

Commercial Energy Standards and Codes Building Thermal Envelope Provisions in ASHRAE 90.1-2013/2015 IECC

PAM COLE, PNNL
DAVE CONOVER, PNNL

Building Energy Codes Program

AIA Provider #: I014

Course # CED2015

August 12, 2015



Building Thermal Envelope Provisions in ASHRAE 90.1-2013/2015 IECC



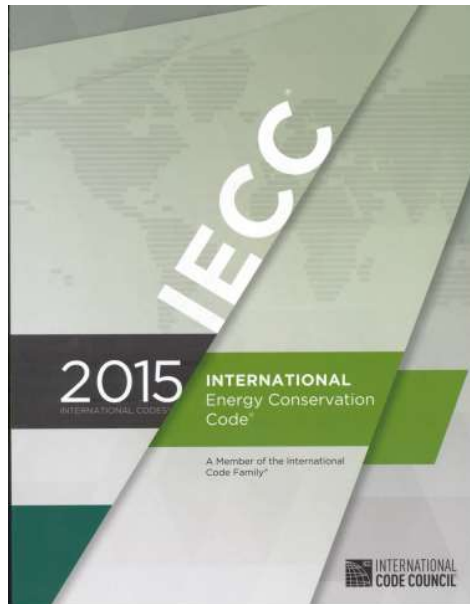
This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to constitute approval, sponsorship or endorsement by the AIA of any method, product, service, enterprise or organization. The statements expressed by speakers, panelists, and other participants reflect their own views and do not necessarily reflect the views or positions of The American Institute of Architects or of AIA components, or those of their respective officers, directors, members, employees, or other organizations, groups or individuals associated with them. Questions related to specific products and services may be addressed at the conclusion of this presentation.

Commercial Energy Standards and Codes Building Thermal Envelope Provisions in ASHRAE 90.1-2013/2015 IECC

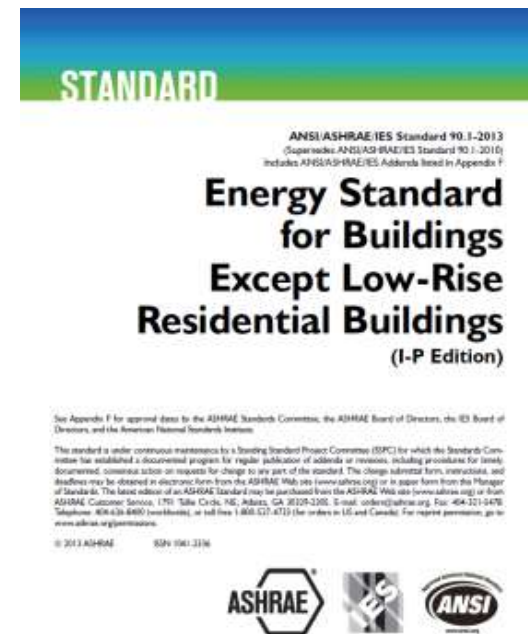
Learning Objectives

1. Understand the different compliance paths and methods that apply to the building thermal envelope of commercial buildings.
2. Learn the differences between new construction, additions, alterations, and repairs.
3. Become familiar with the mandatory requirements for the building thermal envelope.
4. Learn the differences between 90.1-2013 and 2015 IECC building thermal envelope provisions.

What is covered in the scope of the documents?



2015 IECC



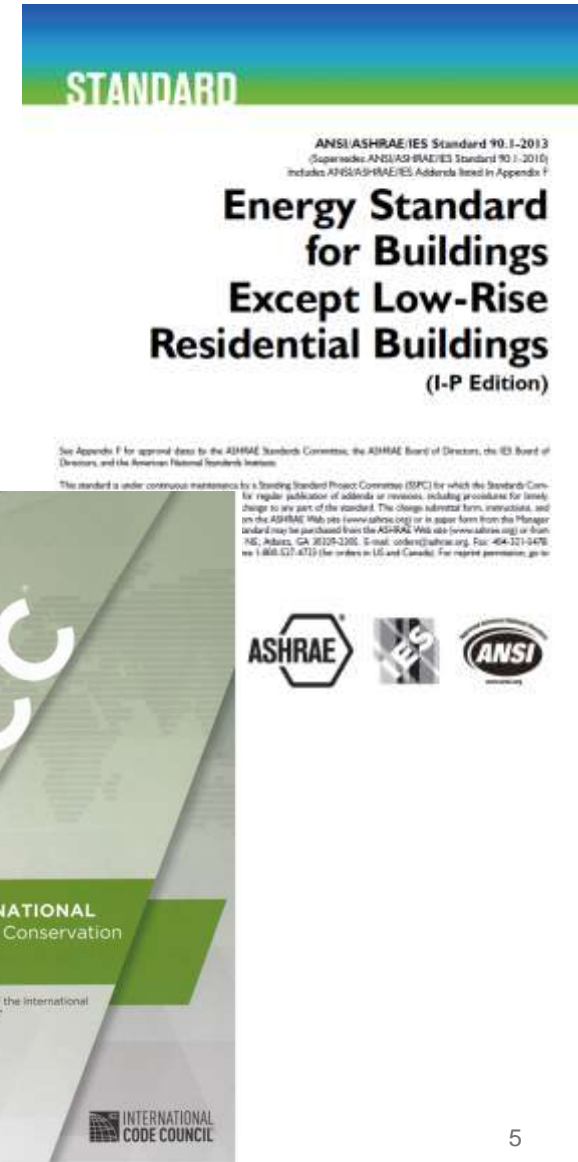
ANSI/ASHRAE/IES 90.1-2013

Scope



Proudly Operated by Battelle Since 1965

- New buildings and their systems
- New portions of existing buildings and their systems
- New systems and equipment in existing buildings
- Alterations, renovations and repairs of existing buildings, including replacement of portions of buildings
- Conversion of spaces that change space conditioning (90.1)/cause a non-conditioned space to become conditioned (IECC)
- Changes in occupancy or use that cause an increase in demand for energy (IECC)/involving a change in equipment or systems (90.1)
- New equipment or building systems specifically identified in the standard that are part of industrial or manufacturing processes
- Does not apply to one and two family dwellings and multi-family residential buildings less than 3 stories in height above grade



Alterations – Exceptions to the Building Thermal Envelope Provisions



90.1-2013 – Section 5.1.3

- ✓ Installation of storm windows or glazing panels
- ✓ Replacement of glazing in existing sash and frame
- ✓ Alterations to envelope cavities provided they are insulated to full depth with a nominal R-3.0 per in.
- ✓ Wall and floor alterations where no new cavities are created
- ✓ Roof recovering
- ✓ Removal and replacement of roof membranes
- ✓ Replacement of existing doors
- ✓ Replacement of existing fenestration, provided area of replacement is no more than 25% of total fenestration area

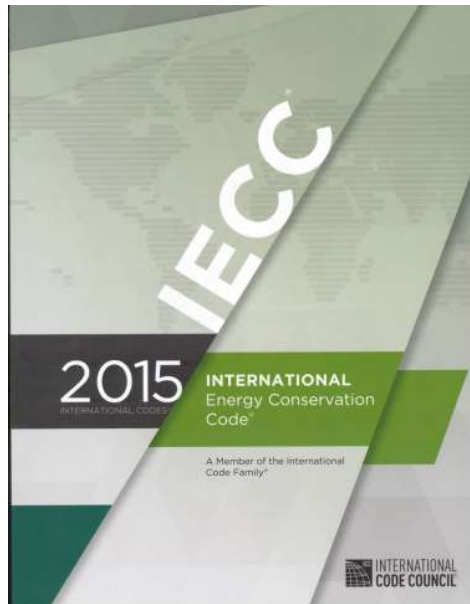
2015 IECC – C503

- ✓ Storm windows over existing fenestration
- ✓ Surface-applied window film installed on existing single pane
- ✓ Exposed, existing ceiling, wall or floor cavities if already filled with insulation
- ✓ Where existing roof, wall or floor cavity isn't exposed
- ✓ Roof recover
- ✓ Reroofing for roofs where neither sheathing nor insulation exposed

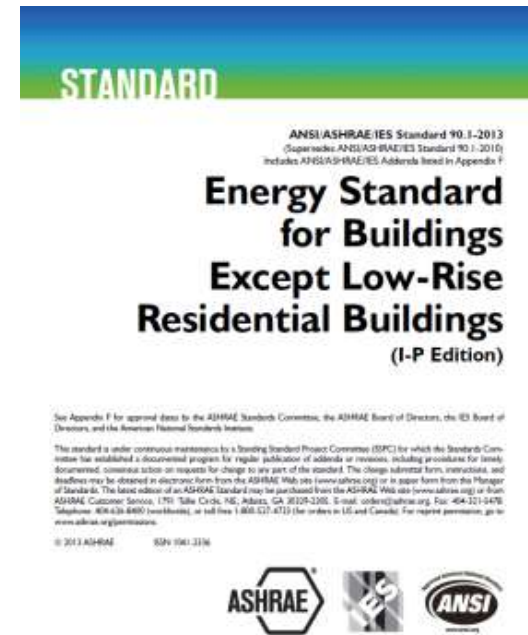
Insulate above or below the sheathing

- Roofs without insulation in the cavity
- Sheathing or insulation is exposed

What are the different paths to compliance?



2015 IECC



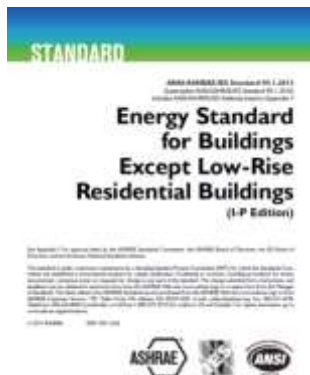
ANSI/ASHRAE/IES 90.1-2013

Options and Compliance Paths



1

ASHRAE 90.1-2013



OR

2

2015 IECC - Prescriptive

- C402 - Envelope
- C403 - Mechanical
- C404 - SWH
- C405 - Lighting
- C406 - Pick One

OR

3

2015 IECC - Performance

- C407 - Total Building Performance ****
- C402.5 - Air Leakage
- C403.2 - Provisions applicable to all mechanical systems

- C404 - SWH

- Lighting Mandatory Sections

C405.2

C405.3

C405.4

C405.6

**** Building energy cost to be $\leq 85\%$ of standard reference design building

90.1-13 - Prescriptive

OR

90.1-13 - Performance

C406.2 - Eff. HVAC Performance

C406.3 - Reduced Lighting Power Density

C406.4 - Enhanced Lighting Controls

C406.5 - On-site Supply of Renewable energy

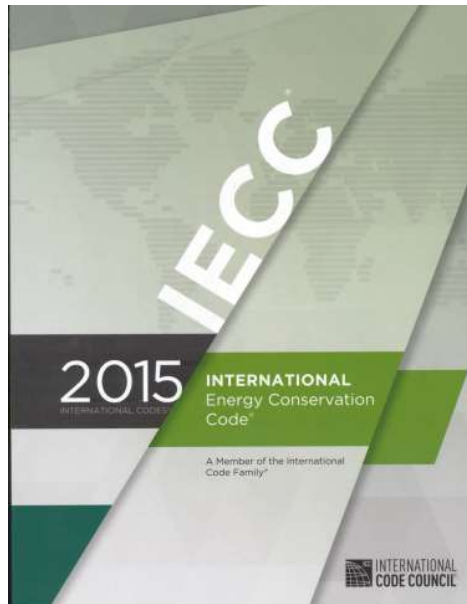
C406.6 - Dedicated Outdoor Air System

C406.7 - High Eff. Service Water Heating

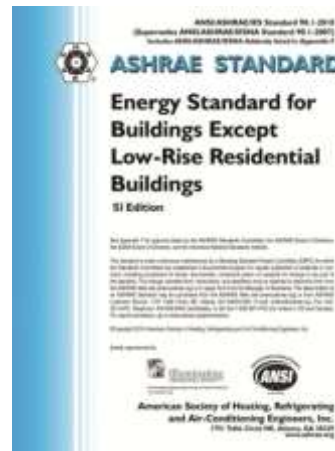
Can you summarize key envelope changes from the prior editions?



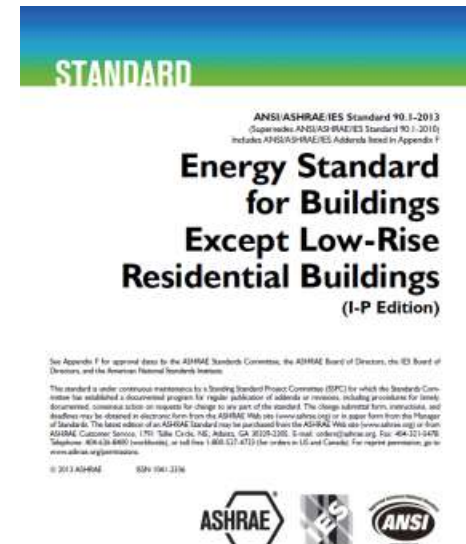
2012 IECC



2015 IECC



ANSI/ASHRAE/IES
90.1-2010



ANSI/ASHRAE/IES 90.1-2013

Highlights of 90.1-2013 Changes from 90.1-2010 – Building Thermal Envelope



- ▶ Changes references from clerestory to roof monitor (*Chapter 5*)
- ▶ Adds low-e requirements for storm window retrofits (5.1.3)
- ▶ Clarifies roof insulation requirements, differentiating between roof recovering (on top of existing roof covering) and replacement of roof covering (5.1.3)
- ▶ Relaxes air leakage requirements for high-speed doors for vehicle access and material transport (5.4.3.2)
- ▶ Adds specific vestibule requirements for large (40K sf+) spaces (5.4.3.4)
- ▶ Requires roof solar reflectance and thermal emittance testing to be in accordance with the CRRC-1 Standard (5.5.3.1)

Highlights of 90.1-2013 Changes from 90.1-2010 – Building Thermal Envelope



- ▶ Reduces the area threshold at which skylights and daylighting controls are required (5.5.4.2.2)
- ▶ Terms - Modifies daylighting definitions
- ▶ Fenestration criteria revised by adding consideration of orientation
- ▶ More stringent opaque and fenestration criteria
- ▶ Appendix C on envelope tradeoffs rewritten to use a simulation based approach

For more detail on differences between 90.1-10 and 90.1-13 and their impact on energy use see <https://www.energycodes.gov/regulations/determinations>



Highlights of 2015 IECC Changes from 2012 IECC – Building Thermal Envelope



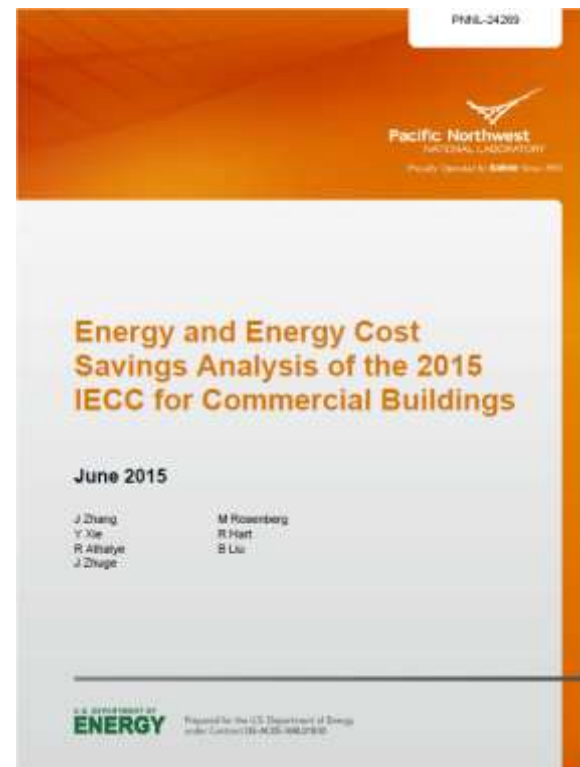
- ▶ More stringent thermal performance requirements for opaque assemblies and fenestration
- ▶ Fenestration criteria revised by adding consideration of orientation
- ▶ Requirements for complying prescriptively when $WWR > 30\%$ but less than 40% are changed. Controlled daylighted area
 - 50% of floor area in 2012 IECC
 - 50% of “net floor area” (NFA) for 1-2 story and 25% of NFA for taller buildings in 2015 IECC
- ▶ A new component performance alternative (UA-based trade-off)

Highlights of 2015 IECC Changes from 2012 IECC – Building Thermal Envelope



- ▶ Changed the 'trigger' at which a minimum area of the roof be skylights is required
 - From 10K sf to 2.5K sf; and added more space types to the scope
- ▶ Extended continuous air barrier to all climate zones except for 2B (hot/dry parts of TX, AZ and CA)
- ▶ Now allow doors with an air curtain to satisfy the vestibule requirements

For more detail on the changes in the IECC see https://www.energycodes.gov/sites/default/files/documents/2015_IECC_Commercial_Analysis.pdf.



Structure of 90.1-2013 and 2015 IECC Building Thermal Envelope Provisions



90.1-2013 Chapter 5

General (*Section 5.1*)

- Scope
- Space-Conditioning Categories
- Envelope Alterations
- Climate

Compliance Paths (*Section 5.2*)

Simplified Building (*Section 5.3*) *Not Used*

Mandatory Provisions (*Section 5.4*)

- Insulation
- Fenestration and Doors
- Air Leakage

Prescriptive Building Envelope Option (*Section 5.5*)

- Opaque Areas
- Fenestration

Building Envelope Trade-Off Option (*Section 5.6*)

Submittals (*Section 5.7*)

Product Information and Installation Requirements (*Section 5.8*)

2015 IECC Section C402

General (*Section C402.1*)

- Opaque, roof SR and TE, fenestration and air leakage
- Low-energy buildings
- Equipment buildings
- Insulation component R-value method
- Assembly U, C or F factor method
- Component performance method

Specific BTE insulation requirements (*Section C402.2*)

Roof SR and TE (*Section C402.3*)

Fenestration (*Section C402.4*)

Air leakage (*Section C402.5*)

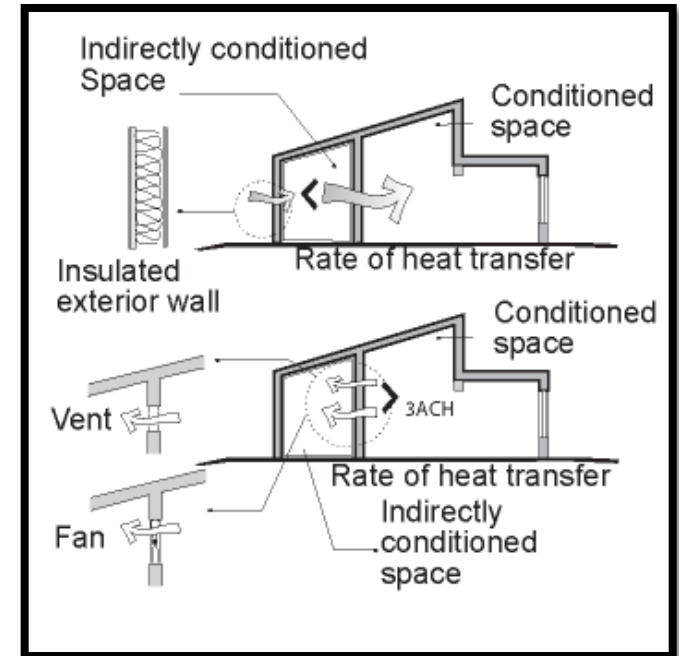
- Opaque Areas
- Fenestration

Space-conditioning Categories



Separate building thermal envelope component requirements apply to different types of conditioned spaces

- Nonresidential
- Residential (90.1) – spaces used primarily for living and sleeping
- Group R (IECC) – R1, R2, R3 and R4
- Semi heated (90.1) - spaces that are not cooled and are nominally heated



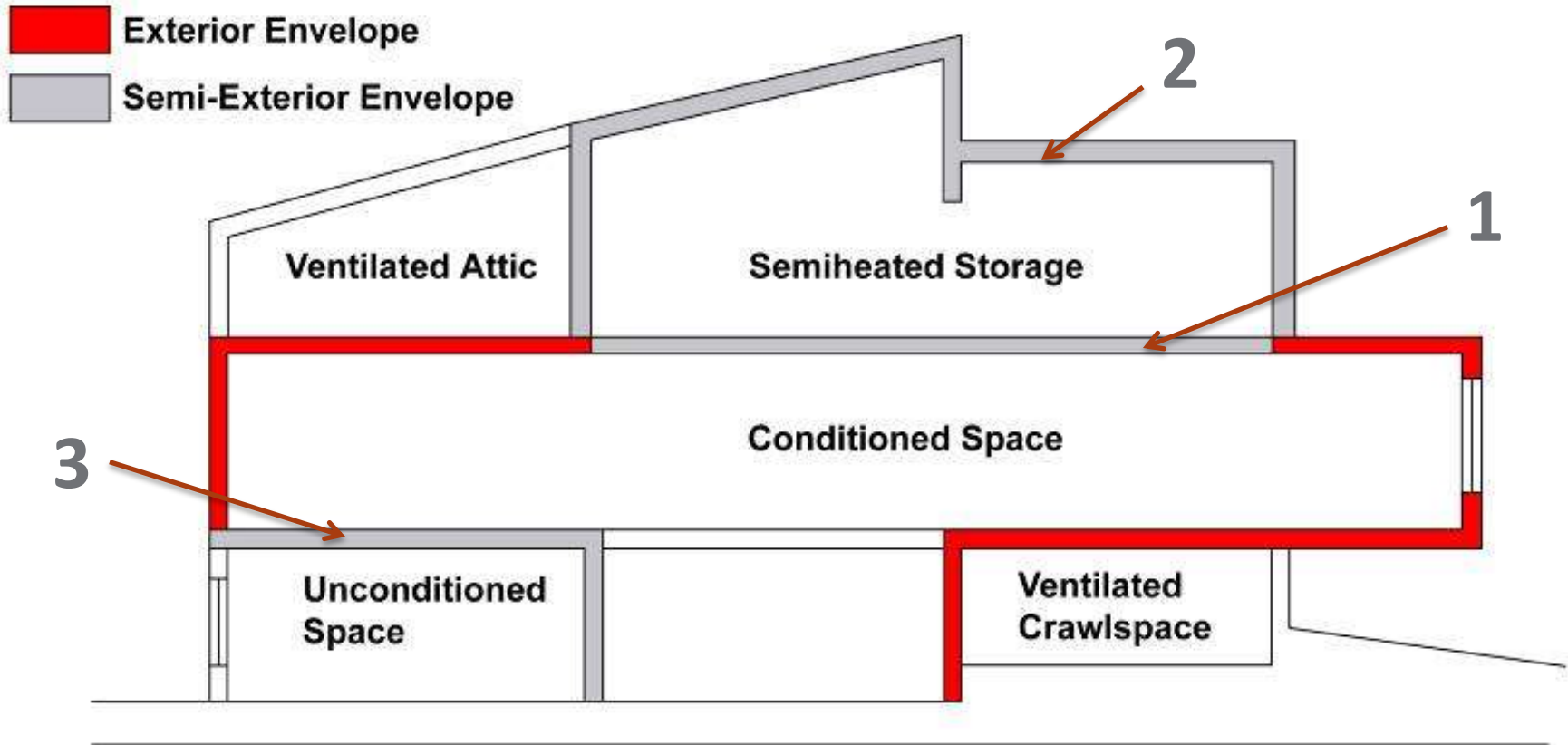
(User's Manual – 90.1.-2013)

Heating Output, Btu/h·ft ²	Climate Zone
5	1 and 2
10	3
15	4 and 5
20	6 and 7
25	8

Building Thermal Envelope - Defined



ASHRAE 90.1



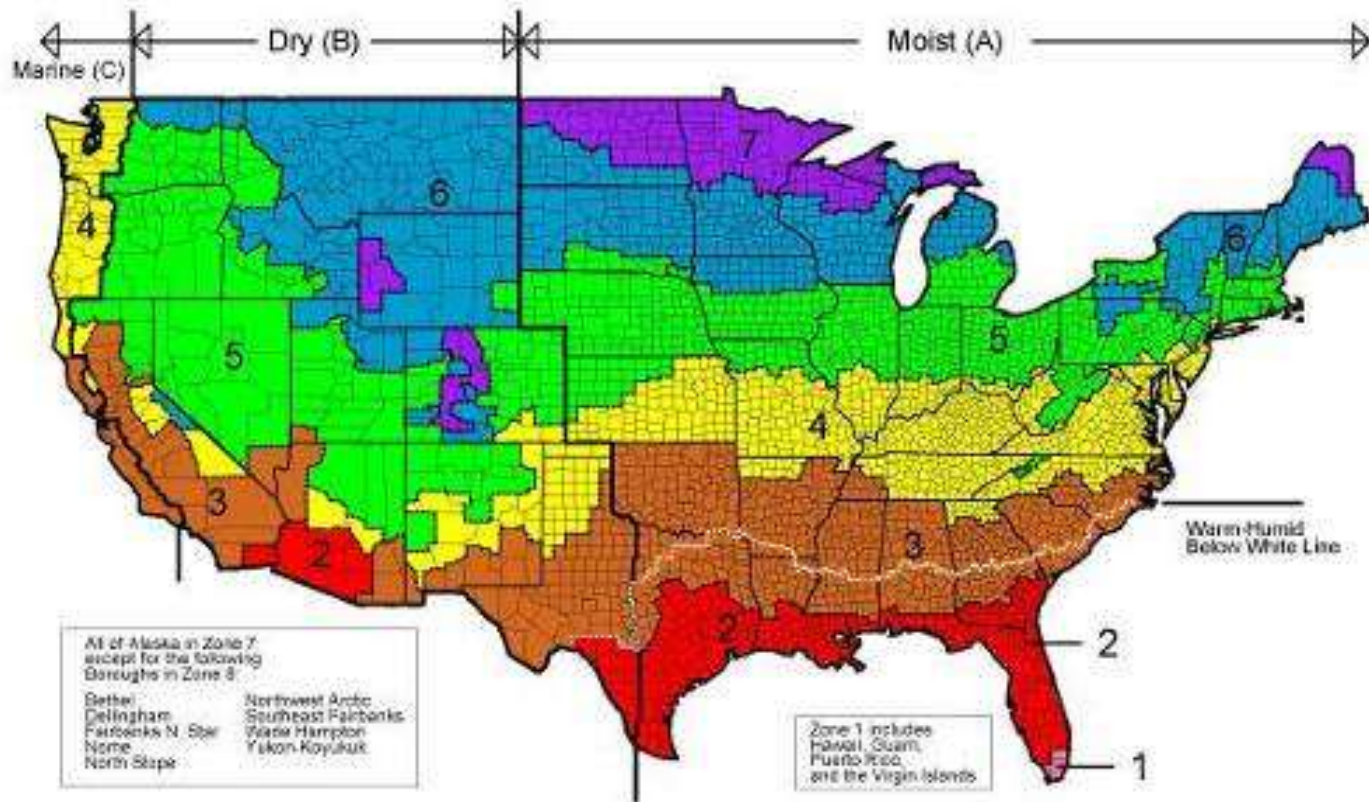
IECC

- Semi-heated = Conditioned
- Item 1 is NOT part of the building thermal envelope
- Items 2 and 3 ARE part of the building thermal exterior envelope

Building Location



- Where you are located determines the required thermal envelope criteria
- Locations listed in Appendix B (90.1) and C301 (IECC) on county-by-county basis for United States

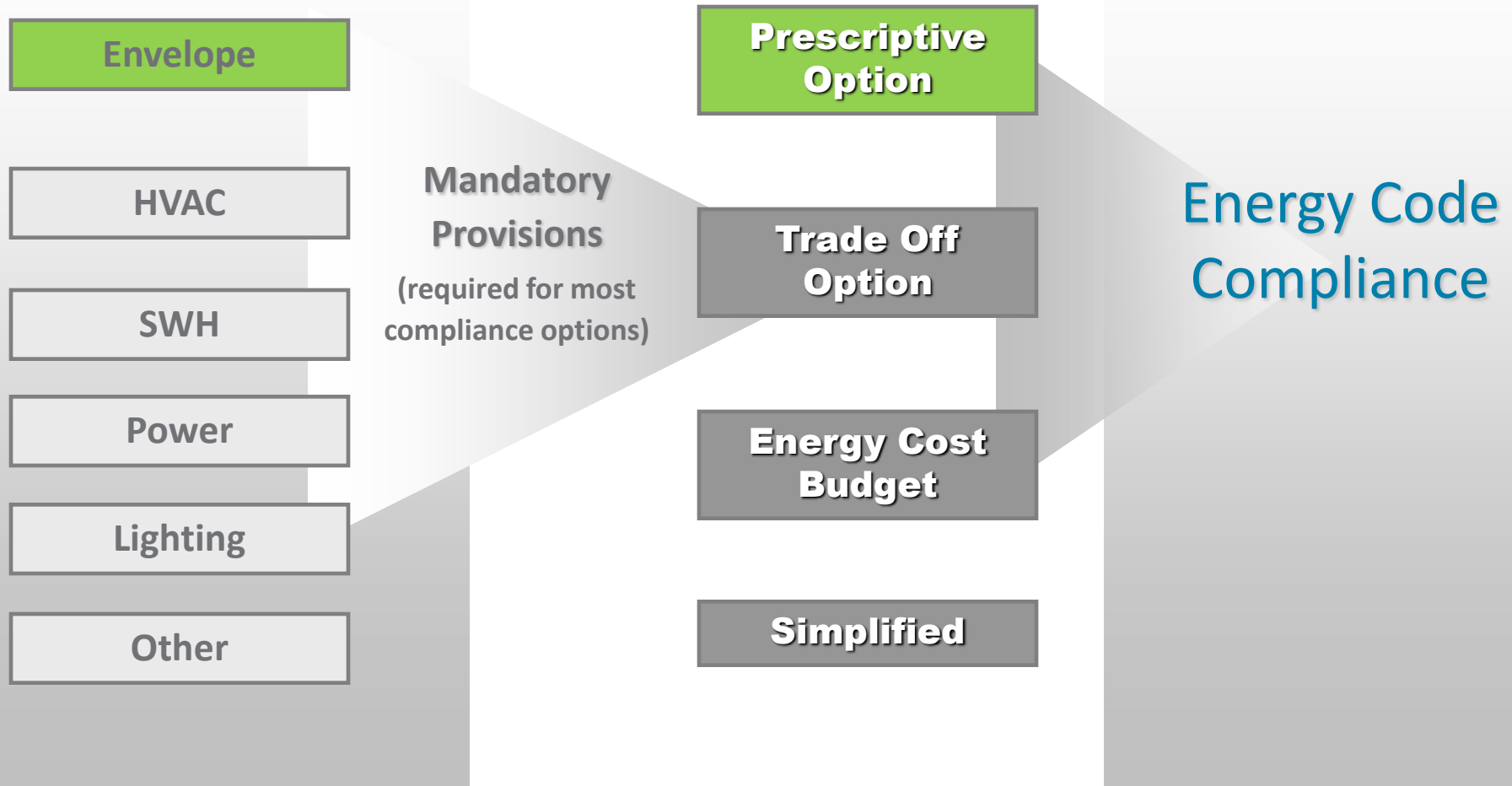


Compliance Approach - Prescriptive Building Thermal Envelope – 90.1 and IECC



Building System

Compliance Options



Compliance

- ✓ Meet or exceed minimum R-values in table
 - Only R-value of insulation, not to include air films, etc.

OR

- ✓ Meet maximum U-factor, C-factor, or F-factor for the entire assembly (typical construction assemblies described in Appendix A)

OR

- ✓ Perform area-weighted average U-factor, C-factor, or F-factor
 - Only if there are multiple assemblies within a single class of construction for a single space-conditioning category

Prescriptive requirements for each component specified by climate zone and space conditioning category (Tables 5.5-1 through 5.5-8)

- ▶ Insulation levels for roofs, walls, floors and doors
- ▶ Fenestration criteria for windows, glazed doors and skylights

3 Methods for compliance of building components:

- C402.1.3 – Insulation component R-value based method
- C402.1.4 – Assembly U-factor, C-factor or F-factor based method
- C402.1.5 – Component Performance Alternative
 - UA Calculation

Prescriptive requirements for each component specified by climate zone and space conditioning category (Tables C402.1.3, C402.1.4, and C402.4)

- Insulation levels for roofs, walls, floors and doors
- Fenestration criteria for windows, glazed doors and skylights

90.1-2013/2015 IECC similar language

Three types of roofs are defined

- ✓ Roofs with insulation entirely above deck
 - R-value is for continuous insulation
 - Interruptions for mechanical equipment $\leq 1\%$ of surface of the total roof area
- ✓ Metal building roofs
 - First value is for insulation
 - ◆ draped over purlins and then compressed when metal spanning members attached or
 - ◆ hung between purlins provided there's a min. of 1" thermal break between purlins and metal spanning members
 - Second value is for double-layer installations with insulation installed parallel to the purlins
- ✓ Attics and other roofs
 - R-value is for insulation installed both inside and outside the roof or entirely inside the roof cavity



Skylight curbs insulated to level of roofs with insulation entirely above deck or R-5, whichever is less

90.1-2013 - Section 5 – 5.5.1

Prescriptive – Roof Insulation, Climate Zone 4 Example



Opaque Elements	Nonresidential		Residential		Semi heated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.032	R-30 c.i.	U-0.032	R-30 c.i.	U-0.093	R-10 c.i.
Metal Building	U-0.037	R-19+R-11 Ls or R-25+R-8 Ls	U-0.037	R-19+R-11 Ls or R-25+R-8 Ls	U-0.082	R-19
Attic and Other	U-0.021	R-49	U-0.021	R-49	U-0.034	R-30

Using the Tables

- ID the building location and climate zone
- Choose the table corresponding to that climate zone
- Determine the type of building(s) and spaces involved (non-residential, residential and/or semi-heated)
- Determine relevant type(s) of opaque roof construction (insulation entirely above deck, metal building, attic and other)
- Choose relevant maximum assembly U-factor(s) or minimum insulation R-value(s) and apply in design

Table 5.5-4 Building Envelope Requirements for Climate Zone 4 (A,B,C)*

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
<i>Roofs:</i>						
Insulation Entirely above Deck	U-0.032	R-30 c.i.	U-0.032	R-30 c.i.	U-0.093	R-10 c.i.
Metal Building ^a	U-0.037	R-19 + R-11 Ls or R-25 + R-8 Ls	U-0.037	R-19 + R-11 Ls or R-25 + R-8 Ls	U-0.082	R-19
Attic and Other	U-0.021	R-49	U-0.021	R-49	U-0.034	R-30

Reference Table 5.5-4 on page 30 in 90.1-2013

2015 IECC – Table C402.1.3

Prescriptive Roof Example



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

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 ^{a,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-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-38	R-49	R-49	R-49	R-49	R-49	R-49
Walls, above grade																
Mass	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci	R-4.75ci

Climate Zone	1	2	3	4	5	6	7	8								
				Except Marine	And Marine 4											
Insulation entirely above 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 ^{a, 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-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

	12" below	12" below	12" below	12" below	24" below	24" below	24" below	24" below	24" below	36" below	36" below	36" below	48" below	24" below	48" below	48" below	48" below
Opaque doors																	
Nonswinging	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75

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. Assembly descriptions can be found in ANSI/ASHRAE/IESNA 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 C402.1.4.

c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C 90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less 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 exterior insulation requirements for heated slabs.

e. "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.

f. Steel floor joist systems shall be insulated to R-38.

**Second column is always
Group R and first column is
always Other than Group R**

High Albedo Roofs



90.1-2013

Required in climate zones 1-3

Minimum three-year aged solar reflectance of 0.55 and minimum three-year aged thermal emittance of 0.75 (tested in accordance with CRRC-1 Standard)

OR

Minimum Solar Reflectance Index of 64, based on

- ▶ Three-year aged solar reflectance
- ▶ Three-year aged thermal emittance
 - Tested in accordance with CRRC-1 Standard

OR

Increase roof insulation levels in Table 5.5.3.1.1

2015 IECC

Required in Climate Zones 1-3 for low-sloped roofs (less than 2 units vertical in 12 horizontal), directly above cooled conditioned spaces

Comply with one or more options:

1) Minimum three-year aged solar reflectance of 0.55 and minimum three-year aged thermal emittance of 0.75

OR

2) Three-year aged solar reflectance index of 64

Where aged solar reflectance required by Section C402.3 is not available, it should be determined with Equation 4-3

$$R_{\text{aged}} = [0.2 + 0.7(R_{\text{initial}} - 0.2)]$$

Roofs	Nonresidential		Residential	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Insulation entirely above deck	U-0.030	R-33	U-0.029	R-34
Metal buildings	U-0.028	R-35		



High Albedo Roofs - Exceptions



90.1-2013

- ▶ Ballasted roofs with minimum stone ballast of 17 lb/ft² or 23 lb/ft² pavers
- ▶ Vegetated roof systems containing minimum thickness of 2.5 in. of growing medium that covers minimum of 75% of roof area with durable plantings
- ▶ Roofs, where a minimum of 75% of the roof area is:
 1. shaded during peak sun angle on June 21 by permanent components or features of the building
 2. covered by off-set PV arrays, building-integrated PV arrays, or solar air or water collectors **OR**
 3. permitted to be interpolated using a combination of 1 and 2 above
- ▶ Steep-sloped roofs
- ▶ Low-sloped metal building roofs in **climate zones 2-3**
- ▶ Roofs over: ventilated attics, semi heated spaces, or conditioned spaces that aren't cooled spaces
- ▶ Asphaltic membranes in **climate zones 2-3**

2015 IECC

- ▶ Portions of roofs that include or are covered by:
 - PV systems or components
 - Solar air or water heating systems or components
 - Roof gardens or landscaped roofs
 - Above-roof decks or walkways
 - Skylights
 - HVAC systems, components, and other opaque objects mounted above the roof
- ▶ Portions of roofs shaded during peak sun angle on June 21 by permanent features of the building or permanent features of adjacent buildings
- ▶ Ballasted roofs with minimum stone ballast of 17 lbs/ft² or 23 lbs/ft² pavers
- ▶ Roofs, where a minimum of 75% of the roof area meets one or more of the above exceptions

Above-Grade Wall Insulation

Four types of walls are defined:

- Mass
- Metal building wall R-value
 - for insulation compressed between metal wall panels and the steel structure
- Steel-framed wall R-value
 - for uncompressed insulation installed in the cavity between steel studs; also acceptable to be continuous insulation uninterrupted by studs
- Wood-framed and other R-value
 - for uncompressed insulation installed in the cavity between wood studs; also acceptable to be continuous insulation uninterrupted by studs



Wall R-Value

Mass Walls



Walls weighing at least 35
lbs/ft² of wall surface area

OR

25 lbs/ft² of wall surface
area if material weight is
 $\leq 120 \text{ lb/ft}^3$

Wall R-Value

Wood, Metal Frame, and Other



Photo courtesy of Dow Building Solutions

- ▶ Cavity insulation or cavity plus continuous (ci)
- ▶ Continuous insulation = insulation that is not broken up by framing members such as rigid board insulation

90.1-2013 - Section 5 – 5.5.1

Prescriptive – Above Grade Wall Insulation, Climate Zone 4



Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
<i>Walls, above Grade</i>						
Mass	U-0.104	R-9.5 c.i.	U-0.090	R-11.4 c.i.	U-0.580	NR
Metal Building	U-0.060	R-0 + R-15.8 c.i.	U-0.050	R-0 + R-19 c.i.	U-0.162	R-13
Steel Framed	U-0.064	R-13 + R-7.5 c.i.	U-0.064	R-13 + R-7.5 c.i.	U-0.124	R-13
Wood Framed and Other	U-0.064	R-13 + R-3.8 c.i. or R-20	U-0.064	R-13 + R-3.8 c.i. or R-20	U-0.089	R-13

Reference Table 5.5-4 on page 30 in 90.1-2013

Using the Tables

- ID the building location and climate zone
- Choose the table corresponding to that climate zone
- Determine the type of building(s) and spaces involved (non-residential, residential and/or semi-heated)
- Determine relevant type(s) of above grade wall construction (mass, metal building, steel framing, wood framed/other)
- Choose relevant maximum assembly U-factor(s) or minimum insulation R-value(s) and apply in design

2015 IECC – Table C402.1.3

Prescriptive Above Grade Walls



Second column is always Group R and first column is always Other than Group R

Climate Zone 1 2 3 4
Except Marine

Mass	R-5.7ci	R-5.7ci	R-5.7ci	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci
Metal building	R-13+ 6.5ci	R-13+ 6.5ci	R-13+ 6.5ci	R-13+R- 13 ci	R-13+R- 6.5 ci	R-13+R- 13 ci	R-13+R- 13 ci	R-13+R-13 ci
Metal Framed	R-13+ R-5 ci	R-13+ R-5 ci	R-13+ R-5 ci	R-13+ 7.5ci	R-13+ 7.5ci	R-13+ 7.5ci	R-13+ 7.5ci	R-13+ 7.5ci
Wood Framed & 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 3	R-13+R- 3.8ci or R- 20

2015 IECC – Table C402.1.3

Prescriptive Above Grade Walls



<i>Second column is always Group R and first column is always Other than Group R</i>								
Climate Zone	5 And Marine 4	6	7	8				
Mass	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-13 ci	R-13+R-13 ci	R-13+R-13 ci	R-13+R-13 ci	R-13+R-13 ci	R-13+R-19.5 ci	R-13+R-13 ci	R-13+R-19.5 ci
Metal Framed	R-13+7.5ci	R-13+7.5ci	R-13+7.5ci	R-13+7.5ci	R-13+7.5ci	R-13+15.6ci	R-13+7.5ci	R-13+17.5ci
Wood Framed & Other	R-13+R-3.8ci or R-20	R-13+R-7.5ci or R-20+R-3.8 ci	R-13+R-7.5ci or R-20+R-3.8 ci	R-13+R-7.5ci or R-20+R-3.8 ci	R-13+R-7.5ci or R-20+R-3.8 ci	R-13+R-7.5ci or R-20+R-3.8 ci	R-13+R-15.6ci or R-20+R-10ci	R-13+R-15.6ci or R-20+R-10 ci

Below Grade Walls



- What is a below grade wall?
 - Any basement or first-story wall that is $\geq 85\%$ below grade and on the exterior of the building (*IECC*) that portion of a wall in the building envelope that is entirely below the finish grade and in contact with the ground (*90.1*)
 - A wall not considered below grade is then by definition above grade
- Insulation must extend down 10 ft from the outside finished grade level or to the level of the lowest floor, whichever is less
- Heated slabs installed below grade (*footnoted to Tables C402.1.3 and C402.1.4*)
 - Below grade walls must meet exterior insulation requirements for heated slabs



90.1-2013 Section 5.5.3.3

Below-Grade Wall Insulation



	CZ 1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8
Non Res Assembly Max C	1.14	1.14	1.14	0.119	0.119	0.092	0.063	0.063
Non Res Min R	NR	NR	NR	7.5 ci	7.5 ci	10.0 ci	15.0 ci	15.0 ci
Res Assembly Max C	1.14	1.14	1.14	0.092	0.092	0.063	0.063	0.063
Res Min R	NR	NR	NR	10.0 ci	10.0 ci	15.0 ci	15.0 ci	15.0 ci
Semi Htd Assembly Max C	1.14	1.14	1.14	1.14	1.14	0.119	0.119	0.119
Semi Htd Min R	NR	NR	NR	NR	NR	7.5 ci	7.5 ci	7.5 ci

2015 IECC – Table C402.1.3

Prescriptive Below Grade Walls



Second column is always Group R and first column is always Other than Group R

Climate Zone	1		2		3		4 Except Marine		5 And Marine 4		6		7		8	
Below grade wall	N R	N R	N R	N R	N R	N R	N R	R- 7.5ci	R- 7.5ci	R- 7.5ci	R- 7.5ci	R- 7.5ci	R- 10ci	R- 10ci	R- 10ci	R- 12.5ci



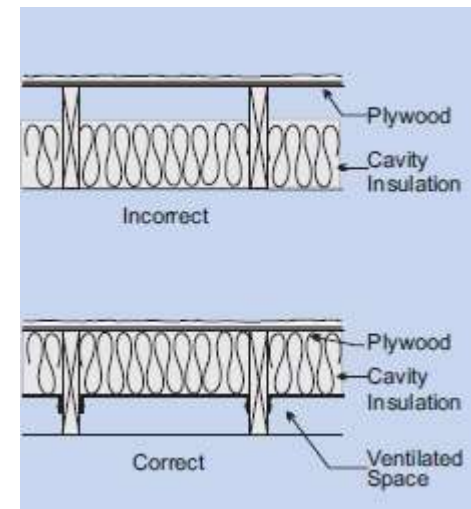
Floor Insulation

3 classes of floors over unconditioned space are defined in 90.1-2013:

- Mass floors
 - R-value is for continuous insulation
 - If framing is used, compliance is based on maximum assembly U-factor
- Steel-joist floors
 - R-value is for uncompressed insulation or spray-on insulation, but is also acceptable for continuous insulation
- Wood-framed and others
 - R-value is for uncompressed insulation, but is also acceptable for continuous insulation

2 classes are defined in 2015 IECC:

- Mass
- Joist/framing



90.1-2013 Section 5.5.3.4

Floor Insulation - Mass



	CZ 1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8
Non Res Assembly Max U	0.322	0.107	0.074	0.057	0.057	0.051	0.042	0.038
Non Res Min R	NR	6.3 ci	10.0 ci	14.6 ci	14.6 ci	16.7 ci	20.9 ci	23.0 ci
Res Assembly Max U	0.322	0.087	0.074	0.051	0.051	0.051	0.042	0.038
Res Min R	NR	8.3 ci	10.0 ci	16.7 ci	16.7 ci	16.7 ci	20.9 ci	23.0 ci
Semi Htd Assembly Max U	0.322	0.322	0.137	0.107	0.107	0.087	0.074	0.064
Semi Htd Min R	NR	NR	4.2 ci	6.3 ci	6.3 ci	8.3 ci	10.4 ci	12.5 ci

90.1-2013 Section 5.5.3.4

Floor Insulation – Steel Joist



	CZ 1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8
Non Res Assembly Max U	0.350	0.038	0.038	0.038	0.038	0.032	0.032	0.032
Non Res Min R	NR	30.0	30.0	30.0	30.0	38.0	38.0	38.0
Res Assembly Max U	0.350	0.038	0.038	0.038	0.038	0.032	0.032	0.032
Res Min R	NR	30.0	30.0	30.0	30.0	38.0	38.0	38.0
Semi Htd Assembly Max U	0.350	0.069	0.052	0.052	0.052	0.052	0.052	0.052
Semi Htd Min R	NR	13.0	19.0	19.0	19.0	19.0	19.0	19.0

90.1-2013 Section 5.5.3.4

Floor Insulation – Wood Framed and Other



	CZ 1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8
Non Res Assembly Max U	0.282	0.033	0.033	0.033	0.033	0.027	0.027	0.027
Non Res Min R	NR	30.0	30.0	30.0	30.0	38.0	38.0	38.0
Res Assembly Max U	0.282	0.033	0.033	0.033	0.033	0.027	0.027	0.027
Res Min R	NR	30.0	30.0	30.0	30.0	38.0	38.0	38.0
Semi Htd Assembly Max U	0.282	0.066	0.051	0.051	0.051	0.051	0.051	0.033
Semi Htd Min R	NR	13.0	19.0	19.0	19.0	19.0	19.0	30.0

90.1-2013 - Section 5 – Appendix A5.3

Opaque Areas – Steel Joist Floors Example



TABLE A5.3.3.1 Assembly U-Factors for Steel Joist Floors

Overall U-Factor for Assembly of Base Floor Panel (Continuous Insulation (Uninterrupted by Framing))																						
Framing Type and Spacing Width (Actual Depth)	Cavity Insulation R-Value: Rated (Effective Installed [See Table A9.2-1])	Overall U-Factor for Entire Base Floor Assembly	Rated R Value of Continuous Insulation:																			
			R-1.00	R-2.00	R-3.00	R-4.00	R-5.00	R-6.00	R-7.00	R-8.00	R-9.00	R-10.00	R-11.00	R-12.00	R-13.00	R-14.00	R-15.00	R-20.00	R-25.00	R-30.00	R-35.00	R-40.00
Steel Joist Floor with Rigid Foam																						
	None (0.0)	0.153	0.259	0.106	0.07	0.046	0.027	0.017	0.013	0.01	0.008	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001
Steel Joist Floor with Spray-on Insulation																						
1 in.	R-4 (3.88)	0.148	0.129	0.114	0.097	0.081	0.068	0.058	0.05	0.043	0.037	0.032	0.027	0.023	0.02	0.017	0.015	0.01	0.008	0.007	0.006	0.005
2 in.	R-8 (7.52)	0.096	0.088	0.081	0.072	0.062	0.053	0.046	0.04	0.034	0.029	0.025	0.021	0.018	0.016	0.013	0.011	0.007	0.006	0.005	0.004	0.004
2 in.	R-24 (10.80)	0.073	0.068	0.064	0.060	0.057	0.054	0.051	0.049	0.047	0.045	0.043	0.041	0.04	0.038	0.036	0.034	0.03	0.028	0.026	0.025	0.024
4 in.	R-36 (16.20)	0.060	0.056	0.053	0.05	0.048	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.034	0.033	0.031	0.03	0.027	0.025	0.024	0.023	0.022
5 in.	R-54 (27.00)	0.050	0.048	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.035	0.034	0.033	0.032	0.031	0.03	0.028	0.026	0.025	0.024	0.023	0.022
6 in.	R-72 (36.00)	0.044	0.042	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.032	0.031	0.03	0.029	0.028	0.027	0.026	0.024	0.023	0.022	0.021	0.021
Steel Joist Floor with Batt Insulation																						
	None (0.0)	0.150	0.259	0.216	0.171	0.134	0.10	0.077	0.061	0.05	0.043	0.037	0.032	0.027	0.023	0.02	0.017	0.015	0.01	0.008	0.007	0.006
	R-11 (0.00)	0.078	0.107	0.087	0.069	0.054	0.039	0.035	0.031	0.024	0.02	0.017	0.015	0.013	0.011	0.01	0.009	0.008	0.006	0.005	0.004	0.004
	R-13 (1.70)	0.069	0.064	0.060	0.057	0.054	0.051	0.049	0.047	0.045	0.043	0.041	0.04	0.038	0.037	0.036	0.034	0.033	0.03	0.028	0.026	0.025
	R-15 (2.20)	0.063	0.059	0.055	0.052	0.050	0.048	0.046	0.044	0.042	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.031	0.029	0.027	0.026	0.024
	R-19 (6.34)	0.057	0.050	0.047	0.045	0.043	0.041	0.04	0.038	0.037	0.036	0.035	0.034	0.033	0.032	0.031	0.03	0.028	0.026	0.025	0.024	0.023
	R-21 (7.64)	0.049	0.047	0.046	0.045	0.044	0.043	0.042	0.041	0.04	0.039	0.038	0.037	0.036	0.035	0.034	0.033	0.032	0.03	0.028	0.027	0.026
	R-23 (20.25)	0.042	0.041	0.040	0.039	0.038	0.037	0.036	0.035	0.034	0.033	0.032	0.031	0.03	0.029	0.028	0.027	0.026	0.024	0.023	0.022	0.021
	R-30 (23.70)	0.038	0.036	0.035	0.034	0.033	0.032	0.031	0.03	0.029	0.028	0.027	0.026	0.025	0.024	0.023	0.022	0.021	0.02	0.019	0.018	0.017
	R-36 (28.70)	0.038	0.036	0.035	0.034	0.033	0.032	0.031	0.03	0.029	0.028	0.027	0.026	0.025	0.024	0.023	0.022	0.021	0.02	0.019	0.018	0.017

2015 IECC – Table C402.1.3

Prescriptive Floors Over Unconditioned Spaces/Outdoor Air



Second column is always Group R and first column is always Other than Group R

Climate Zone	1		2		3		4 Except Marine		5 And Marine 4		6		7		8	
Mass	N R	N R	R- 6.3ci	R- 8.3ci	R- 10ci	R- 10ci	R- 10ci	R- 10.4ci	R- 10ci	R- 12.5ci	R- 12.5ci	R- 12.5ci	R- 15ci	R- 16.7ci	R- 15ci	R- 16.7ci
Joist/ Framing Steel/ (Wood)	N R	N R	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30

Slab-on-Grade Floor Insulation



Meet or exceed values in appropriate table for climate zone (*includes R-value and depth or width of insulation*)

Be installed around the perimeter to the distance specified

- **Inside foundation wall** – downward from the top of the slab or footing, whichever is less, for the minimum distance specified in the table OR downward to at least the bottom of the slab and then horizontally to the interior for the total distance specified in the table
- **Outside foundation wall** – downward from the top of the slab or footing, whichever is less, to the minimum distance specified in the table OR downward to at least the bottom of the slab and then horizontally to the exterior for the total distance specified in the table



90.1-2013 Section 5.5.3.5

Unheated Slab on Grade Floor Insulation



	CZ 1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8
Non Res Assembly Max F	0.730	0.730	0.730	0.520	0.520	0.510	0.510	0.434
Non Res Min R	NR	NR	NR	15.0 for 24"	15.0 for 24"	20.0 for 24"	20.0 for 24"	20.0 for 48"
Res Assembly Max F	0.730	0.730	0.540	0.520	0.510	0.434	0.434	0.424
Res Min R	NR	NR	10.0 for 24"	15.0 for 24"	20.0 for 24"	20.0 for 48"	20.0 for 48"	25.0 for 48"
Semi Htd Assembly Max F	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.054
Semi Htd Min R	NR	NR	NR	NR	NR	NR	NR	10.0 for 24"

90.1-2013 Section 5.5.3.5

Heated Slab on Grade Floor Insulation



	CZ 1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8
Non Res Assembly Max F	1.020	0.900	0.860	0.843	0.688	0.688	0.671	0.671
Non Res Min R	7.5 for 12"	10.0 for 24"	15.0 for 24"	20.0 for 24"	20.0 for 48"	20.0 for 48"	25.0 for 48"	25.0 for 48"
Res Assembly Max F	1.020	0.860	0.860	0.688	0.688	0.671	0.671	0.373
Res Min R	7.5 for 12"	15.0 for 24"	15.0 for 24"	20.0 for 48"	20.0 for 48"	25.0 for 48"	25.0 for 48"	20.0 full slab
Semi Htd Assembly Max F	1.020	1.020	1.020	0.900	0.900	0.860	0.860	0.860
Semi Htd Min R	7.5 for 12"	7.5 for 12"	7.5 for 12"	10.0 for 24"	10.0 for 24"	15.0 for 24"	15.0 for 24"	15.0 for 24"

2015 IECC – Table C402.1.3

Prescriptive Slab on Grade



Second column is always Group R and first column is always Other than Group R

Climate Zone	1	2	3	4
				Except Marine
Unheated Slabs	NR	NR	NR	NR
Heated Slabs	R-7.5 for 12 in. below	R-7.5 for 12 in. below	R-7.5 for 12 in. below	R-10 for 24 in. below

2015 IECC – Table C402.1.3

Prescriptive Slab on Grade



Second column is always Group R and first column is always Other than Group R

Climate Zone		5 And Marine 4		6	7	8		
Unheated Slabs	R-10 for 24 in. below	R-10 for 24 in. below	R-10 for 24 in. below	R-15 for 24 in. below	R-15 for 24. in. below	R-15 for 24 in. below	R-15 for 24 in. below	R-20 for 24 in. below
Heated Slabs	R-15 for 36 in. below	R-15 for 36 in. below	R-15 for 48 in. below	R-20 for 48 in. below	R-20 for 24 in. below	R-20 for 48 in. below	R-20 for 48 in. below	R-20 for 48 in. below

90.1-2013 Section 5.5.3.6

Opaque Doors – Maximum Assembly U Factor



	CZ 1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8
Non Res Swinging	0.700	0.700	0.700	0.500	0.500	0.500	0.500	0.500
Non Res Nonswinging	1.450	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Res Swinging	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Res Nonswinging	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Semi Htd Swinging	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.500
Semi Htd Nonswinging	1.450	1.450	1.450	1.450	1.450	0.500	0.500	0.500

Opaque Doors

2015 IECC C402.4.4



Doors that are opaque for at least 50% glass of their area

Swinging doors

- ▶ $U \leq 0.61$ in Climate Zones 1-3 and 4 other than marine
- ▶ $U \leq 0.37$ in Climate Zones 5 -8 and 4 marine

Roll-up or sliding doors

- ▶ $R-4.75$ in all climate zones

Are considered part of the gross area of above-grade walls that are part of the building thermal envelope

Criteria apply to fenestration, including windows, glass doors, glass block, plastic panels, and skylights

- ▶ specified by fenestration type, space conditioning category (90.1-2013 only) and by climate zone

Compliance with values in 90.1-2013 (Tables 5.5-1 through 5.5-8) and 2015 IECC Table C402.4

- U-factor not greater than specified
- SHGC not greater than specified
- **Meet or exceed minimum VT/SHGC**
- Use NFRC ratings or default values in Appendix A or Section C303
- Area weighting allowed within same class of construction and space conditioning category



90.1-2013 - Section 5 – 5.5-1

Prescriptive – Fenestration Climate Zone 4 Example



Fenestration	Assembly Max. U	Assembly Max. SHGC	Assembly Min. VT/SHGC	Assembly Max. U	Assembly Max. SHGC	Assembly Min. VT/SHGC	Assembly Max. U	Assembly Max. SHGC	Assembly Min. VT/SHGC
<i>Vertical Fenestration, 0%–40% of Wall</i>		(for all frame types)			(for all frame types)			(for all frame types)	
Nonmetal framing, all	U-0.50 ^c			U-0.50 ^c			U-0.93		
Metal framing, fixed	U-0.57 ^c			U-0.57 ^c			U-1.20		
Metal framing, operable	U-0.65 ^c	SHGC-0.25	1.10	U-0.65 ^c	SHGC-0.25	1.10	U-1.20	NR	NR
Metal framing, entrance door	U-1.10 ^c			U-1.10 ^c			U-1.10 ^c		
<i>Skylight, 0%–3% of Roof</i>									
All types	U-0.75	SHGC-0.35	NR	U-0.75	SHGC-0.35	NR	U-1.80	NR	NR

* The following definitions apply: c.i. = continuous insulation (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), Ls = liner system (see Section A2.3.2.4), NR = no (insulation) requirement.

a. When using the R-value compliance method for metal building roofs, a thermal spacer block is required (see Section A2.3.2).

b. Exception to Section 5.5.3.2 applies for mass walls above grade.

c. For locations in Climate Zone 1 with a cooling design temperature of 95°F and greater, see Section 5.5.4.3 for the maximum U-factors for vertical fenestration.

- Percentage of Vertical Fenestration Area to Gross Wall Area is based on total wall area including below grade walls

2015 IECC – Table C402.4

Prescriptive - Fenestration



CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7	
Vertical fenestration														
U-factor														
Fixed fenestration	0.50		0.50		0.46		0.38		0.38		0.36		0.29	
Operable fenestration	0.65		0.65		0.60		0.45		0.45		0.43		0.37	
Entrance doors	1.10		0.83		0.77		0.77		0.77		0.77		0.77	
SHGC														
Orientation ^a	SEW	N	SEW	N	SEW	N	SEW	N	SEW	N	SEW	N	SEW	N
PF < 0.2	0.25	0.33	0.25	0.33	0.25	0.33	0.40	0.53	0.40	0.53	0.40	0.53	0.45	NR
0.2 ≤ PF < 0.5	0.30	0.37	0.30	0.37	0.30	0.37	0.48	0.58	0.48	0.58	0.48	0.58	NR	NR
PF ≥ 0.5	0.40	0.40	0.40	0.40	0.40	0.40	0.64	0.64	0.64	0.64	0.64	0.64	NR	NR
Skylights														
U-factor	0.75		0.65		0.55		0.50		0.50		0.50		0.50	
SHGC	0.35		0.35		0.35		0.40		0.40		0.40		NR	

NR = No requirement, PF = Projection factor.

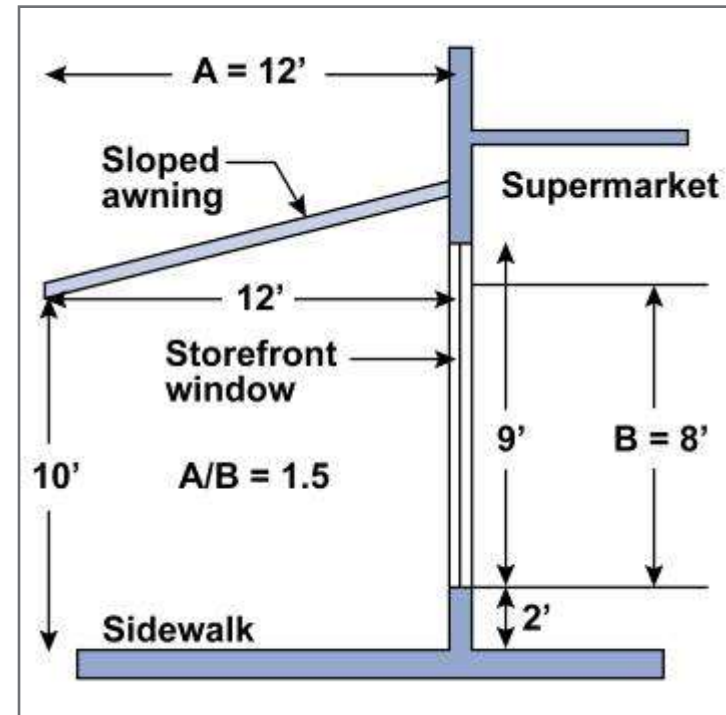
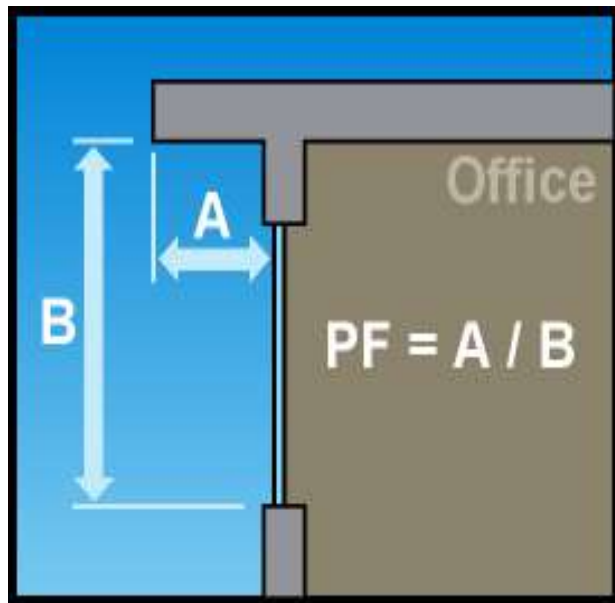
a. "N" indicates vertical fenestration oriented within 45 degrees of true north. "SEW" indicates orientations other than "N." For buildings in the southern hemisphere, reverse south and north. Buildings located at less than 23.5 degrees latitude shall use SEW for all orientations.

- Percentage of Vertical Fenestration Area to Gross Wall Area
- Allowed up to 30% maximum of above wall grade
 - In Climate Zones 1-6, up to 40% maximum of above grade wall with daylighting and daylighting controls

IECC Section C402.4.3 Projection Factor



Required SHGC is adjusted based on projection factor associated with any overhangs



Increased Vertical Fenestration with Daylighting Controls – IECC C402.4.1.1



- ▶ Up to 40% vertical fenestration area allowed in climate zones 1-6, provided
 - No less than 50% of the net floor area is within a daylight zone in buildings not over 2 stories above grade
 - No less than 25% of the net floor area is within a daylight zone in buildings 3 stories or more above grade
 - Daylight responsive controls are installed in daylight zones; and
 - VT of vertical fenestration is ≥ 1.1 times SHGC

Exception:

Fenestration that is outside the scope of NFRC 200 isn't required to comply with VT

Fenestration Area



90.1-2013

Total vertical fenestration area to be smaller than specified values in Tables 5.5-1 through 5.5-8 (40% for all climate zones)

- Including both fixed and operable vertical fenestration
- Exception: street-level vertical fenestration (5.5.4.4.1)

Total skylight area smaller than specified in Tables 5.5-1 through 5.5-8 (3% of roof area for all climate zones)

- Permitted to be no greater than 6% of roof area provided criteria in exception 1 to skylight SHGC requirements are met (5.5.4.4.2) and daylight area under skylights is more than or equal to half the floor area of the space

2015 IECC

Total vertical fenestration area to be smaller than specified values in Section C402.4.1-C402.4.1.1

- ✓ Allowed up to 30% maximum of above grade wall
 - ✓ In Climate Zones 1-6, up to 40% maximum of above grade wall with daylighting controls

Skylights – C402.4.1 and C402.4.1.2

- ✓ Limited to $\leq 3\%$ of Roof Area
- ✓ Up to 5% allowed if automatic daylighting controls installed in daylight zones under skylights

Vertical Fenestration Requirement

IECC C402.4.1

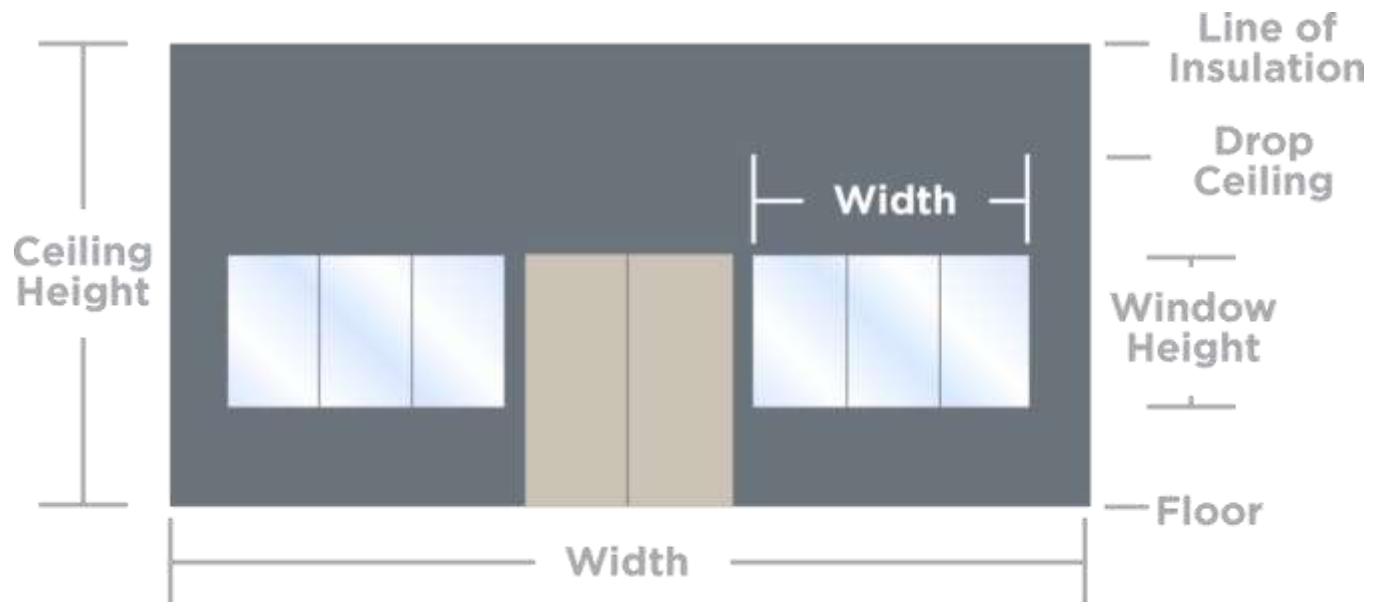


Based on above-grade wall area (*gross*)

- ✓ Includes walls between conditioned space and unconditioned space or the great outdoors
 - Includes walls that are $> 15\%$ above grade

Total fenestration area (*includes frame and glazing*)

- ✓ Does not include opaque door area



ASHRAE 90.1 Section 5.5.4.2.3

Minimum Skylight Fenestration Area



Minimum skylight area must be provided in enclosed spaces that are

- ▶ $\geq 2,500 \text{ ft}^2$
- ▶ In spaces with ceiling height $> 15 \text{ ft}$ and
- ▶ Space types
 - ▶ Gymnasium seating
 - ▶ Convention exhibit/event space
 - ▶ Courtroom
 - ▶ Automotive space
 - ▶ Fire state engine room
 - ▶ Manufacturing
 - Office
 - Lobby
 - Atrium
 - Concourse
 - Corridor
 - Storage (incl. nonrefrigerated warehouse)
 - Gymnasium/fitness/exercise
 - Area, playing area
 - Corridor/transition and bay areas
 - Retail
 - Library reading and stack areas
 - Distribution/sorting area
 - Transportation
 - Baggage and seating areas
 - Workshop

ASHRAE 90.1 Section 5.5.4.2.3

Minimum Skylight Fenestration Area



The skylight area must daylight a minimum of half the floor area and provide

- ▶ Minimum ratio of 3% of skylight area to daylight area with a skylight VLT at least 0.40 **OR**
- ▶ a minimum skylight effective aperture of at least 1%

Exceptions

- ▶ Climate zones 6-8
- ▶ Spaces under shaded roofs (beam sunlight blocked for more than 1500 daytime hours between 8 a.m. and 4 p.m.)
- ▶ Daylight area under rooftop monitors is > 50% of floor area
- ▶ Documented that 90% of skylight area is shaded on June 21 (Northern Hemisphere)/December 21 (Southern Hemisphere) at noon by permanent features
- ▶ Where total space area minus the primary and secondary sidelighted area(s) is < 2,500 ft and where lighting is controlled according to sidelighting requirements of Section 9.4.1

Minimum Skylight Fenestration Area

IECC Section C402.4.2



- ▶ In certain types of enclosed spaces $> 2,500 \text{ ft}^2$ in floor area directly under a roof with $> 75\%$ of ceiling area with ceiling height $> 15 \text{ ft}$.
 - total daylight zone under skylights to not be $< \frac{1}{2}$ the floor area and provide one of the following
 - Minimum of 3% of skylight area to daylight zone where all skylights have a VLT at least 0.40 **OR**
 - Provide a minimum skylight effective aperture of at least 1%

Exceptions:

- ▶ Climate Zones 6-8
- ▶ Spaces with LPDs $< 0.5 \text{ W/ft}^2$
- ▶ Documented shaded spaces
- ▶ Daylight area under rooftop monitors is $> 50\%$ of floor area
- ▶ Spaces where total area minus area of daylight zones adjacent to vertical fenestration is $< 2,500 \text{ ft}^2$ and lighting is controlled per C405.2.5 (Exterior Lighting Controls)

ASHRAE 90.1 Section 5.8.2.4

Solar Heat Gain Coefficient (SHGC)



Determined in accordance with NFRC 200

Exceptions

- $SC \times 0.86$ is acceptable for overall fenestration area (NFRC 300)
- SHGC of center-of-glass is acceptable (NFRC 300) for overall fenestration area
- SHGC from A8.1 for skylights is acceptable
- SHGC from A8.2 for other vertical fenestration is acceptable

ASHRAE 90.1 Section 5.5.4.4.2

Skylight SHGC



Skylights

- SHGC values < Table value for appropriate total skylight area

Exceptions:

If skylights

- ▶ Have a glazing material or diffuser with measured haze value > 90% when tested according to ASTM D1003
- ▶ Have a skylight VT > 0.40
- ▶ Have all general lighting in daylight area under skylights controlled by multilevel photocontrols per Section 9.4.1.1 (f)

Dynamic Glazing

- ▶ Minimum SHGC is used to demonstrate compliance
- ▶ Considered separately from other vertical fenestration
- ▶ Area-weighted averaging with other vertical fenestration that isn't dynamic glazing isn't allowed

ASHRAE 90.1 Section 5.5.4.5 Fenestration Orientation



Two options to comply – **NOTE FENESTRATION AREA AS A FUNCTION OF ORIENTATION IS CONTROLLED NOT BUILDING ORIENTATION**

(a) $A_w \leq A_t/4$ and $A_e \leq A_t/4$

OR

(b) $A_w \times SHGC_w \leq (A_t \times SHGC_c)/4$ and
 $A_e \times SHGC_e \leq (A_t \times SHGC_c)/4$

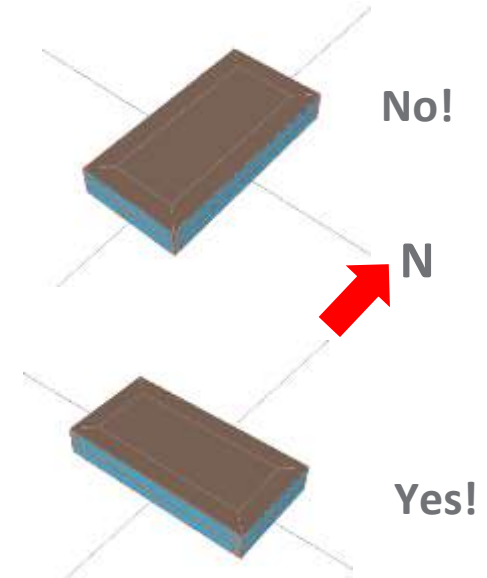
Where,

A_w and $SHGC_w$ = west-oriented vertical fenestration area and SHGC

A_e and $SHGC_e$ = east-oriented vertical fenestration area and SHGC

A_t = total vertical fenestration area

$SHGC_c$ = SHGC criteria in Tables 5.5-1 through 5.5-8



Exceptions

- ▶ Complies with Exception 3 of Section 5.5.4.4.1
- ▶ Buildings shaded by other buildings within 20 ft to the south which is at least ½ as tall as the proposed building
- ▶ Buildings with shade on 75% of the west and east
- ▶ Alterations and additions that don't increase vertical fenestration area
- ▶ Buildings where west- and east-oriented vertical fenestration area < 20% of gross wall area for each of those facades and SHGC on those facades < 90% of $SHGC_c$
- ▶ In climate zone 8

ASHRAE 90.1 Section 5.5.4.6

Visible Transmittance/SHGC Ratio



When automatic daylighting controls are required per 9.4.1.1 (e) or (f)

- ▶ fenestration to have a ratio of VT/SHGC not less than listed in Tables 5.5-1 through 5.5-8 (>1.1 for all climate zones)

Exceptions:

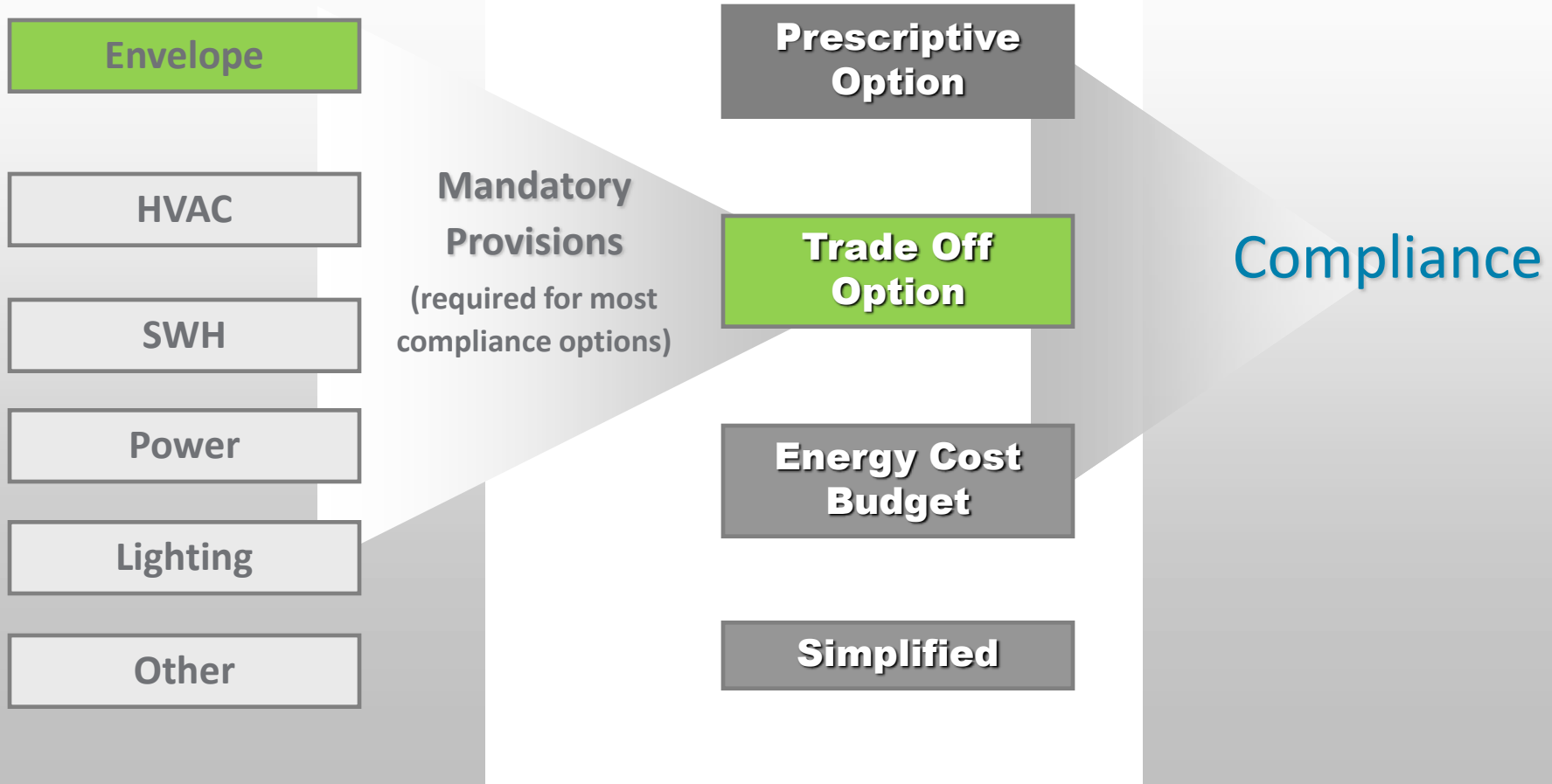
- ▶ Can have a light-to-solar-gain ratio (LSG) of not less than 1.25
 - center-of-glass SHGC and VT determined per NFRC 300 and NFRC 301 by independent lab or included in a database published by a government agency and certified by a manufacturer
- ▶ Fenestration not covered in scope of NFRC 200
- ▶ Enclosed spaces
 - where daylight area under rooftop monitors is $> 50\%$ of enclosed floor area
 - with skylights complying with 5.5.4.2.3
 - where sidelighting effective aperture is ≥ 0.15
- ▶ Dynamic glazing
 - VT/SHGC ratio and LSG determined using maximum VT and maximum SHGC
 - Considered separately from other fenestration; cannot include dynamic glazing with other fenestration for area-weighted averaging

Building Thermal Envelope Tradeoff Compliance Approach – ASHRAE 90.1



Building System

Compliance Options



ASHRAE 90.1 Section 5.6.1

Building Envelope Trade-Off Option “Rules”



Building must comply with Sections 5.1, 5.4, 5.7, and 5.8

Complies with trade-off option if envelope performance factor (EPF) of proposed design is less than or equal to that of budget building defined by rules in Appendix C

- ▶ All building envelope components shown on drawings or installed in existing buildings to be included in proposed building design
- ▶ Fenestration and opaque envelope types and area used in simulation model to be consistent with design documents
- ▶ Don't need to separately describe any envelope assembly covering $< 5\%$ of total area of that assembly
 - as long as it's similar to an assembly being modeled
 - if not separately described, add the area of that assembly to an assembly with same orientation and thermal properties

ASHRAE 90.1 Section 5.6.1.2

Trade-Off Limits



- ▶ If building permit will apply to less than the whole building
 - Parameters relating to unmodified existing conditions or future building components to be identical for both proposed EPF and base EPF
- ▶ Future components must meet prescriptive requirements of Section 5.5



Air Leakage Overview (Mandatory)



90.1-2013

- ✓ Air Leakage (*Section 5.4.3*)
 - *Continuous air barrier*
 - *Loading dock weatherseals*
 - *Vestibules*
- ✓ Insulation (*Section 5.4.1 refers to 5.8.1.1 through 5.8.1.10*)
 - *Labeling (Section 5.8.1.1)*
 - *Substantial Contact (Section 5.8.1.5)*
 - *Recessed Equipment (Section 5.8.1.6)*
 - *Insulation Protection (Section 5.8.1.7)*
 - *Insulation Above Suspended Ceilings (Section 5.8.1.8)*
 - *Joints in Rigid Insulation (Section 5.8.1.10)*
- ✓ Fenestration and Doors (*Section 5.4.2 that refers to 5.8.2*)

2015 IECC

- ✓ Air Leakage – C402.5
- ✓ Air barriers – C402.5.1.1
 - ✓ Continuous air barrier
- ✓ Fenestration air leakage – C402.5.2
- ✓ Rooms Containing Fuel-burning Appliances – C402.5.3
- ✓ Doors and access openings to shafts, chutes stairways, and elevator lobbies – C402.5.4
- ✓ Air intakes, exhaust openings, stairways and shafts – C402.5.5
- ✓ Loading dock weatherseals – C402.5.6
- ✓ Vestibules – C402.5.7
- ✓ Recessed lighting – C402.5.8

Air Leakage – Continuous Air Barrier



90.1-2013

- Continuous air barrier required except in:
 - Semi heated spaces in **climate zones 1-6**
 - Single wythe concrete masonry buildings in **climate zone 2B**
- Plans
 - Air barrier components identified or noted in construction documents
 - Joints, intersections, and penetrations of air barrier components (incl. lighting fixtures) detailed
- To extend over all surfaces of building envelope
 - At lowest floor, exterior walls, and ceiling or roof
- Designed to resist positive and negative pressures
 - Wind, stack effect, and mechanical ventilation

2015 IECC

- Continuous air barrier required except in:
 - **Climate Zone 2B**
- Air barrier placement allowed:
 - Inside of building envelope
 - Outside of building envelope
 - Located within assemblies composing envelope **OR**
 - Any combination thereof
- Continuous for all assemblies part of the thermal envelope and across joints and assemblies
- Joints and seams sealed including sealing transitions in places and changes in materials, securely installed in or on the joint for its entire length to not dislodge, loosen or otherwise impair its ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation

Air Leakage – Acceptable Air Barrier Materials and Assemblies



90.1-2013/2015 IECC similar language and table

Materials with air permeance ≤ 0.004 cfm/ft² under pressure differential of 0.3 in. water tested in accordance with ASTM E 2178

These materials meet these requirements:

Material	Thickness (minimum)
Plywood	3/8 in.
Oriented strand board	3/8 in.
Extruded polystyrene insulation board	1/2 in.
Foil-faced urethane insulation board	1/2 in.
Exterior gypsum sheathing or interior gypsum board	1/2 in.
Cement board	1/2 in.
Built up roofing membrane	
Modified bituminous roof membrane	
Fully adhered single-ply roof membrane	
A Portland cement/sand parge, stucco, or gypsum plaster	1/2 in.
Cast-in-place and precast concrete	
Sheet metal	
Closed cell 2 lb/ft ³ nominal density spray polyurethane foam	1 in.

90.1-2013/2015 IECC similar language and table

OR

Assemblies of materials and components (sealants, tapes, etc.) with average air leakage ≤ 0.04 cfm/ft² under pressure differential of 0.3 in. water tested in accordance with ASTM E 2357, 1677, **1680(90.1 only)**, or 283

These assemblies meet these requirements:

- Concrete masonry walls that are fully grouted OR painted to fill the pores

90.1-2013 - Section 5.4.3.2

Air Leakage – Fenestration and Doors



Product	cfm/ft ²	Procedure	psf
Glazed swinging entrance doors and revolving doors	1.0	AAMA/WDMA/CSA 101/I.S.2/A440, NFRC 400, or ASTM E283	1.57
Curtain wall and storefront glazing	0.06	NFRC 400 or ASTM E283	1.57
Unit skylights with condensation weepage openings	0.3	AAMA/WDMA/CSA 101/I.S.2/A440 or NFRC 400	1.57
Unit skylights with condensation weepage openings	0.5	AAMA/WDMA/CSA 101/I.S.2/A440	6.24
Nonswinging doors for vehicular access and material transportation (min. opening of 32 in/s)	1.3	ANSI/DASMA 105, NFRC 400, or ASTM E283	1.57
Nonswinging opaque doors, glazed sectional garage doors, and upward acting nonswinging glazed doors	0.4	ANSI/DASMA 105, NFRC 400, or ASTM E283	1.57
All other products	0.2	AAMA/WDMA/CSA 101/I.S.2/A440 or NFRC 400	1.57
All other products	0.3	AAMA/WDMA/CSA 101/I.S./A440	6.24

Exceptions

- Field-fabricated fenestration and doors
- Metal coiling doors in semi heated spaces
In **climate zones 1-6**
- Products in buildings that comply with a whole building air leakage rate of 0.4 cfm/ft² under pressure differential of 0.3 in. H₂O, 1.57 psf per ASTM E779

2015 IECC - Air Leakage of Fenestration

Section C402.5.2



Fenestration Assembly	cfm/ft ²	Test Procedure
Windows, sliding glass doors, and swinging doors	0.20	AAMA/WDMA/CSA 101/I.S.2/A440 or NFRC 400
Skylights - with condensation weepage openings	0.30	
Skylights – all other	0.20	
Curtain walls and storefront glazing	0.06	NFRC 400 or ASTM E 283 at 1.57 psf
Commercial glazed swinging entrance doors	1.00	
Revolving doors	1.00	
Garage doors	0.4	ANSI/DASMA 105, NFRC 400, or ASTM E 283 at 1.57 psf
Rolling doors	1.00	
High-speed doors	1.30	

✓ **Exceptions:**

Field-fabricated fenestration assemblies

Fenestration in buildings that meet the building test for air barrier compliance option

90.1-2013/2015 IECC similar language

The following areas are to be wrapped, sealed, caulked, gasketed, or taped

- ▶ Joints around fenestration and door frames (both manufactured and site-built)
- ▶ Junctions between walls
 - and foundations
 - at building corners
 - and roofs or ceilings
- ▶ Penetrations for roofs, walls, and floors
- ▶ Building assemblies used as ducts or plenums
- ▶ Joints, seams, connections between planes, and other changes in air barrier materials



90.1-2013/2015 IECC similar language except

90.1-2013 - In climate zones 4-8/2015 IECC – all climate zones

- Cargo doors and loading dock doors equipped with weatherseals
 - To restrict infiltration when vehicles are parked in the loading



90.1-2013 Section 5.4.3.4 Air Leakage – Vestibules



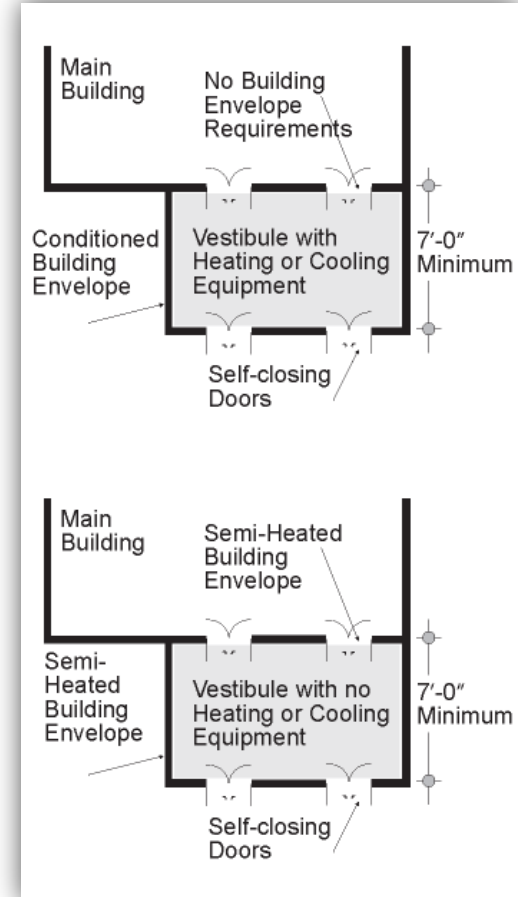
Required in

- **Climate Zone 3** for building entrances in > 4 story buildings > 10,000 ft²
- **Climate Zones 4-8** for building entrances in buildings > 1000 ft²

Vestibules must have

- ▶ Self-closing doors
- ▶ Interior and exterior doors not open at the same time
- ▶ Distance between interior and exterior doors not < 7 ft when in closed position (*remember ADA!*)

Floor area of each vestibule to not exceed the greater of 50 ft² or 2% of the gross conditioned floor area for that level of the building



Vestibule envelope requirements

- ▶ Exterior envelope of vestibule complies with appropriate requirements when vestibules are conditioned or when they constitute a semi heated space

Vestibules opening into large conditioned spaces (large retail)

- ▶ spaces having a gross conditioned floor area for that level of the building of 40,000 ft² and greater,
- ▶ and when the doors opening into and out of the vestibule are equipped with automatic, electrically driven, self-closing devices,
- ▶ the interior and exterior doors shall have a minimum distance between them of not less than 16 ft

90.1-2013 Section 5.4.3.4

Air Leakage – Vestibules Exceptions



- Non-entrance doors
- Building entrances with revolving doors
- All building entrances in climate zones 1 and 2 **OR** in buildings < 4 stories and < 10,000 ft² in gross conditioned floor area in climate zone 3 **OR** in buildings < 1000 ft² in gross conditioned floor area in climate zones 4-8
- All doors that open from spaces < 3000 ft² (*separate from building entrance*) **OR** from dwelling units

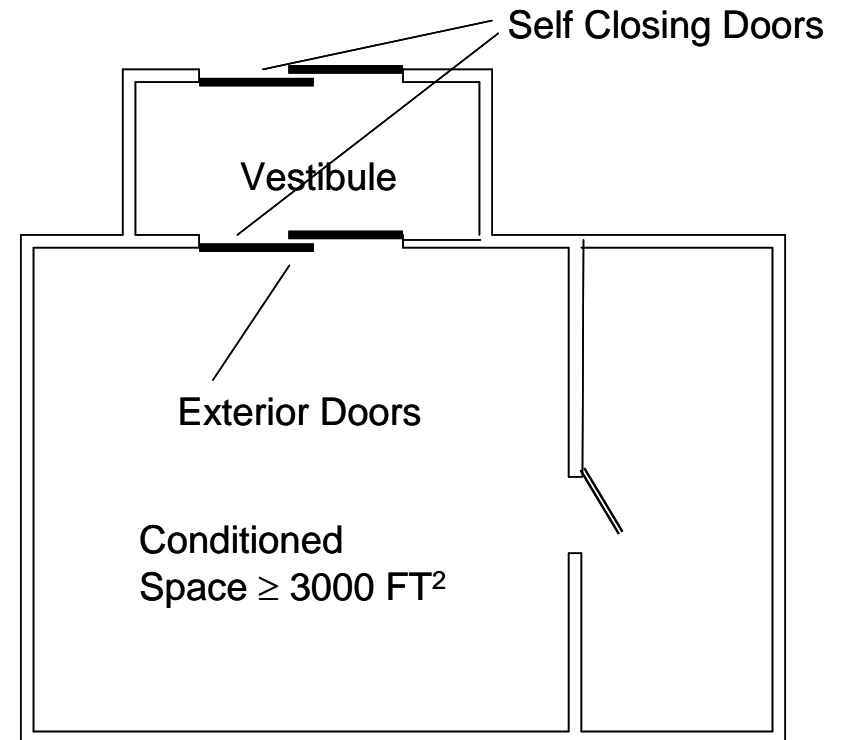


2015 IECC - Vestibules

Section C402.5.7



- ✓ Required to reduce infiltration into spaces
- ✓ Required on entrance doors leading into spaces $\geq 3,000 \text{ ft}^2$
- ✓ Doors must have self-closing devices
- ✓ **Exceptions:**
 - Buildings in Climate Zones 1 and 2
 - Doors from a sleeping unit or dwelling unit
 - Revolving doors
 - Doors that have an air curtain with velocity $> 6.56 \text{ ft/second}$ at the floor tested in accordance with ANSI/AMCA 220 installed in accordance with manufacturer's instructions. Manual or automatic controls provided that will operate the air curtain with opening and closing. Air curtain and their controls to comply with Section C408.2.3.



U.S. DOE: BECP Resources



Proudly Operated by Battelle Since 1965

- ▶ Compliance software
 - ▶ Compliance checklists
 - ▶ Technical support
 - ▶ Code notes
 - ▶ Publications
 - ▶ Resource guides
 - ▶ Training programs
- www.energycodes.gov



Building Energy Codes RESOURCE CENTER

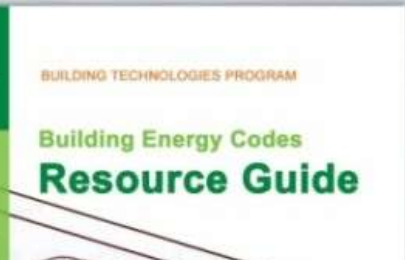
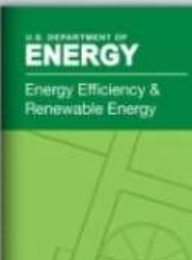
Drywall Clips - Code Notes

Metal or plastic drywall clips can be used to replace a third stud at a corner, if it is in the ceiling to replace a rafter. The reduced attachment (wood to drywall) resin allows small movements without drywall cracking and nail pops. Small movement changes in temperature and moisture content over time.

Eliminating unnecessary wood framing within walls can increase the thermal efficiency of the wall. The reduced attachment (wood to drywall) resin allows more insulation to be installed and also eliminates hot and cold air leaks within the wall system.

Nails and screws are used only to fasten the clip to the stud; they are not used to fasten the clip to the drywall.

Two-stud corners and drywall clips are often used in combination with airtight drywall seams to provide an effective interior air barrier.



Commercial Energy Standards and Model Code Resources



▶ ASHRAE Standard 90.1-2013 Slide decks for:

Envelope

■ Lighting

■ Mechanical

<http://www.energycodes.gov/training-courses/ansiashraeies-standard-901-2013>

▶ 2015 IECC slides decks for:

Envelope

■ Lighting

■ Mechanical

<http://www.energycodes.gov/resource-center/training-courses/commercial-envelope-requirements-2015-iecc>

- Use either 2015 IECC or 90.1-2013 for the entire project
- ID project scope and IF all or some of the envelope provisions will apply
- Determine location (for climate zone)
- Determine building type(s)
- Determine what constitutes the building thermal envelope components
- Apply relevant thermal criteria from the document selected to the
 - Opaque portions of the building thermal envelope
 - Fenestration
 - Adjust allowable fenestration area in accordance with daylighting criteria
- Apply air leakage criteria to fenestration and opaque materials or assemblies
- Apply loading dock weatherseal and vestibule criteria where applicable
- Don't forget alternative approaches to overall envelope performance or total building performance
- Use available support resources and consider development of 'cheat sheets' for specific climate zones and building type

Questions and How to Contact Us



- ▶ Paul Karrer (paulkarrer@aia.org)
- ▶ Pam Cole (pam.cole@pnnl.gov)
- ▶ Dave Conover (david.conover@pnnl.gov)



BECP Website:

www.energycodes.gov

BECP Solutions & Help Center:

www.energycodes.gov/help/

