Study Session

3

2018 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), 2018 *International Energy Conservation Code*

KEY POINTS:

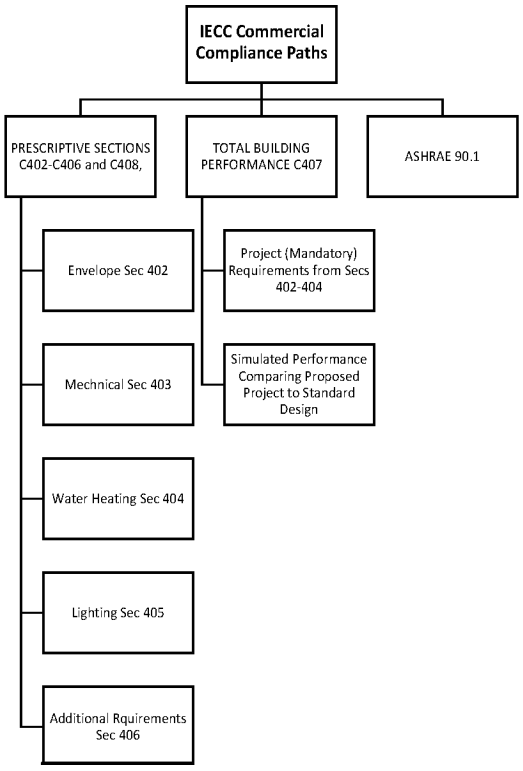
- Which compliance options are available for demonstrating compliance with the IECC for commercial buildings? When should one be utilized instead of the other for the building envelope?
- Which parts of the building envelope are covered under Chapter 4 [CE]?
- What types of buildings are exempt from 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?
- Which options are available when the design includes more than 3 percent of the roof area in skylights?
- How should slab edge insulation be installed to meet the code requirements? Below grade walls?

Topic: Application | **Category:** Commercial Energy Efficiency
Reference: IECC C401.2 | **Subject:** General

Code Text: *Commercial buildings shall comply with one of the following:*

1. *The requirements of ANSI/ASHRAE/IESNA 90.1.*
2. *The requirements of Sections C402 through C405 and C408. In addition, commercial buildings shall comply with Section C406 and tenant spaces shall comply with Section C406.1.1.*
3. *The requirements of Sections C402.5, C403.2, C403.3 through C403.3.2, C403.4 through C403.4.2.3, C403.5.5, C403.7, C403.8.1 through C403.8.4, C403.10.1 through C403.10.3, C403.11, C403.12, C404, C405, C407 and C408. The building energy cost shall be equal to or less than 85 percent of the standard reference design building.*

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 C401–406 and C408, without trade-offs between envelope, lighting, service water or mechanical, or modeling energy cost of the building through a simulated performance approach. As an alternative to Chapter 4 [CE], ASHRAE/IESNA Standard 90.1 can be used to demonstrate compliance with the IECC. ASHRAE/IESNA 90.1 is also to be used when the building system is not covered under Chapter 4 [CE].



Sections C402 through C406 are prescriptive in nature. Because of this, there are no trade-offs between the envelope, lighting, service water and mechanical systems. The project may be made to comply by using either IECC Chapter 4 [CE] or ASHRAE 90.1, but not a combination of both. Typically, if ASHRAE Standard 90.1 is selected for the building's compliance it will be selected because the proposed system falls out of the scope of IECC Chapter 4 [CE]. IECC Section C407 allows trade-offs between levels of efficiency in the building envelope, mechanical and lighting systems.

Topic: General | **Category:** Commercial Energy Efficiency

Reference: IECC C402.1 | **Subject:** Building Envelope Compliance

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 2 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 C402.1.3; 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 Section C401.2, Item 1 or Section C401.2, Item 3.

Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.10.1 or C403.10.2.

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[a, i]

CLIMATE ZONE	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 + R11 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-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	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-49
Walls, above grade																
Mass[g]	R-5.7ci[c]	R-5.7ci[c]	R-5.7ci[c]	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-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building	R-13+ R-6.5ci	R-13 + R-6.5ci	R13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13+ R-19.5ci	R-13 + R-13ci	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-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13 + R-7.5ci	R-13+ R17.5ci
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-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	R13 + R-15.6ci or R-20 + R-10ci	R13 + R-15.6ci or R-20 + R-10ci
Walls, below grade																
Below-grade wall[d]	NR	NR	NR	NR	NR	NR	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-10ci	R-10ci	R-10ci	R-12.5ci

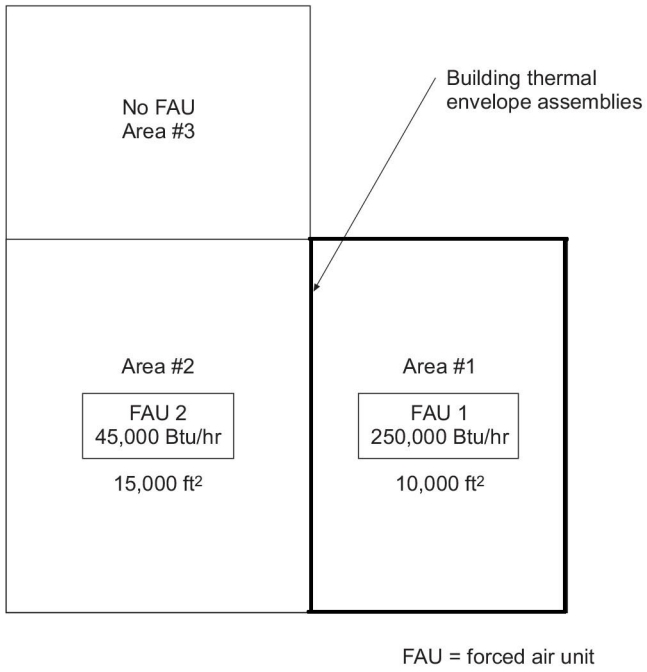
The differences in insulation requirements for metal-framed, wood framed and mass walls reflect the variation on heat transfer in different materials. For example, in Climate Zone 3, metal wall systems must be provided with continuous insulation in addition to the required insulation installed between 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.

Topic: Low-Energy Buildings **Category:** Commercial and Residential Energy Efficiency
Reference: IECC C402.1.1, R402.1 **Subject:** Building Envelope

Code Text: *The following low-energy buildings, or portions thereof, separated from the remainder of the building by building thermal envelope assemblies complying with the* IECC *shall be exempt from the building thermal envelope provisions of the* IECC*:*

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/ft^2 (10.7 W/m^2) of floor area for space conditioning purposes.*
2. *Those that do not contain conditioned space.*
3. *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 • ft^2 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 exception to residential Section R402.1 also exempts 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 • ft^2. Area #2 of the building is exempt from the envelope requirements because the capacity of the equipment is less than 3.4 Btu/h • ft^2. 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.

Topic: Equipment Buildings | **Category:** Commercial Energy Efficiency
Reference: IECC C402.1.2 | **Subject:** Building Envelope Requirements

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 500 square feet (50 m^2).*
2. *Are intended to house electronic 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 (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, in Climate Zone 1 the buildings are required to follow roof solar reflectance and thermal emittance provisions.

Topic: Cold-Formed Steel Walls | **Category:** Commercial Energy Efficiency
Reference: IECC C402.1.4.1 | **Subject:** Building Envelope Requirements

Code Text: U-*factors of walls with cold-formed steel studs shall be permitted to be determined in accordance with Equation 4-1:*

$U = 1/[R_s + (ER)]$ ***(Equation 4-1)***

where:

R_s = *The cumulative* R-*value of the wall components along the path of heat transfer, excluding the cavity insulation and steel studs.*

ER = *The effective* R-*value of the cavity insulation with steel studs as specified in Table C402.1.4.1.*

Discussion and Commentary: The intent of the code is not to favor one building material over another, so Section C402.1.4.1 provides the code user and building official an accepted calculation method for determining the effective *R*-values for steel stud wall assemblies in the body of the code for use in the Assembly *U*-factor building envelope compliance method of Section C402.1.4.

TABLE C402.1.4.1
EFFECTIVE *R*-VALUES FOR STEEL STUD WALL ASSEMBLIES

NOMINAL STUD DEPTH (inches)	SPACING OF FRAMING (inches)	CAVITY *R*-VALUE (insulation)	CORRECTION FACTOR (F_c)	EFFECTIVE *R*-VALUE (ER) (Cavity *R*-Value × F_c)
$3^1/_2$	16	13	0.46	5.98
		15	0.43	6.45
$3^1/_2$	24	13	0.55	7.15
		15	0.52	7.80
6	16	19	0.37	7.03
		21	0.35	7.35
6	24	19	0.45	8.55
		21	0.43	9.03
8	16	25	0.31	7.75
	24	25	0.38	9.50

Table C402.1.4.1 provides the effective *R*-value (ER) for use in Equation 4-1 based on the depth and spacing of the steel studs and the *R*-value of the cavity insulation.

Topic: Component Performance Alternative **Category:** Commercial and Residential Energy Efficiency
Reference: IECC C402.1.5, R402.1.5 **Subject:** Building Envelope Requirements

Code Text: *Building envelope values and fenestration areas determined in accordance with Equation 4-2 shall be an alternative to compliance with the* U-*,* F- *and* C-*factors in Tables C402.1.4 and C402.4 and the maximum allowable fenestration areas in Section C402.4.1. Fenestration shall meet the applicable SHGC requirements of Section C402.4.3.*

$A + B + C + D + E \leq Zero$ ***(Equation 4-2)***

See the code text in the box below for a description of A, B, C, D and E.

Discussion and Commentary: The Component Performance Alternative allows various envelope components to be traded off against each other, provided that the overall calculated building heat loss of the proposed design is no greater than a code-compliant design. The idea is the same as the Total UA Alternative approach allowed as a residential compliance path in Section R402.1.5 but accounts for slab-edge *F*-factors, basement wall *C*-values and fenestration areas in excess of the prescriptive code limits. This optional building envelope compliance path provides significant flexibility, allowing the trade-off of the *U*-factors of various building envelope components without having to do a full Total Building Performance computation.

$A + B + C + D + E \leq Zero$ **(Equation 4-2)**

Where each factor represents the difference between the proposed design and a prescriptive design for:

A. The sum of the *U*-factor for each envelope assembly times its area.
B. The sum of the *F*-factor for each slab edge assembly times its length.
C. The sum of the *C*-value for each basement wall assembly times its area.
D. The additional amount for vertical glazing area in excess of maximum. *(Substitutes the average wall* U-*factor for the average vertical glazing* U-*factor in the prescriptive case for the excess vertical glazing area.)*
E. The additional amount for skylight area in excess of code maximum. *(Substitutes the average roof* U-*factor for the average skylight* U-*factor in the prescriptive case for the excess skylight area.)*

The component performance alternative may allow greater window area than the maximum allowed in the prescriptive approach. One example is the exchange for a roof insulation level that exceeds the prescriptive code minimums.

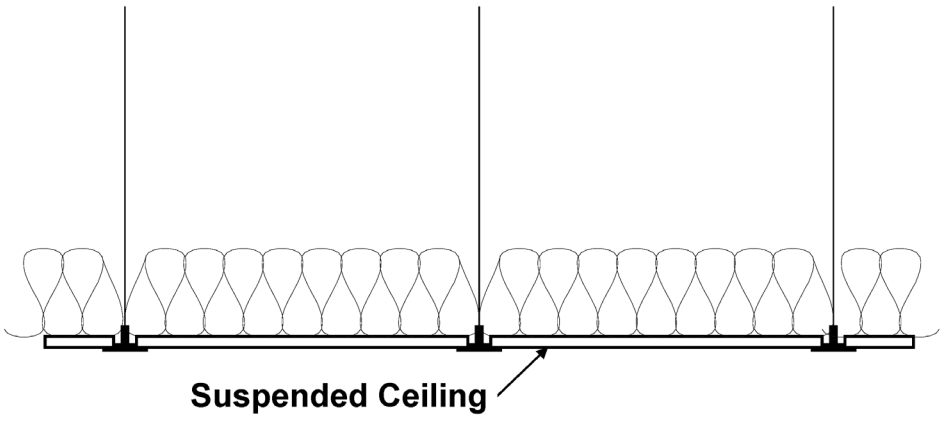
Topic: Roof Assembly | **Category:** Commercial Energy Efficiency
Reference: IECC C402.2.1 | **Subject:** Building Envelope Requirements

Code Text: *The minimum thermal resistance (*R*-value) of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as specified in Table C402.1.3 based on construction materials used in the roof assembly. Insulation installed on a suspended ceiling having removable ceiling tiles shall not be considered as part of the minimum thermal resistance of the roof insulation. Continuous insulation board shall be installed in not less than 2 layers and the edge joints between each layer of insulation shall be staggered.*

Exceptions:

1. *Continuously insulated roof assemblies, where the thickness of insulation varies 1 inch (25 mm) or less and where the area-weighted* U*-factor is equivalent to the same assembly with the* R*-value specified in Table C402.1.3.*
2. *Where tapered insulation is used with insulation entirely above deck, the* R*-value where the insulation thickness varies 1 inch (25 mm) or less from the minimum thickness of tapered insulation shall comply with the* R*-value specified in Table C402.1.3.*
3. *Two layers of insulation are not required where insulation tapers to the roof deck, such as at roof drains.*

Discussion and Commentary: The insulation requirements for a roof/ceiling assembly will vary depending on how the roof is constructed and where the insulation is placed. Three different roof assemblies are addressed in Table C402.1.3. Based on the roof type, insulation is required to be placed between framing or be continuous. For example, in most climate zones a vented attic space will be required to have a minimum R-38 insulation installed between framing.



Insulation installed on top of a suspended ceiling system cannot contribute toward the ceiling insulation requirement. Insulation must be installed at the same location as the air barrier. A suspended ceiling cannot be considered an air barrier, unless each ceiling tile is individually sealed.