness of insulation. A minimum R-5 thermal spacer block between the purlins and the metal <i>roof</i> panels is required unless compliance is shown by the overall assembly <i>U</i> -factor.	ANSI/ASHRAE/IESNA 90.1-2016
WALLS		
R-13 + R-17ci	The first rated <i>R</i> -value of insulation is for insulation compressed between metal building wall panels and the steel structure. The second rated <i>R</i> -value is for continuous insulation (e.g., insulation boards). It is assumed that the insulation boards are installed on the inside of the girts and uninterrupted by the framing members. Insulation exposed to the conditioned space or semi-heated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.	ANSI/ASHRAE/IESNA 90.1-2016
R-22.1ci	The rated <i>R</i> -value is for continuous insulation (e.g., insulation boards). It is assumed that the insulation boards are installed on the inside of the girts and uninterrupted by the framing members. Insulation exposed to the conditioned space or semi-heated space shall have a facing, and all insulation seams shall be continuously sealed to provide a continuous air barrier.	ANSI/ASHRAE/IESNA 90.1-2016