

Study Session

3

2021 IECC Sections C401 through C402 (partial) Commercial Energy Efficiency—Part I

OBJECTIVE: To obtain an understanding of the choice of compliance options and of specific insulation requirements (prescriptive) for the building thermal envelope of commercial buildings.

REFERENCE: Sections C401 and C402 (partial), 2021 *International Energy Conservation Code*

KEY POINTS:

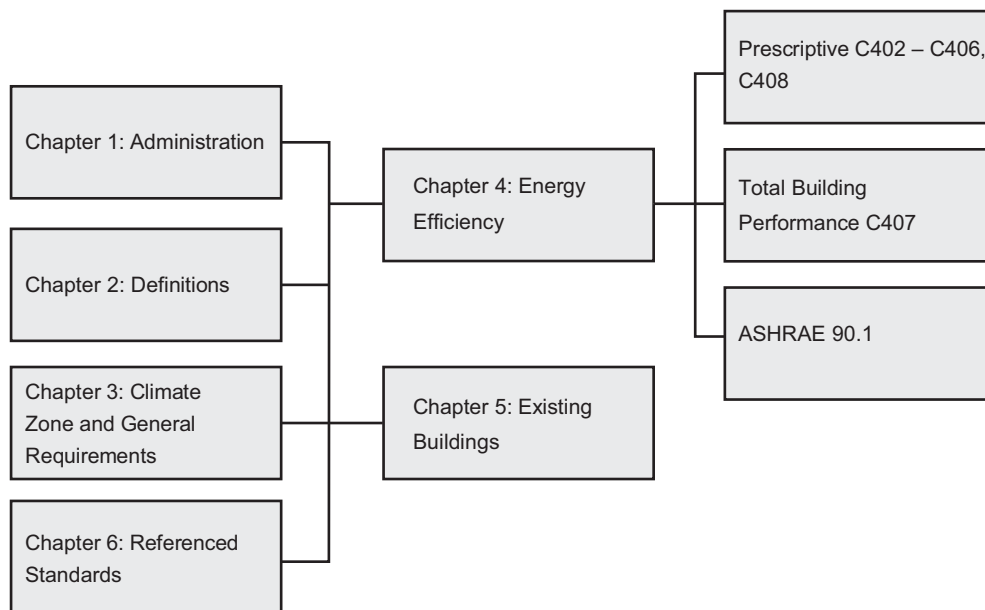
- Which compliance options are available for demonstrating compliance with the IECC for commercial buildings? When should one be utilized instead of the other for the building envelope?
- Which parts of the building envelope are covered under Chapter 4 [CE]?
- What types of buildings are exempt from the thermal envelope requirements of the code?
- Can higher levels of efficiency be traded off from one part of the building for lower levels in another part of the building?
- What two parameters must be determined before the thermal requirements for the building envelope can be selected?
- What are the different wall types addressed in Chapter 4 [CE]?
- Where can roof insulation be installed to meet the envelope requirements? What are the requirements for metal roof systems?
- How does the IECC apply to metal wall systems?
- Which options are available for insulated framed wall systems? Which options are available for insulated concrete or concrete masonry unit wall systems?
- What are the solar reflectance and thermal emittance requirements for low-sloped roofs?
- How should slab edge insulation be installed to meet the code requirements? Below grade walls?

Code Text: *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 without systems serving multiple units shall be deemed to be in compliance with this chapter, provided that they comply with Section R406; (2) Total Building Performance. The Total 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.*

Discussion and Commentary: Compliance for a commercial building is demonstrated by using Chapter 4 [CE] in one of two ways—following the prescribed measures of C402–406 and C408, or using the Total Building Performance compliance option of Section C407. As an alternative to Chapter 4 [CE], ANSI/ASHRAE/IES Standard 90.1 can be used to demonstrate compliance with the IECC.



Sections C402 through C406 are prescriptive in nature. As such, there are no trade-offs between the envelope, lighting, service water and mechanical systems. The Total Building Performance compliance option, however, considers heating systems, cooling systems, service water heating, fan systems, lighting power, receptacle loads and process loads when determining compliance with the IECC. The project may comply by using one of the IECC compliance options or ASHRAE 90.1, but not a combination of both.

Code Text: *A permanent thermal envelope certificate shall be completed by an approved party. Such certificate shall be posted on a wall in the space where the space conditioning equipment is located, a utility room or other approved location. If located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. A copy of the certificate shall also be included in the construction files for the project. The certificate shall include the following: (1) R-values of insulation installed in or on ceilings, roofs, walls, foundations and slabs, basement walls, crawl space walls and floors and ducts outside conditioned spaces; (2) U-factors and solar heat gain coefficients (SHGC) of fenestrations; (3) Results from any building envelope air leakage testing performed on the building. Where there is more than one value for any component of the building envelope, the certificate shall indicate the area-weighted average value where available. If the area-weighted average is not available, the certificate shall list each value that applies to 10 percent or more of the total component area.*

Discussion and Commentary: A permanent certificate is required for commercial buildings that captures basic information related to the building's thermal envelope. This complements the information required in Section C408 related to the documentation of mechanical and lighting systems. The certificate requirement is simplified to cover only the basic elements of the thermal envelope, similar to the requirement for residential buildings in Section R401.3.

The information contained in this certificate, while readily available at construction, is often lost as the building ages and ownership is transferred. As future owners or lessors undertake load calculations for HVAC sizing or other measures that require a working knowledge of the building's thermal envelope characteristics, this information will be important.

Energy Efficiency Certificate			
Code edition			
Compliance path			
Insulation Rating		R-Value	R-Value
Ceiling/Roof		R-	R-
Walls	Frame	R-	Mass
	Basement	R-	Crawl space
Floors	Over unconditioned space	R-	Slab edge
Ducts	Attic	R-	Other
Air Leakage Test Results			
Envelope testing	ACH	Pa.	Duct testing
			cfm/100 ft ²
Fenestration Rating		NFRC U-Factor	NFRC SHGC
Window	U-		
Opaque door	U-		
Skylight	U-		
Weighted average	U-		
Designer/builder		Date	
This Certificate is to be posted in accordance with Section C401.3 of the International Energy Conservation Code.			

Recording the information in a permanent manner at an approved location in the building, as well as including documentation in the construction files for the project, provides the needed information for future alterations and additions to the building.

Code Text: *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 either the R-value-based method of Section C402.1.3; the U-, C- and F-factor-based method of Section C402.1.4; or the component performance alternative of Section C402.1.5; (2) Roof solar reflectance and thermal emittance shall comply with Section C402.3; (3) Fenestration in building envelope assemblies shall comply with Section C402.4; (4) Air leakage of building envelope assemblies shall comply with Section C402.5.*

Alternatively, where buildings have a vertical fenestration area or skylight area exceeding that allowed in Section C402.4, the building and building thermal envelope shall comply with Item 2 of Section C401.2.1 or Section C401.2.2.

Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.11.

Discussion and Commentary:

The opaque envelope provisions contain specific requirements addressing two types of buildings: (1) those buildings housing Group R occupancies defined as commercial buildings by Chapter 2 and (2) all other commercial buildings. Typically, the insulation requirements for Group R occupancies defined as *commercial* are more stringent than for other commercial buildings so as to be more consistent with the insulation requirements for Group R buildings defined as *residential*.

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

CLIMATE ZONE	0 AND 1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings ^b	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + 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-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-60	R-60	R-60	R-60
Walls, above grade																
Mass ^c	R-5.7ci ^d	R-5.7ci ^d	R-5.7ci ^d	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci	R-25ci
Metal building	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-14ci	R-13 + R-17ci	R-13 + R-19.5ci	R-13 + R-19.5ci	R-13 + R-19.5ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-10ci	R-13 + R-10ci	R-13 + R-12.5ci	R-13 + R-12.5ci	R-13 + R-12.5ci	R-13 + R-15.6ci	R-13 + R-18.8ci	R-13 + R-18.8ci	R-13 + R-18.8ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-18.8ci	R-13 + R-18.8ci
Walls, below grade																
Below-grade wall ^e	NR	NR	NR	NR	NR	NR	R-7.5ci	R-10ci	R-7.5ci	R-10ci	R-10ci	R-15ci	R-15ci	R-15ci	R-15ci	R-15ci
Floors																
Mass ^c	NR	NR	R-6.3ci	R-8.3ci	R-10ci	R-10ci	R-14.6ci	R-16.7ci	R-14.6ci	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-38	R-38	R-38	R-38	R-38	R-38
Slab-on-grade floors																
Unheated slabs	NR	NR	NR	NR	NR	R-10 for 24" below	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 24" below	R-20 for 24" below	R-20 for 24" below	R-20 for 24" below	R-25 for 48" below
Heated slabs ^f	R-7.5 for 12" below+ R-5 full slab	R-7.5 for 12" below+ R-5 full slab	R-7.5 for 12" below+ R-5 full slab	R-7.5 for 12" below+ R-5 full slab	R-10 for 24" below+ R-5 full slab	R-10 for 24" below+ R-5 full slab	R-15 for 24" below+ R-5 full slab	R-15 for 24" below+ R-5 full slab	R-15 for 24" below+ R-5 full slab	R-15 for 24" below+ R-5 full slab	R-20 for 24" below+ R-5 full slab	R-20 for 24" below+ R-5 full slab	R-20 for 24" below+ R-5 full slab	R-20 for 24" below+ R-5 full slab	R-20 for 24" below+ R-5 full slab	R-25 for 48" below+ R-5 full slab

The differences in insulation requirements for metal-framed, wood framed and mass walls reflect the variation on heat transfer in different materials. For example, in Climate Zone 3, metal wall systems must be provided with continuous insulation in addition to the required insulation installed between the framing members. A wood-framed wall in the same climate zone is only required to have insulation installed between the framing members, depending on the dimensions of the framing.

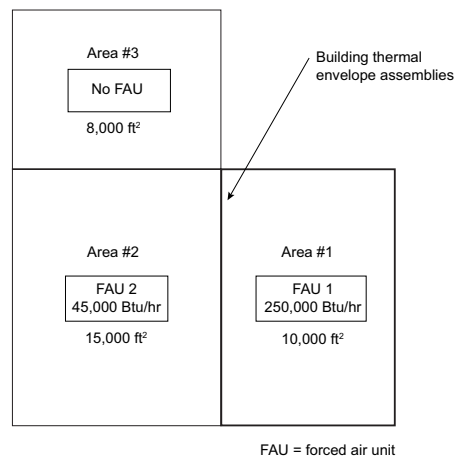
Code Text: *The following low-energy buildings, or portions thereof, separated from the remainder of the building by building thermal envelope assemblies complying with this section shall be exempt from the building thermal envelope provisions of Section C402: (1) Those with a peak design rate of energy usage less than 3.4 Btu/h • ft² (10.7 W/m²) or 1.0 watt/ft² (10.7 W/m²) of floor area for space conditioning purposes, (2) Those that do not contain conditioned space.*

*Greenhouse structures or areas that are mechanically heated or cooled and that comply with all of the following shall be exempt from the building envelope requirements of this code: (1) Exterior opaque envelope assemblies comply with Sections C402.2 and C402.4.5. **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, C402.4.3 and C402.4.5; (3) Fenestration assemblies that comply with the 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. **Exception:** Unconditioned greenhouses.*

**Discussion and
Commentary:**

The IECC has an allowance for buildings that are minimally conditioned. These are buildings that have an output capacity of less than 3.4 Btu/h • ft² for space conditioning systems. Buildings that fall under this category are exempt from the building thermal envelope requirements but must still comply with the lighting, mechanical and service water heating requirements contained in the IECC. In addition, buildings or spaces within the building that do not contain a heating or cooling system are exempt from the envelope requirements.

The exceptions to residential Section R402.1 also exempt low-energy buildings and log homes designed to ICC 400.



Area #1 of the commercial building shown must comply with the envelope requirements contained in Chapter 4 [CE] of the IECC because the output capacity of the equipment is greater than 3.4 Btu/h • ft². Area #2 of the building is exempt from the envelope requirements because the capacity of the equipment is less than 3.4 Btu/h • ft². Area #3 has no heating or cooling system and is exempt from the envelope requirements. Areas #1 and #2 must be separated from each other by meeting the building thermal envelope provisions of the code with vertical assemblies.

Code Text: *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 (110 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 (17,000 Btu/hr) (5 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 0.200 in Climate Zones 1 through 5 and less than 0.120 in Climate Zones 6 through 8, (5) Comply with the roof solar reflectance and thermal emittance provisions for Climate Zone 1.*

Discussion and Commentary: Unlike many provisions of the IECC written with a focus on buildings that are conditioned, this provision addresses buildings that exist primarily to shelter equipment from the weather. The spaces are primarily cooled due to the heat generated by the equipment, and depending on the location, less insulation may be desirable from an annual energy use standpoint.



While exempt from the thermal envelope requirements, equipment buildings are required to follow roof solar reflectance and thermal emittance provisions for Climate Zone 1.