

CHAPTER 4 [CE]

COMMERCIAL ENERGY EFFICIENCY

User notes:

About this chapter: Chapter 4 presents the paths and options for compliance with the energy efficiency provisions. Chapter 4 contains energy efficiency provisions for the building envelope, mechanical and water-heating systems, lighting and additional efficiency requirements. A performance alternative is also provided to allow for energy code compliance other than by the prescriptive method.

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 Section C401.2.1 or C401.2.2.

C401.2.1 International Energy Conservation Code. *Commercial buildings* shall comply with one of the following:

1. **Prescriptive Compliance.** The Prescriptive Compliance option requires compliance with Sections C402 through C406 and Section C408. *Dwelling units* and *sleeping units* in Group R-2 buildings shall be deemed to be in compliance with this chapter, provided that they comply with Section R406.
2. **Simulated Building Performance.** The *Simulated Building Performance* option requires compliance with Section C407.

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

C401.2.2 ASHRAE 90.1. *Commercial buildings* shall comply with the requirements of ANSI/ASHRAE/IES 90.1, Appendix CI and the requirements of the sections indicated within Table C401.2.2.

**TABLE C401.2.2
REQUIREMENTS FOR ASHRAE 90.1 COMPLIANCE**

SECTION ^a	TITLE
New Construction	
C405.4	Horticultural lighting
C405.14	Electric vehicle power transfer infrastructure
C405.16	Electrical energy storage system
C405.18	Electric infrastructure
Additions and Alterations	
C502.3.7	Additional energy efficiency credit requirements
C503.3.2	Mechanical system acceptance testing
C503.3.3	Duct testing
C503.3.4	Controls
C503.3.5	System sizing
C503.6	Additional energy efficiency credit requirements for alterations
C505.1.3	Additional energy efficiency for changes of occupancy

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

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 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. Wall solar reflectance and thermal *emittance* shall comply with Section C402.3.
3. Roof solar reflectance and thermal *emittance* shall comply with Section C402.4.
4. *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.

5. Air leakage of building thermal envelope shall comply with Section C402.6.
6. Thermal bridges in above-grade walls shall comply with Section C402.7.
7. 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 and greenhouses. The following low-energy buildings, or portions thereof separated from the remainder of the building by building thermal envelope assemblies complying with this section, shall be exempt from the building thermal envelope provisions of Section C402.

C402.1.1.1 Low-energy buildings. Buildings that comply with either of the following:

1. Those with a peak design rate of energy usage less than 3.4 Btu/h × ft² (10.7 W/m²) or 1.0 watt per square foot (10.7 W/m²) of floor area for space conditioning purposes.
2. Those that do not contain conditioned space.

C402.1.1.2 Greenhouses. Greenhouse structures or areas that are mechanically heated or cooled and that comply with all of the following shall be exempt from the building thermal envelope requirements of this code:

1. Exterior opaque envelope assemblies that comply with Sections C402.2 and C402.5.5.

Exception: Low-energy greenhouses that comply with Section C402.1.1.

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 C402.1.1.2. The U-factor for a roof shall be for the roof assembly or a roof that includes the assembly and an internal curtain system.

Exception: Unconditioned greenhouses.

**TABLE C402.1.1.2
FENESTRATION BUILDING THERMAL
ENVELOPE MAXIMUM REQUIREMENTS**

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

C402.1.1.3 Equipment buildings. Buildings that comply with the following shall be exempt from the building thermal envelope provisions of this code:

1. Are separate buildings with floor area not more than 1,200 square feet (111 m²).

2. Are intended to house electric equipment with installed equipment power totaling not less than 7 watts per square foot (75 W/m²) 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 1 through 5 and less than 0.12 in Climate Zones 6 through 8.
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.

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 ANSI/ASHRAE/IES 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 ANSI/ASHRAE/IES 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 nonuniform 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.

OPAQUE BUILDING THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, U-FACTOR METHOD^{a, b}

CLIMATE ZONE	0 AND 1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
Roofs																
Insulation entirely above roof deck	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039	U-0.039	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.028	U-0.028	U-0.028	U-0.028
Metal buildings	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.031	U-0.029	U-0.029	U-0.029	U-0.026	U-0.026
Attic and other	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.017	U-0.017	U-0.017	U-0.017	U-0.017
Walls, above grade																
Mass ^f	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.071	U-0.071	U-0.037	U-0.037
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.050	U-0.050	U-0.050	U-0.050	U-0.050	U-0.044	U-0.039	U-0.039	U-0.039	U-0.039
Metal framed	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.055	U-0.049	U-0.049	U-0.049	U-0.042	U-0.037	U-0.037	U-0.037
Wood framed and other ^c	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.032	U-0.032	U-0.032
Walls, below grade																
Below-grade wall ^e	C-1.140°	C-1.140°	C-1.140°	C-1.140°	C-1.140°	C-1.140°	C-0.092	C-0.092	C-0.092	C-0.092	C-0.063	C-0.063	C-0.063	C-0.063	C-0.063	C-0.063
Floors																
Mass ^d	U-0.322°	U-0.322°	U-0.107	U-0.087	U-0.074	U-0.074	U-0.057	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.042	U-0.042	U-0.038	U-0.038
Joist/framing	U-0.066°	U-0.066°	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027
Slab-on-grade floors																
Unheated slabs	F-0.73°	F-0.73°	F-0.73°	F-0.73°	F-0.54	F-0.52	F-0.52	F-0.52	F-0.51	F-0.51	F-0.434	F-0.51	F-0.434	F-0.434	F-0.424	F-0.424
Heated slabs	F-0.69	F-0.69	F-0.69	F-0.69	F-0.66	F-0.66	F-0.62	F-0.62	F-0.62	F-0.62	F-0.602	F-0.602	F-0.602	F-0.602	F-0.602	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	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31
Swinging door ^f	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37
Garage door < 14% glazing ^h	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31

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 ANSI/ASHRAE/IES 90.1 Appendix A, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table, and provided that the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/IES 90.1 Appendix A.
- 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. These *C*-, *F*- and *U*-factors are based on assemblies that are not required to contain insulation.
- 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 in Climate Zones 0 through 6 and less than or equal to 0.36 in Climate Zones 7 and 8, provided that the fenestration area is not less than 14 percent and not more than 25 percent of the total door area.

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 *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 ceilings and walls shall be permitted to be determined in accordance with AISI S250 as modified herein.

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.
2. Where the steel-framed wall contains framing at 24 inches (610 mm) on center with a 23 percent framing factor or framing at 16 inches (406 mm) on center with a 25 percent framing factor, the next lower framing member spacing input values shall be used when calculating using AISI S250.

3. Where the steel-framed wall contains less than 23 percent framing factors, the AISI S250 shall be used without any modifications.

4. Where the steel-framed wall contains other than standard C-shape framing members, the AISI S250 calculation option for other than standard C-shape framing is permitted to be used.

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

C402.1.2.1.8 Mechanical equipment penetrations. Where the total area of through penetrations of mechanical equipment 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 C402.1.2.1.7
EFFECTIVE *U*-FACTORS FOR SPANDREL PANELS^a**

RATED <i>R</i> -VALUE OF INSULATION BETWEEN FRAMING MEMBERS		R-4	R-7	R-10	R-15	R-20	R-25	R-30
Frame Type	Spandrel Panel	Default <i>U</i> -Factor						
Aluminum without thermal break ^b	Single glass pane, stone, or metal panel	0.285	0.259	0.247	0.236	0.230	0.226	0.224
	Double glazing with no low-e coatings	0.273	0.254	0.244	0.234	0.229	0.226	0.223
	Triple glazing or double glazing with low-e glass	0.263	0.249	0.241	0.233	0.228	0.225	0.223
Aluminum with thermal break ^c	Single glass pane, stone, or metal panel	0.243	0.212	0.197	0.184	0.176	0.172	0.169
	Double glazing with no low-e coatings	0.228	0.205	0.193	0.182	0.175	0.171	0.168
	Triple glazing or double glazing with low-e glass	0.217	0.199	0.189	0.180	0.174	0.170	0.167
Structural glazing ^d	Single glass pane, stone, or metal panel	0.217	0.180	0.161	0.145	0.136	0.130	0.126
	Double glazing with no low-e coatings	0.199	0.172	0.157	0.143	0.135	0.129	0.126
	Triple glazing or double glazing with low-e glass	0.186	0.165	0.152	0.140	0.133	0.128	0.125
No framing or insulation is continuous ^e	Single glass pane, stone, or metal panel	0.160	0.108	0.082	0.058	0.045	0.037	0.031
	Double glazing with no low-e coatings	0.147	0.102	0.078	0.056	0.044	0.036	0.030
	Triple glazing or double glazing with low-e glass	0.139	0.098	0.076	0.055	0.043	0.035	0.030

- a. Extrapolation outside of the table shall not be permitted. Assemblies with distance between framing less than 30 inches, or not included in the default table, shall have a *U*-factor determined by testing in compliance with ASTM C1363 or modeling in compliance with ANSI/NFRC 100. Spandrel panel assemblies in the table do not include metal backpans. For designs with metal backpans, multiply the *U*-factor by 1.2.
- b. This frame type shall be used for systems that do not contain a nonmetallic element separating the metal exposed to the exterior from the metal exposed to the interior condition.
- c. This frame type shall be used for systems where a nonmetallic element separates the metal exposed to the exterior from the metal that is exposed to the interior condition.
- d. This frame type shall be used for systems that have no exposed mullion on the exterior.
- e. This frame type shall be used for systems where there is no framing or the insulation is continuous and uninterrupted between framing.

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

CLIMATE ZONE	0 AND 1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings ^b	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-25 + R-11 + R-11 LS	R-25 + R-11 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-49	R-49	R-60	R-60	R-60	R-60
Walls, above grade																
Mass ^f	R-5.7ci ^e	R-5.7ci ^e	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci
Metal building	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-19.5ci	R-13 + R-19.5ci
Metal framed ^{h,i}	R-0 + R-10ci or R-13 + R-5ci or R-20 + R-3.8ci	R-0 + R-10ci or R-13 + R-5ci or R-20 + R-3.8ci	R-0 + R-12.6ci or R-13 + R-7.5ci or R-20 + R-6.3ci	R-0 + R-12.6ci or R-13 + R-7.5ci or R-20 + R-6.3ci	R-0 + R-12.6ci or R-13 + R-7.5ci or R-20 + R-6.3ci	R-0 + R-12.6ci or R-13 + R-7.5ci or R-20 + R-6.3ci	R-0 + R-15.2ci or R-13 + R-10ci or R-20 + R-9ci	R-0 + R-15.2ci or R-13 + R-10ci or R-20 + R-9ci	R-0 + R-17.3ci or R-13 + R-12.5ci or R-20 + R-11ci	R-0 + R-17.3ci or R-13 + R-12.5ci or R-20 + R-11ci	R-0 + R-17.3ci or R-13 + R-12.5ci or R-20 + R-11ci	R-0 + R-17.3ci or R-13 + R-12.5ci or R-20 + R-11ci	R-0 + R-21ci or R-13 + R-15.6ci or R-20 + R-14.3ci	R-0 + R-21ci or R-13 + R-15.6ci or R-20 + R-14.3ci	R-0 + R-24ci or R-13 + R-18.8ci or R-20 + R-17.5ci	R-0 + R-24ci or R-13 + R-18.8ci or R-20 + R-17.5ci
Wood framed and other ^{h,i}	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-12ci or R-13 + R-3.8ci or R-20	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-16ci or R-13 + R-7.5ci or R-20 + R-3.8ci or R-27	R-0 + R-27.5ci or R-13 + R-18.8ci or R-20 + R-14ci	R-0 + R-27.5ci or R-13 + R-18.8ci or R-20 + R-14ci
Walls, below grade																
Below-grade wall ^d	NR	NR	NR	NR	R-7.5ci	R-7.5ci	R-10ci	R-10ci	R-10ci	R-10ci	R-10ci	R-10ci	R-15ci	R-15ci	R-15ci	R-15ci
Mass ^f	NR	NR	R-10ci	R-10ci	R-14.6ci	R-14.6ci	R-16.7ci	R-16.7ci	R-16.7ci	R-16.7ci	R-16.7ci	R-16.7ci	R-20.9ci	R-20.9ci	R-23ci	R-23ci
Joist/framing	R-13	R-13	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-38	R-38	R-38	R-38
Slab-on-grade floors																
Unheated slabs	NR	NR	NR	NR	R-10 for 24" below	R-10 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 24" below	R-20 for 24" below	R-20 for 24" below	R-20 for 24" below	R-20 for 48" below	R-25 for 48" below
Heated slabs ^g	R-7.5 for 12" below + R-5 full slab	R-7.5 for 12" below + R-5 full slab	R-10 for 24" below + R-5 full slab	R-10 for 24" below + R-5 full slab	R-15 for 24" below + R-5 full slab	R-15 for 24" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-15 for 36" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab	R-20 for 48" below + R-5 full slab

For Sl: 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.

(continued)

TABLE C402.1.3—continued
OPAQUE BUILDING THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD^a

- a. Assembly descriptions can be found in ANSI/ASHRAE/IES 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. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C90, ungrouted or partially grouted not less than 32 inches on center vertically and not less than 48 inches on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-ft²-F.
- d. Where heated slabs are below grade, below-grade walls shall comply with the *R*-value requirements for above-grade mass walls.
- 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 insulation 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-0 + R-12ci" means R-12 continuous insulation and no cavity insulation; "R-13 + R-3.8ci" means R-13 cavity insulation and R-3.8 continuous insulation; "R-20" means R-20 cavity insulation and no continuous insulation. R-13, R-20 and R-27 cavity insulation, as used in this table, apply to a nominal 4-inch, 6-inch and 8-inch-deep wood or cold-formed steel stud cavities, respectively.
- 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.