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

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Course Description and Learning Objectives

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?

ANSI/ASHRAE/IES 90.1-2013
(Replaces ANSI/ASHRAE/IES Standard 90.1-2010)
Includes ANSI/ASHRAE/IES Addenda issued to Appendix F

Energy Standard for Buildings Except Low-Rise Residential Buildings
(I-P Edition)

ANSI/ASHRAE/IES 90.1-2013

2015 IECC
Scope

- 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) to 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

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?
Options and Compliance Paths

1. ASHRAE 90.1-2013

2. 2015 IECC - Prescriptive
   - C402 - Envelope
   - C403 - Mechanical
   - C404 - SWH
   - C405 - Lighting
   - C406 – Pick One
     - 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

3. 2015 IECC - Performance
   - C407 – Total Building Performance ****
     - C407.2 – Air Leakage
     - C407.3 – Provisions applicable to all mechanical systems
     - C407.4 – SWH
     - Lighting Mandatory Sections
       - C405.2
       - C405.3
       - C405.4
       - C405.6

**** Building energy cost to be ≤ 85% of standard reference design building

90.1-13 - Prescriptive

90.1-13 - Performance
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
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.
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
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

### Space-conditioning Categories

<table>
<thead>
<tr>
<th>Heating Output, Btu/h-ft²</th>
<th>Climate Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1 and 2</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>4 and 5</td>
</tr>
<tr>
<td>20</td>
<td>6 and 7</td>
</tr>
<tr>
<td>25</td>
<td>8</td>
</tr>
</tbody>
</table>
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
Mandatory Provisions (required for most compliance options)

Building System

- Envelope
- HVAC
- SWH
- Power
- Lighting
- Other

Compliance Options

- Prescriptive Option
- Trade Off Option
- Energy Cost Budget
- Simplified

Energy Code Compliance
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
Roof Insulation

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 ≤ 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

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

### 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

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

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4 Except Marine</th>
<th>5 And Marine 4</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
</table>

**Second column is always Group R and first column is always Other than Group R**
High Albedo Roofs

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

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

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

OR

25 lbs/ft² of wall surface area if material weight is ≤ 120 lb/ft³
Wall R-Value
Wood, Metal Frame, and Other

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

Photo courtesy of Dow Building Solutions
90.1-2013 - Section 5 – 5.5.1
Prescriptive – Above Grade Wall Insulation, Climate Zone 4

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

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4 Except Marine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>R-5.7ci</td>
<td>R-5.7ci</td>
<td>R-5.7ci</td>
<td>R-7.6ci</td>
</tr>
<tr>
<td>Metal building</td>
<td>R-13+6.5ci</td>
<td>R-13+6.5ci</td>
<td>R-13+R-13ci</td>
<td>R-13+R-13ci</td>
</tr>
<tr>
<td>Metal Framed</td>
<td>R-13+R-5ci</td>
<td>R-13+R-5ci</td>
<td>R-13+7.5ci</td>
<td>R-13+7.5ci</td>
</tr>
<tr>
<td>Wood Framed &amp; Other</td>
<td>R-13+R-3.8ci or R-20</td>
<td>R-13+R-3.8ci or R-20</td>
<td>R-13+R-3.8ci or R-20</td>
<td>R-13+R-3.8ci or R-20</td>
</tr>
</tbody>
</table>
### 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**

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Framed</td>
<td>R-13+ 7.5ci</td>
<td>R-13+ 7.5ci</td>
<td>R-13+ 7.5ci</td>
<td>R-13+ 15.6ci</td>
</tr>
<tr>
<td>Wood Framed &amp; Other Other</td>
<td>R-13+R-7.5ci or R-20+R-3.8 ci</td>
<td>R-13+R-7.5ci or R-20+R-3.8 ci</td>
<td>R-13+R-7.5ci or R-20+R-3.8 ci</td>
<td>R-13+R-15.6ci or R-20+R-10ci</td>
</tr>
</tbody>
</table>
Below Grade Walls

- What is a below grade wall?
  - Any basement or first-story wall that is ≥ 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

<table>
<thead>
<tr>
<th></th>
<th>CZ 1</th>
<th>CZ2</th>
<th>CZ3</th>
<th>CZ4</th>
<th>CZ5</th>
<th>CZ6</th>
<th>CZ7</th>
<th>CZ8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non Res Assembly Max C</strong></td>
<td>1.14</td>
<td>1.14</td>
<td>1.14</td>
<td>0.119</td>
<td>0.119</td>
<td>0.092</td>
<td>0.063</td>
<td>0.063</td>
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<tr>
<td><strong>Non Res Min R</strong></td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>7.5 ci</td>
<td>7.5 ci</td>
<td>10.0 ci</td>
<td>15.0 ci</td>
<td>15.0 ci</td>
</tr>
<tr>
<td><strong>Res Assembly Max C</strong></td>
<td>1.14</td>
<td>1.14</td>
<td>1.14</td>
<td>0.092</td>
<td>0.092</td>
<td>0.063</td>
<td>0.063</td>
<td>0.063</td>
</tr>
<tr>
<td><strong>Res Min R</strong></td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>10.0 ci</td>
<td>10.0 ci</td>
<td>15.0 ci</td>
<td>15.0 ci</td>
<td>15.0 ci</td>
</tr>
<tr>
<td><strong>Semi Htd Assembly Max C</strong></td>
<td>1.14</td>
<td>1.14</td>
<td>1.14</td>
<td>1.14</td>
<td>1.14</td>
<td>0.119</td>
<td>0.119</td>
<td>0.119</td>
</tr>
<tr>
<td><strong>Semi Htd Min R</strong></td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>7.5 ci</td>
<td>7.5 ci</td>
<td>7.5 ci</td>
</tr>
</tbody>
</table>
### 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*

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4 Except Marine</th>
<th>5 And Marine 4</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below grade wall</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>R-7.5ci</td>
<td>R-7.5ci</td>
<td>R-7.5ci</td>
<td>R-7.5ci</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th></th>
<th>CZ 1</th>
<th>CZ2</th>
<th>CZ3</th>
<th>CZ4</th>
<th>CZ5</th>
<th>CZ6</th>
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<tr>
<td>Assembly</td>
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<tr>
<td>Max U</td>
<td>0.322</td>
<td>0.107</td>
<td>0.074</td>
<td>0.057</td>
<td>0.057</td>
<td>0.051</td>
<td>0.042</td>
<td>0.038</td>
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<tr>
<td>Non Res</td>
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</tr>
<tr>
<td>Min R</td>
<td>NR</td>
<td>6.3 ci</td>
<td>10.0 ci</td>
<td>14.6 ci</td>
<td>14.6 ci</td>
<td>16.7 ci</td>
<td>20.9 ci</td>
<td>23.0 ci</td>
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<td>Res</td>
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<td>Max U</td>
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<td>0.087</td>
<td>0.074</td>
<td>0.051</td>
<td>0.051</td>
<td>0.051</td>
<td>0.042</td>
<td>0.038</td>
</tr>
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## 90.1-2013 Section 5.5.3.4
Floor Insulation – Wood Framed and Other

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### Table A5.3.3.1 Assembly U-Factors for Steel Joist Floors

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<th>Framing Type and Spacing Width (Actual Depth)</th>
<th>Overall U-Factor for Assembly of Base Floor Plus Continuous Insulation (Uninterrupted by Framing)</th>
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<td>R-Value Based on Effective Installed Insulation</td>
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<td>2 in.</td>
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<tr>
<td>5 in.</td>
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#### Steel Joist Floor with Rigid Foam

- None (0.0): 0.350, 0.259, 0.206
- 1 in.: R-4 (3.88): 0.148, 0.129, 0.114
- 2 in.: R-8 (7.52): 0.096, 0.088, 0.081

#### Steel Joist Floor with Spray-on Insulation

- None (0.0): 0.350, 0.259, 0.206
- 1 in.: R-4 (3.88): 0.148, 0.129, 0.114
- 2 in.: R-8 (7.52): 0.096, 0.088, 0.081
## 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*

<table>
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<tr>
<th>Climate Zone</th>
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<td>R-10ci</td>
<td>R-10.4ci</td>
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Slab-on-Grade Floor Insulation

Meet or exceed values in appropriate table for climate zone \textit{(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
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<td><strong>20.0 for 24”</strong></td>
<td><strong>20.0 for 48”</strong></td>
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## 90.1-2013 Section 5.5.3.5
Heated Slab on Grade Floor Insulation

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### 2015 IECC – Table C402.1.3

**Prescriptive Slab on Grade**

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<td><strong>NR</strong></td>
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<td>R-15 for 24 in. below</td>
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</tbody>
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*Second column is always Group R and first column is always Other than Group R*
### 2015 IECC – Table C402.1.3
Prescriptive Slab on Grade

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<td>R-10 for 24 in. below</td>
<td>R-10 for 24 in. below</td>
<td>R-15 for 24 in. below</td>
</tr>
<tr>
<td><strong>Heated Slabs</strong></td>
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<td>R-15 for 36 in. below</td>
<td>R-15 for 48 in. below</td>
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*Second column is always Group R and first column is always Other than Group R*
### 90.1-2013 Section 5.5.3.6
Opaque Doors – Maximum Assembly U Factor

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<tbody>
<tr>
<td>Non Res Swinging</td>
<td>0.700</td>
<td>0.700</td>
<td>0.700</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
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<tr>
<td>Non Res Nonswinging</td>
<td>1.450</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
</tr>
<tr>
<td>Res Swinging</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
</tr>
<tr>
<td>Res Nonswinging</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
</tr>
<tr>
<td>Semi Htd Swinging</td>
<td>0.700</td>
<td>0.700</td>
<td>0.700</td>
<td>0.700</td>
<td>0.700</td>
<td>0.700</td>
<td>0.700</td>
<td>0.500</td>
</tr>
<tr>
<td>Semi Htd Nonswinging</td>
<td>1.450</td>
<td>1.450</td>
<td>1.450</td>
<td>1.450</td>
<td>1.450</td>
<td>0.500</td>
<td>0.500</td>
<td>0.500</td>
</tr>
</tbody>
</table>
Opaque Doors
2015 IECC C402.4.4

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

Swinging doors
- U <= 0.61 in Climate Zones 1-3 and 4 other than marine
- U<=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
Fenestration

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
### Prescriptive – Fenestration Climate Zone 4 Example

<table>
<thead>
<tr>
<th>Fenestration</th>
<th>Assembly Max. U</th>
<th>Assembly Max. SHGC</th>
<th>Assembly Min. VT/SHGC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Fenestration, 0%-40% of Wall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonmetal framing, all</td>
<td>U-0.50⁰</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal framing, fixed</td>
<td>U-0.57⁰</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal framing, operable</td>
<td>U-0.65⁰ SHGC-0.25</td>
<td>1.10</td>
<td></td>
</tr>
<tr>
<td>Metal framing, entrance door</td>
<td>U-1.10⁰</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Skylight, 0%-3% of Roof       |                 |                    |                       |
| All types                     | U-0.75 SHGC-0.35 | 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

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4 EXCEPT MARINE</th>
<th>5 AND MARINE 4</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-factor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed</td>
<td>0.50</td>
<td>0.50</td>
<td>0.46</td>
<td>0.38</td>
<td>0.38</td>
<td>0.36</td>
<td>0.29</td>
</tr>
<tr>
<td>Operable</td>
<td>0.65</td>
<td>0.65</td>
<td>0.60</td>
<td>0.45</td>
<td>0.45</td>
<td>0.43</td>
<td>0.37</td>
</tr>
<tr>
<td>Entrance</td>
<td>1.10</td>
<td>0.83</td>
<td>0.77</td>
<td>0.77</td>
<td>0.77</td>
<td>0.77</td>
<td>0.77</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SHGC</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation</td>
<td>SEW</td>
<td>N</td>
<td>SEW</td>
<td>N</td>
<td>SEW</td>
<td>N</td>
<td>SEW</td>
</tr>
<tr>
<td>PF &lt; 0.2</td>
<td>0.25</td>
<td>0.33</td>
<td>0.25</td>
<td>0.33</td>
<td>0.25</td>
<td>0.33</td>
<td>0.40</td>
</tr>
<tr>
<td>0.2 ≤ PF &lt; 0.5</td>
<td>0.30</td>
<td>0.37</td>
<td>0.30</td>
<td>0.37</td>
<td>0.30</td>
<td>0.37</td>
<td>0.48</td>
</tr>
<tr>
<td>PF ≥ 0.5</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
<td>0.64</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Skylights</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U-factor</td>
<td>0.75</td>
<td>0.65</td>
<td>0.55</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>SHGC</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
<td>NR</td>
</tr>
</tbody>
</table>

- 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

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.
IECC Section C402.4.3 Projection Factor

Required SHGC is adjusted based on projection factor associated with any overhangs
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 ≤ 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
Minimum skylight area must be provided in enclosed spaces that are

- \( \geq 2500 \text{ ft}^2 \)
- In spaces with ceiling height > 15 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
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 ft² in floor area directly under a roof with > 75% of ceiling area with ceiling height > 15 ft.

- total daylight zone under skylights to not be < ½ 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 W/ft²
- 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 ft² and lighting is controlled per C405.2.5 (Exterior Lighting Controls)
Determined in accordance with NFRC 200

**Exceptions**

- SC x 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) \( A_w \times \text{SHGC}_w \leq (A_t \times \text{SHGC}_c)/4 \) and \( A_e \times \text{SHGC}_e \leq (A_t \times \text{SHGC}_c)/4 \)

Where,
\( A_w \) and \( \text{SHGC}_w \) = west-oriented vertical fenestration area and SHGC
\( A_e \) and \( \text{SHGC}_e \) = east-oriented vertical fenestration area and SHGC
\( A_t \) = total vertical fenestration area
\( \text{SHGC}_c \) = 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 \( \text{SHGC}_c \)
- 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**
- Envelope
- HVAC
- SWH
- Power
- Lighting
- Other

**Compliance Options**
- Prescriptive Option
- Trade Off Option
- Energy Cost Budget
- Simplified

**Mandatory Provisions**
(required for most compliance options)
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
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 $\leq 0.004$ cfm/ft$^2$ under pressure differential of 0.3 in. water tested in accordance with ASTM E 2178

These materials meet these requirements:

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness (minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plywood</td>
<td>3/8 in.</td>
</tr>
<tr>
<td>Oriented strand board</td>
<td>3/8 in.</td>
</tr>
<tr>
<td>Extruded polystyrene insulation board</td>
<td>½ in.</td>
</tr>
<tr>
<td>Foil-faced urethane insulation board</td>
<td>½ in.</td>
</tr>
<tr>
<td>Exterior gypsum sheathing or interior gypsum board</td>
<td>½ in.</td>
</tr>
<tr>
<td>Cement board</td>
<td>½ in.</td>
</tr>
<tr>
<td>Built up roofing membrane</td>
<td></td>
</tr>
<tr>
<td>Modified bituminous roof membrane</td>
<td></td>
</tr>
<tr>
<td>Fully adhered single-ply roof membrane</td>
<td></td>
</tr>
<tr>
<td>A Portland cement/sand parget, stucco, or gypsum plaster</td>
<td>½ in.</td>
</tr>
<tr>
<td>Cast-in-place and precast concrete</td>
<td></td>
</tr>
<tr>
<td>Sheet metal</td>
<td></td>
</tr>
<tr>
<td>Closed cell 2 lb/ft$^3$ nominal density spray polyurethane foam</td>
<td>1 in.</td>
</tr>
</tbody>
</table>
90.1-2013/2015 IECC similar language and table

OR

Assemblies of materials and components (sealants, tapes, etc.) with average air leakage \(\leq 0.04 \text{ cfm/ft}^2\) 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

<table>
<thead>
<tr>
<th>Product</th>
<th>cfm/ft²</th>
<th>Procedure</th>
<th>psf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glazed swinging entrance doors and revolving doors</td>
<td>1.0</td>
<td>AAMA/WDMA/CSA 101/I.S.2/A440, NFRC 400, or ASTM E283</td>
<td>1.57</td>
</tr>
<tr>
<td>Curtain wall and storefront glazing</td>
<td>0.06</td>
<td>NFRC 400 or ASTM E283</td>
<td>1.57</td>
</tr>
<tr>
<td>Unit skylights with condensation weepage openings</td>
<td>0.3</td>
<td>AAMA/WDMA/CSA 101/I.S.2/A440 or NFRC 400</td>
<td>1.57</td>
</tr>
<tr>
<td>Unit skylights with condensation weepage openings</td>
<td>0.5</td>
<td>AAMA/WDMA/CSA 101/I.S.2/A440</td>
<td>6.24</td>
</tr>
<tr>
<td>Nonswinging doors for vehicular access and material transportation</td>
<td>1.3</td>
<td>ANSI/DASMA 105, NFRC 400, or ASTM E283</td>
<td>1.57</td>
</tr>
<tr>
<td>Nonswinging opaque doors, glazed sectional garage doors, and upward</td>
<td>0.4</td>
<td>ANSI/DASMA 105, NFRC 400, or ASTM E283</td>
<td>1.57</td>
</tr>
<tr>
<td>acting nonswinging glazed doors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All other products</td>
<td>0.2</td>
<td>AAMA/WDMA/CSA 101/I.S.2/A440 or NFRC 400</td>
<td>1.57</td>
</tr>
<tr>
<td>All other products</td>
<td>0.3</td>
<td>AAMA/WDMA/CSA 101/I.S./A440</td>
<td>6.24</td>
</tr>
</tbody>
</table>

### 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

<table>
<thead>
<tr>
<th>Fenestration Assembly</th>
<th>cfm/ft²</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows, sliding glass doors, and swinging doors</td>
<td>0.20</td>
<td>AAMA/WDMA/CSA 101/I.S.2/A440 or NFRC 400</td>
</tr>
<tr>
<td>Skylights - with condensation weepage openings</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Skylights – all other</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Curtain walls and storefront glazing</td>
<td>0.06</td>
<td>NFRC 400 or ASTM E 283 at 1.57 psf</td>
</tr>
<tr>
<td>Commercial glazed swinging entrance doors</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Revolving doors</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Garage doors</td>
<td>0.4</td>
<td>ANSI/DASMA 105, NFRC 400, or ASTM E 283 at 1.57 psf</td>
</tr>
<tr>
<td>Rolling doors</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>High-speed doors</td>
<td>1.30</td>
<td></td>
</tr>
</tbody>
</table>

✔ **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 ft\(^2\) 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 ≥ 3,000 ft²
- 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 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

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

- 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

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BECP Website:  
www.energycodes.gov

BECP Solutions & Help Center:  
www.energycodes.gov/help/