Acknowledgements

PNNL and DOE would like to thank ASHRAE Standing Standard Project Committee 90.1 for their contributions to the development of this presentation and their technical review of the content.
Summary of Changes

- Comprehensive update to the fenestration prescriptive requirements in Tables 5-5-0 through 5-5-8
- Orientation requirements for vertical fenestration were tightened
- SHGC credit for shading by permanent projections was modified to correct how it addressed north-facing fenestration
- Whole building air leakage testing added as an option
- Thresholds for conditioned space were lowered
Compliance Paths
Building Envelope

Building System
- Envelope
- HVAC
- SWH
- Power
- Lighting
- Other

Compliance Options
- Mandatory Provisions (required for all compliance options)
- Prescriptive Option
- Trade Off Option
- Energy Cost Budget
- Performance Rating Method

Energy Code Compliance
Section 5.1 General
   - Scope
   - Space-Conditioning Categories
   - Envelope Alterations
   - Climate

Section 5.2 Definition of Compliance Paths

Section 5.3 Simplified Building (Not Used)

Section 5.4 Mandatory Provisions
   - Insulation
   - Fenestration and Doors
   - Air Leakage
   - Loading Dock Weatherseals
   - Vestibules
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)

Inspection and Verification (Section 5.9)
Separate envelope component requirements apply to three types of conditioned spaces

- **Nonresidential**
- **Residential**
- **Semiheated**

*Semiheated spaces* are heated, but not to comfort levels, and not cooled.
Section 5
Building Envelope

Diagram:
- Exterior Envelope
- Semi-Exterior Envelope
- Ventilated Attic
- Semiheated Storage
- Conditioned Space
- Unconditioned Space
- Ventilated Crawlspace
Envelope Requirements Are Specified by Space-Conditioning Categories

- Conditioned space must be
  - a *cooled space* with a cooling system sensible cooling output capacity larger than 3.4 Btu/h·ft² of floor area
  - a *heated space* with a heating system output capacity larger than that specified in table below
  - Or, an *indirectly conditioned space*

<table>
<thead>
<tr>
<th>Heating Output, Btu/h·ft²</th>
<th>Climate Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;5</td>
<td>0, 1, 2</td>
</tr>
<tr>
<td>&gt;9</td>
<td>3A, 3B</td>
</tr>
<tr>
<td>&gt;7</td>
<td>3C</td>
</tr>
<tr>
<td>&gt;10</td>
<td>4A, 4B</td>
</tr>
<tr>
<td>&gt;8</td>
<td>4C</td>
</tr>
<tr>
<td>&gt;12</td>
<td>5</td>
</tr>
<tr>
<td>&gt;14</td>
<td>6</td>
</tr>
<tr>
<td>&gt;16</td>
<td>7</td>
</tr>
<tr>
<td>&gt;19</td>
<td>8</td>
</tr>
</tbody>
</table>
Semiheated space

- has a heating system with a capacity $\geq 3.4 \text{ Btu/h-ft}^2$ of floor area but is not conditioned space
- Space is not cooled at all

Spaces are assumed to be conditioned space and comply with requirements of conditioned space at time of construction regardless of whether the mechanical or electrical equipment is included in the building permit application or installed at that time

Exceptions:

- Space is designated as semiheated or unconditioned and
- Approved as such by the building official
## Section 5
### Envelope Alteration Exceptions

**Allowed if they don’t increase energy usage of building**

- ✔ Installation of storm windows or glazing panels with low-emissivity coating
- ✔ Replacement of glazing in existing sash and frame provided $U$-factor and $SHGC < \text{than previous glass}$
- ✔ *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* that separate *conditioned space* from exterior do not require a vestibule provided existing vestibule is not removed
- ✔ Replacement of existing fenestration, provided area of replacement is no more than 25% of total fenestration area provided $U$-factor and $SHGC < \text{than previous fenestration}$
Section 5 – 5.1.4
Climate – Climate Zone Update

- More accurately represents recent climate, better data
- Aligns with ASHRAE Standard 169-2013
- Retains same climate zone definitions (based on HDDs)
  - Some U.S. counties have shifted zones
- Reflects weather over the most recent 30 years
- Adds new Climate Zone 0 (extremely hot)
- Approximately 10% of U.S. counties reassigned to a different climate zone with a majority reassigned to a warmer climate zone
United States Locations – Use ASHRAE Standard 169 Table Annex 1-1

<table>
<thead>
<tr>
<th>State/County</th>
<th>Zone</th>
<th>State/County</th>
<th>Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama (AL)</td>
<td>2A</td>
<td>Arkansas (AR)</td>
<td></td>
</tr>
<tr>
<td>Zone 3A except...</td>
<td></td>
<td>Zone 3A except...</td>
<td></td>
</tr>
<tr>
<td>Baldwin</td>
<td>2A</td>
<td>Baxter</td>
<td>4A</td>
</tr>
<tr>
<td>Coffee</td>
<td>2A</td>
<td>Benton</td>
<td>4A</td>
</tr>
<tr>
<td>Covington</td>
<td>2A</td>
<td>Boone</td>
<td>4A</td>
</tr>
<tr>
<td>Dale</td>
<td>2A</td>
<td>Carroll</td>
<td>4A</td>
</tr>
<tr>
<td>Escambia</td>
<td>2A</td>
<td>Fulton</td>
<td>4A</td>
</tr>
<tr>
<td>Geneva</td>
<td>2A</td>
<td>Izard</td>
<td>4A</td>
</tr>
<tr>
<td>Henry</td>
<td>2A</td>
<td>Madison</td>
<td>4A</td>
</tr>
<tr>
<td>Houston</td>
<td>2A</td>
<td>Marion</td>
<td>4A</td>
</tr>
</tbody>
</table>
Compliance Option

Building System

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

Mandatory Provisions
(required for all compliance options)

Compliance Options

- Prescriptive Option
- Trade Off Option
- Energy Cost Budget
- Performance Rating Method

Energy Code Compliance
Section 5 – 5.4
Mandatory Provisions

Insulation (Section 5.4.1 refers to 5.8.1. through 5.8.1.10)

- Labeling (Section 5.8.1.1)
- Compliance with Manufacturers’ Requirements (Section 5.8.1.2)
- Loose-Fill Insulation Limitation (Section 5.8.1.3)
- Baffles (Section 5.8.1.4)
- Substantial Contact (Section 5.8.1.5)
- Recessed Equipment (Section 5.8.1.6)
- Insulation Protection (Section 5.8.1.7)
- Location of roof insulation (Section 5.8.1.8)
- Extent of Insulation (Section 5.8.1.9)
- Joints in Rigid Insulation (Section 5.8.1.10)
Section 5 – 5.4
Mandatory Provisions

✓ Fenestration and Doors (Section 5.4.2 that refers to 5.8.2)
✓ Air Leakage (Section 5.4.3)

Photo courtesy of Ken Baker, K energy
Section 5 – 5.4.3
Air Leakage

- Continuous air barrier
- Fenestration and doors
- Loading dock weather seals
- Vestibules
Section 5 – 5.4.3.1
Air Leakage – Continuous Air Barrier

- **Continuous air barrier** required except in:
  - *Semiheated spaces* in climate zones 0-6
  - 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 from wind, stack effect, and mechanical ventilation
Section 5 – 5.4.3.1.2
Air Leakage – Air Barrier Installation

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 *continuous air barrier* materials
New Whole-Building Testing Option

3 Options to Comply (a, b, or c):
Whole-Building Testing
Materials Testing
Assemblies of Materials Testing
Option 1: Whole-Building Testing [5.4.3.1.3(a) Whole-building pressurization testing]

Buildings > 50,000 sf
Can comply by testing only (and all) the following portions and area-weighting measured air leakage:

a) Floor areas under roof or with building entrances
b) Representative above-grade wall sections totaling at least 25% of wall area, not including floor area in (a)

Buildings < 50,000 sf
Must comply by testing entire building

1. Building complies if measured air leakage rate is less than 0.40 cfm/ft² at 0.30 in. of water
2. If measured air leakage rate is greater than 0.40 cfm/ft² but less than 0.60 cfm/ft²
   • Perform diagnostic evaluation (smoke tracer, infrared imaging, etc.) and seal identified leaks
   • Perform visual inspection of air barrier and seal identified leaks
   • Submit report to code official and building owner identifying corrective actions taken to seal leaks
Option 2: Materials Testing [5.4.3.1 (b)]

Materials with an air permeance of < 0.004 cfm/ft² under pressure differential of 0.3 in. of H₂O when 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><strong>Single-ply</strong> roof membrane</td>
<td></td>
</tr>
<tr>
<td>A Portland cement/sand parge, 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/ft³ nominal density spray polyurethane foam</td>
<td>1 in.</td>
</tr>
</tbody>
</table>
Option 3: Assemblies of Materials Testing \([5.4.3.1\text{ (c)}]\)

Assemblies of materials and components (sealants, tapes, etc.) that have an average air leakage \(< 0.04 \text{ cfm/ft}^2\) under a pressure differential of 0.3 in. of H\(_2\)O when tested in accordance with ASTM E 2357, 1677, 1680, or 283. The following assemblies meet these requirements:

Concrete masonry *walls* that are

a. Fully grouted, or

b. Painted to fill the pores.
### Section 5 – 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 <em>swinging entrance doors</em>, glazed power-operated sliding <em>entrance doors</em>, glazed power-operated folding <em>entrance doors</em>, and revolving <em>doors</em></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>Curtainwall 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 <em>skylights</em> 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><em>Nonswinging doors</em> for vehicular access and material transportation (min. opening of 32 in/s)</td>
<td>1.3</td>
<td>ANSI/DASMA 105, NFRC 400, or ASTM E283</td>
<td>1.57</td>
</tr>
<tr>
<td><em>Opaque nonswinging doors</em>, glazed sectional garage doors, and upward acting glazed nonswinging doors</td>
<td>0.4</td>
<td>ANSI/DASMA 105, NFRC 400, or ASTM E283</td>
<td>1.57</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 semiheated spaces in climate zones 0-6** not to exceed 1.0 cfm/ft² when tested at 1.57 psf in accordance with same procedures as revolving doors
- 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
In climate zones 0 and 4-8

- Cargo doors and loading dock doors equipped with weatherseals
  - To restrict infiltration when vehicles are parked in the loading dock/doorway
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
- *Floor* area of each vestibule to not exceed the greater of 50 ft\(^2\) or 2\% of the gross *conditioned floor area* for that level of the *building*
- Exterior envelope of conditioned vestibule comply with *conditioned space* requirements
- Interior/exterior envelope of unconditioned vestibule comply with *semiheated space* requirements
Section 5
Air Leakage – Vestibules Exceptions

- Non-entrance doors or doors opening from dwelling unit
- Building entrances with revolving doors
- All building entrances in climate zones 1 and 2 OR in buildings < 4 stories and < 10,000 ft\(^2\) in gross conditioned floor area in climate zone 3 OR in buildings < 1000 ft\(^2\) in gross conditioned floor area in climate zones 0 and 4-8
- All doors that open from spaces < 3000 ft\(^2\) and separate from building entrance
- Semiheated spaces
- Enclosed elevator lobbies for building entrances directly from parking garages
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.
Compliance Approach
Building Envelope

**Building System**
- Envelope
- HVAC
- SWH
- Power
- Lighting
- Other

**Compliance Options**
- Prescriptive Option
- Trade Off Option
- Energy Cost Budget
- Performance Rating Method

**Mandatory Provisions**
(required for all compliance options)
Each envelope component must separately meet designated space conditioning requirements: (Nonresidential, Residential, and/or Semiheated)

Opaque Areas (5.5.3)

Fenestration (5.5.4)
- WWR ≤ 40% of gross wall area
- Skylight-roof ratio ≤ 3% of roof area

Prescriptive requirements for each component specified by climate zone and space conditioning category (Tables 5.5-0 through 5.5-8)
- Insulation levels for roofs, walls, floors and doors
- Fenestration criteria for windows, glazed doors and skylights
Compliance

✓ Meet or exceed minimum \textit{R-values} in table
  – Only \textit{R-value} of insulation, not to include air films, etc.
    OR

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

✓ Perform area-weighted average \textit{U-factor}, \textit{C-factor}, or \textit{F-factor}
  – Only if there are multiple assemblies within a \textbf{single} class of construction for a \textbf{single} \textit{space-conditioning} category
## Table 5.5-0 Building Envelope Requirements for Climate Zone 0 (A,B)*

<table>
<thead>
<tr>
<th>Opaque Elements</th>
<th>Nonresidential</th>
<th>Residential</th>
<th>Semiheated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assembly Max.</td>
<td>Insulation Min. R-Value</td>
<td>Assembly Max.</td>
</tr>
<tr>
<td><strong>Roofs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation Entirely above Deck</td>
<td>U-0.039</td>
<td>R-25 c.i.</td>
<td>U-0.032</td>
</tr>
<tr>
<td>Metal Building Attic and Other</td>
<td>U-0.041</td>
<td>R-10 + 19 FC</td>
<td>U-0.041</td>
</tr>
<tr>
<td></td>
<td>U-0.027</td>
<td>R-38</td>
<td>U-0.027</td>
</tr>
</tbody>
</table>

**Wall, below-Grade**

| Below-grade wall | C-1.140 | NR | C-1.140 | NR | C-1.140 | NR |

FC = filled cavity

Reference Table 5.5-0 on page 51 in 90.1-2016
## Section 5 – 5.5.1

### Opaque

#### Reference Table 5.5-1 on page 52 in 90.1-2016

<table>
<thead>
<tr>
<th>Opaque Elements</th>
<th>Nonresidential</th>
<th>Residential</th>
<th>Semiheated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assembly Maximum</td>
<td>Insulation Min. R-Value</td>
<td>Assembly Maximum</td>
</tr>
<tr>
<td><strong>Roofs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation Entirely above Deck</td>
<td>U-0.048</td>
<td>R-20 c.i.</td>
<td>U-0.039</td>
</tr>
<tr>
<td>Metal Building</td>
<td>U-0.041</td>
<td>R-10 + 19 FC</td>
<td>R-38</td>
</tr>
<tr>
<td>Attic and Other</td>
<td>U-0.027</td>
<td>U-0.027</td>
<td>U-0.027</td>
</tr>
<tr>
<td>Wood-framed and other</td>
<td>C-0.088</td>
<td>R-13</td>
<td>C-0.088</td>
</tr>
<tr>
<td><strong>Wall, below Grade</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below-grade wall</td>
<td>C-1.140</td>
<td>NR</td>
<td>C-1.140</td>
</tr>
</tbody>
</table>

FC = filled cavity
### TABLE 5.5-1 (Cont’d)

<table>
<thead>
<tr>
<th>Fenestration</th>
<th>Assembly Max. U</th>
<th>Assembly Max. SHGC</th>
<th>Assembly Min. VT/SHGC</th>
<th>Assembly Max. U</th>
<th>Assembly Max. SHGC</th>
<th>Assembly Min. VT/SHGC</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% to 40% of Wall</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonmetal framing, all</td>
<td>0.50</td>
<td>0.25</td>
<td>1.10</td>
<td>0.50</td>
<td>0.25</td>
<td>1.10</td>
<td>0.93</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Metal framing, fixed</td>
<td>0.57</td>
<td></td>
<td></td>
<td>0.57</td>
<td></td>
<td></td>
<td>1.20</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td>Metal framing, operable</td>
<td>0.65</td>
<td></td>
<td></td>
<td>0.65</td>
<td></td>
<td></td>
<td>1.20</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td>Metal framing, entrance door</td>
<td>1.10</td>
<td></td>
<td></td>
<td>1.10</td>
<td></td>
<td></td>
<td>1.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skylight, 0% to 3% of Roof</td>
<td></td>
<td>0.35</td>
<td>NR</td>
<td>0.75</td>
<td>0.35</td>
<td>NR</td>
<td>1.80</td>
<td>NR</td>
<td>NR</td>
</tr>
</tbody>
</table>

* The following definitions apply: c.i. = continuous insulation (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), 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.
### Table 5.5-2 Building Envelope Requirements for Climate Zone 2 (A,B)*

<table>
<thead>
<tr>
<th>Opaque Elements</th>
<th>Nonresidential</th>
<th>Residential</th>
<th>Semiheated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assembly Max.</td>
<td>Insulation Min. R-Value</td>
<td>Assembly Max.</td>
</tr>
<tr>
<td><strong>Roofs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation Entirely above Deck</td>
<td>U-0.039</td>
<td>R-25 c.i.</td>
<td>U-0.039</td>
</tr>
<tr>
<td>Metal Building</td>
<td>U-0.041</td>
<td>R-10+R-19 FC</td>
<td>U-0.041</td>
</tr>
<tr>
<td>Attic and Other</td>
<td>U-0.027</td>
<td>R-38</td>
<td>U-0.027</td>
</tr>
<tr>
<td><strong>Wood-framed and other</strong></td>
<td>U-0.089</td>
<td>R-13</td>
<td>U-0.089</td>
</tr>
<tr>
<td><strong>Wall, below Grade</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below-grade wall</td>
<td>C-1.140</td>
<td>NR</td>
<td>C-1.140</td>
</tr>
</tbody>
</table>

Reference Table 5.5-2 on page 53 in 90.1-2016
# Table 5.5-3  Building Envelope Requirements for Climate Zone 3 (A,B,C)*

<table>
<thead>
<tr>
<th>Opaque Elements</th>
<th>Nonresidential</th>
<th></th>
<th>Residential</th>
<th></th>
<th>Semiheated</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assembly</td>
<td>Insulation</td>
<td>Assembly</td>
<td>Insulation</td>
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</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>Min. R-Value</td>
<td>Maximum</td>
<td>Min. R-Value</td>
<td>Maximum</td>
<td>Min. R-Value</td>
</tr>
<tr>
<td><strong>Roofs</strong></td>
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<td>Insulation Entirely</td>
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<td>R-25 c.i.</td>
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<td>R-25 c.i.</td>
<td>U-0.119</td>
<td>R-7.6 c.i.</td>
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<tr>
<td>above Deck</td>
<td>U-0.041</td>
<td>R-10+R-19 FC</td>
<td>U-0.041</td>
<td>R-10+R-19 FC</td>
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<td>Metal Building</td>
<td>U-0.027</td>
<td>R-38</td>
<td>R-0.027</td>
<td>R-38</td>
<td>R-0.053</td>
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<tr>
<td>Attic and Other</td>
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Reference Table 5.5-3 on page 54 in 90.1-2016
### Reference Table 5.5-4 on page 55 in 90.1-2016

<table>
<thead>
<tr>
<th>Opaque Elements</th>
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<tr>
<td><strong>Roofs</strong></td>
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<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-0.032</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>
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<tr>
<td>Attic and Other</td>
<td>U-0.021</td>
<td>R-49</td>
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<table>
<thead>
<tr>
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<th>Assembly</th>
<th>Insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wood-framed and other</strong></td>
<td>U-0.064</td>
<td>R-13 + R-3.8 c.i. or R-20</td>
</tr>
<tr>
<td><strong>Wall, below Grade</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Below-grade wall</strong></td>
<td>C-0.119</td>
<td>R-7.5 c.i.</td>
</tr>
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</table>
### Table 5.5-5 Building Envelope Requirements for Climate Zone 5 (A,B,C)*

<table>
<thead>
<tr>
<th>Opaque Elements</th>
<th>Nonresidential</th>
<th>Residential</th>
<th>Semiheated</th>
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<tbody>
<tr>
<td></td>
<td>Assembly</td>
<td>Insulation</td>
<td>Assembly</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>Min. R-Value</td>
<td>Maximum</td>
</tr>
<tr>
<td><strong>Roofs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation Entirely above Deck</td>
<td>R-30 c.i.</td>
<td>R-0.032</td>
<td>U-0.032</td>
</tr>
<tr>
<td>Metal Building</td>
<td>R-0.037</td>
<td>U-0.037</td>
<td>U-0.037</td>
</tr>
<tr>
<td>Attic and Other</td>
<td>R-0.021</td>
<td>U-0.021</td>
<td>U-0.021</td>
</tr>
<tr>
<td><strong>Wood-framed and other</strong></td>
<td>R-13 + R-7.5 c.i. or R-19 + R-5 c.i.</td>
<td>R-0.051</td>
<td>U-0.051</td>
</tr>
<tr>
<td><strong>Wall, below Grade</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below-grade wall</td>
<td>C-0.119</td>
<td>R-7.5 c.i.</td>
<td>C-0.092</td>
</tr>
</tbody>
</table>

Reference Table 5.5-5 on page 56 in 90.1-2016
### Reference Table 5.5-6 on page 57 in 90.1-2016

Table 5.5-6  *Building Envelope Requirements for Climate Zone 6 (A,B)*

<table>
<thead>
<tr>
<th>Opaque Elements</th>
<th>Nonresidential</th>
<th></th>
<th>Residential</th>
<th></th>
<th>Semiheated</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assembly</td>
<td>Insulation Min. R-Value</td>
<td>Assembly</td>
<td>Insulation Min. R-Value</td>
<td>Assembly</td>
<td>Insulation Min. R-Value</td>
</tr>
<tr>
<td><img src="Image" alt="Metal building" /></td>
<td>U-0.050</td>
<td>R-0 + R-19 c.i.</td>
<td>U-0.050</td>
<td>R-0 + R-19 c.i.</td>
<td>U-0.044</td>
<td>R-0 + R-9.8 c.i.</td>
</tr>
<tr>
<td><img src="Image" alt="Steel-framed" /></td>
<td>U-0.049</td>
<td>R-13 + R-12.5 c.i.</td>
<td>U-0.049</td>
<td>R-13 + R-12.5 c.i.</td>
<td>U-0.084</td>
<td>R-13 + R-3.8 c.i.</td>
</tr>
<tr>
<td><img src="Image" alt="Wood-framed and other" /></td>
<td>U-0.051</td>
<td>R-13 + R-7.5 c.i. or R-19 + R-5 c.i.</td>
<td>U-0.051</td>
<td>R-13 + R-7.5 c.i. or R-19 + R-5 c.i.</td>
<td>U-0.089</td>
<td>R-13</td>
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<tr>
<td><img src="Image" alt="Wall, below Grade" /></td>
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</tr>
<tr>
<td><img src="Image" alt="Below-grade wall" /></td>
<td>C-0.092</td>
<td>R-10 c.i.</td>
<td>C-0.083</td>
<td>R-15 c.i.</td>
<td>C-0.119</td>
<td>R-7.5 c.i.</td>
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## Table 5.5-7 Building Envelope Requirements for Climate Zone 7*

<table>
<thead>
<tr>
<th>Opaque Elements</th>
<th>Nonresidential</th>
<th>Residential</th>
<th>Semiheated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assembly</td>
<td>Insulation</td>
<td>Assembly</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>Min. R-Value</td>
<td>Maximum</td>
</tr>
<tr>
<td><strong>Roofs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation Entirely above Deck Metal Building</td>
<td>U-0.028</td>
<td>R-35 c.i.</td>
<td>U-0.028</td>
</tr>
<tr>
<td>Attic and Other</td>
<td>U-0.017</td>
<td>R-60</td>
<td>U-0.017</td>
</tr>
</tbody>
</table>

### Reference
Reference Table 5.5-7 on page 58 in 90.1-2016
### Reference Table 5.5-8 on page 59 in 90.1-2016

#### Section 5 – 5.5.1

##### Opaque

<table>
<thead>
<tr>
<th>Opaque Elements</th>
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<th>Residential</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Assembly</td>
<td>Insulation</td>
<td>Assembly</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>Min. R-Value</td>
<td>Maximum</td>
</tr>
<tr>
<td>Roofs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation Entirely above Deck Metal Building</td>
<td>U-0.028</td>
<td>R-35 c.i.</td>
<td>U-0.028</td>
</tr>
<tr>
<td></td>
<td>U-0.026</td>
<td>R-25+R-11+</td>
<td>U-0.026</td>
</tr>
<tr>
<td></td>
<td>U-0.017</td>
<td>R-11 Ls</td>
<td>U-0.017</td>
</tr>
<tr>
<td>Attic and Other</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>U-0.017</td>
<td>R-60</td>
<td></td>
</tr>
</tbody>
</table>

| Steel-framed                                | U-0.037        | R-13 + R-18.8 c.i. | U-0.037 | R-13 + R-18.8 c.i. | U-0.064 | R-13 + R-7.5 c.i. |
|                                             | U-0.032        | R-13 + R-18.8 c.i. | U-0.032 | R-13 + R-18.8 c.i. | U-0.051 | R-13 + R-7.5 c.i. |

| Wood-framed and other                       | C-0.063        | R-15 c.i. | C-0.063 | R-15 c.i. | C-0.119 | R-7.5 c.i. |

| Wall, below Grade                           |                |           |           |           |           |             |
|                                             |                |           |           |           |           |             |
| Below-grade wall                            | C-0.063        | R-15 c.i. | C-0.063 | R-15 c.i. | C-0.119 | R-7.5 c.i. |
## Table A5.3.3.1 Assembly U-Factors for Steel-Joist Floors

<table>
<thead>
<tr>
<th>Framing Type and Spacing Width (Actual Depth)</th>
<th>Cavity Insulation R-Value: Rated (Effective)</th>
<th>Overall U-Factor for Entire Base Floor Assembly</th>
<th>Overall U-Factor for Assembly of Base Floor Plus Continuous Insulation (Uninterrupted by Framing)</th>
<th>Rated R-Value of Continuous Insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framing Type and Spacing Width (Actual Depth)</td>
<td>Cavity Insulation R-Value: Rated (Effective)</td>
<td>Overall U-Factor for Entire Base Floor Assembly</td>
<td>Overall U-Factor for Assembly of Base Floor Plus Continuous Insulation (Uninterrupted by Framing)</td>
<td>Rated R-Value of Continuous Insulation</td>
</tr>
<tr>
<td>Framing Type and Spacing Width (Actual Depth)</td>
<td>Cavity Insulation R-Value: Rated (Effective)</td>
<td>Overall U-Factor for Entire Base Floor Assembly</td>
<td>Overall U-Factor for Assembly of Base Floor Plus Continuous Insulation (Uninterrupted by Framing)</td>
<td>Rated R-Value of Continuous Insulation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Steel Joist Floor with Rigid Foam</th>
<th>None (0.0)</th>
<th>0.350</th>
<th>0.259</th>
<th>0.206</th>
<th>0.171</th>
<th>0.146</th>
<th>0.127</th>
<th>0.113</th>
<th>0.101</th>
<th>0.092</th>
<th>0.084</th>
<th>0.078</th>
<th>0.067</th>
<th>0.063</th>
<th>0.059</th>
<th>0.056</th>
<th>0.044</th>
<th>0.036</th>
<th>0.030</th>
<th>0.026</th>
<th>0.023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Joist Floor with Batt Insulation</td>
<td>2 in. R-8 (7.52)</td>
<td>0.096</td>
<td>0.088</td>
<td>0.081</td>
<td>0.075</td>
<td>0.070</td>
<td>0.065</td>
<td>0.061</td>
<td>0.058</td>
<td>0.054</td>
<td>0.052</td>
<td>0.049</td>
<td>0.047</td>
<td>0.045</td>
<td>0.043</td>
<td>0.041</td>
<td>0.039</td>
<td>0.033</td>
<td>0.028</td>
<td>0.025</td>
<td>0.022</td>
</tr>
<tr>
<td>Steel Joist Floor with Batt Insulation</td>
<td>3 in. R-12 (10.80)</td>
<td>0.073</td>
<td>0.068</td>
<td>0.064</td>
<td>0.060</td>
<td>0.057</td>
<td>0.054</td>
<td>0.051</td>
<td>0.048</td>
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<td>0.044</td>
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<td>0.041</td>
<td>0.039</td>
<td>0.038</td>
<td>0.036</td>
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<td>0.033</td>
<td>0.030</td>
<td>0.026</td>
<td>0.023</td>
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<tr>
<td>Steel Joist Floor with Batt Insulation</td>
<td>4 in. R-16 (13.92)</td>
<td>0.060</td>
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<td>0.053</td>
<td>0.051</td>
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<td>0.046</td>
<td>0.044</td>
<td>0.042</td>
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<td>0.039</td>
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<td>0.034</td>
<td>0.032</td>
<td>0.031</td>
<td>0.027</td>
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<td>0.021</td>
<td>0.019</td>
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<tr>
<td>Steel Joist Floor with Batt Insulation</td>
<td>5 in. R-20 (17.00)</td>
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<td>0.046</td>
<td>0.044</td>
<td>0.042</td>
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<td>0.030</td>
<td>0.029</td>
<td>0.025</td>
<td>0.022</td>
<td>0.020</td>
<td>0.018</td>
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<tr>
<td>Steel Joist Floor with Batt Insulation</td>
<td>6 in. R-24 (19.68)</td>
<td>0.044</td>
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<td>0.041</td>
<td>0.039</td>
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<td>0.036</td>
<td>0.035</td>
<td>0.034</td>
<td>0.033</td>
<td>0.032</td>
<td>0.031</td>
<td>0.030</td>
<td>0.029</td>
<td>0.028</td>
<td>0.027</td>
<td>0.027</td>
<td>0.024</td>
<td>0.021</td>
<td>0.019</td>
<td>0.017</td>
</tr>
</tbody>
</table>
Meet or exceed minimum R-value in table for climate zone

*Skylight* curbs insulated to level of *roofs* with insulation entirely above deck or R-5, whichever is less.
Three types of *roofs* are defined

- **Roofs** with insulation entirely above deck
  - *R*-value is for continuous insulation
  - Exception: Interruptions for framing and pads 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
Section 5 – 5.8.1
Insulation Installation

- Rated *R*-value clearly identified by an identification mark applied by manufacturer to each piece of *building envelope* insulation
  - **Exception**- provide documentation

- Per manufacturer’s instructions

- Achieve rated *R*-value

- No open-blown or poured loose-fill insulation when ceiling slope is > 3/12

- If eave vents installed
  - Provide baffling of air vents to deflect incoming air above the surface of the insulation

  - **Metal buildings Exception**
    - if roof and *wall* insulation is compressed between *roof* or wall skin and the structure
Section 5
Roof Insulation Examples

Photos courtesy of MBMA
Section 5 – 5.5.3.1.1  
High Albedo Roofs

Required in climate zones 0-3

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
Section 5 – 5.5.3.1
High Albedo Roofs – Exceptions

• 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, *semiheated spaces*, or *conditioned spaces* that aren’t *cooled spaces*
• Asphalritic membranes in climate zones 2-3
Section 5
High Albedo Roof – Example
Meet or exceed *R-value* specified for climate zone in appropriate table

When *wall* consists of both above-grade and below-grade portion, entire *wall* to be insulated on either exterior or interior or be integral

If insulated on interior

- *above-grade wall* insulation requirements apply

If insulated on exterior or integral

- below-grade wall portion to be insulated to the below-grade wall requirements and
- above-grade to above-grade *wall* requirements
• **Above-grade wall** in Climate Zone 0 to meet one of the following:
  
  A. East and west *walls*, minimum of 75% of the opaque wall area to have a minimum SRI 29
     - glass sprandrel areas a minimum solar reflectance of 29% determined in accordance with NFRC 300 or ISO 9050 is permitted
     - Each *wall* is allowed to be considered separately

  B. East and west *walls*, minimum of 30% of the *above-grade wall* area be shaded through the use of shade-providing plants, manmade structures, *existing buildings*, hillsides, permanent *building* projections, *on-site renewable energy systems*, or combination
     - Shade coverage calculated at 10 a.m. for east *walls* and 3 p.m. for west *walls* on summer solstice

The building is allowed to be rotated up to 45 degrees to the nearest cardinal orientation for compliance calculation purposes
Four types of walls are defined

- Mass walls
  - *heat capacity (HC)* determined from Table A3.1-2 or A3.1-3
  - *Rated R-value* is for *continuous insulation* or when uninterrupted by framing other than metal clips no closer than 24 in. o.c. horizontally and 16 in. o.c. vertically

**Exception**
- Requirement of U-0.151
Four types of walls are defined (cont’d)

- 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
Meet or exceed values in appropriate table for climate zone

*R-value* is for continuous insulation

**Exception**
- If framing is used, compliance is based on maximum assembly **C-factor**
## Section 5 – 5.5.3.3

**Below-Grade Wall Insulation**

### Table A4.2.1 Assembly C-Factors for Below-Grade Walls

<table>
<thead>
<tr>
<th>Framing Type and Depth</th>
<th>Rated R-Value of Insulation Alone</th>
<th>Specified C-Factors (Wall Only, without Soil and Air Films)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Framing</td>
<td>R-0</td>
<td>C-1.140</td>
</tr>
<tr>
<td><strong>Exterior Insulation, Continuous and Uninterrupted by Framing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Framing</td>
<td>R-5.0</td>
<td>C-0.170</td>
</tr>
<tr>
<td>No Framing</td>
<td>R-7.5</td>
<td>C-0.119</td>
</tr>
<tr>
<td>No Framing</td>
<td>R-10.0</td>
<td>C-0.092</td>
</tr>
</tbody>
</table>
Meet or exceed values in appropriate table for climate zone

3 classes of floors over *unconditioned* space are defined:

- **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
Section 5 – 5.5.3.5
Slab-on-Grade Floor Insulation

For the *rated R-value* of insulation to be installed around the perimeter of the slab-on-grade floor to the distance specified or exceed the values in the appropriate table for climate zone.

Be installed around the perimeter to the distance specified

- **Inside foundation wall** – extend downward from top of slab a minimum distance specified or to the top of the footing, whichever is less
- **Outside foundation wall** – extend from top of the slab or downward to at least the bottom of the slab and then horizontally to a minimum distance specified
- In all climate zones, the horizontal insulation extending outside of the foundation to be covered by pavement or by soil a minimum of 10 in. thick

Exception: monolithic *slab-on-grade floor*, insulation to extend from the top of the *slab-on-grade* to the bottom of the footing.
**Section 5 – 5.5.3.6**

**Opaque Doors**

*U-factor* not greater than specified for climate zone in appropriate table

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<table>
<thead>
<tr>
<th>Opaque Elements</th>
<th>Nonresidential</th>
<th>Residential</th>
<th>Semiheated</th>
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<tr>
<td></td>
<td>Assembly</td>
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<td></td>
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<td>Opaque Doors</td>
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<td>Swinging</td>
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<td>U-0.370</td>
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<tr>
<td>Nonswinging</td>
<td>U-0.310</td>
<td>U-0.310</td>
<td></td>
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</tbody>
</table>
Criteria apply to fenestration, including windows, glass doors, glass block, plastic panels, and skylights

- specified by fenestration type, space-conditioning category and by climate zone

Compliance with values in Tables 5.5-0 through 5.5-8

- \( U\)-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

- Exceptions:
  - Area weighting allowed within same class of construction and space-conditioning category
  - Area weighting for vertical fenestration allowed across multiple classes of construction for a single space-conditioning category, but not across multiple space-conditioning categories
Total \textit{vertical fenestration area} to be smaller than specified values in Tables 5.5-0 through 5.5-8 (40% for all climate zones)

- Including both fixed and operable \textit{vertical fenestration}
- Exception: street-level \textit{vertical fenestration} (5.5.4.4.1)

Total \textit{skylight} area smaller than specified in Tables 5.5-0 through 5.5-8 (3% of roof area for all climate zones)

- Permitted to be no greater than 6\% of \textit{gross roof area} provided criteria in exception 1 to \textit{skylight SHGC} requirements are met (5.5.4.4.2) and \textit{daylight area under skylights} is more than or equal to half the \textit{floor area} of the \textit{space}
Minimum skylight area must be provided in enclosed spaces that are

- ≥ 2,500 ft²
- In spaces with ceiling height > 15 ft and
- Space types

  - Office
  - Lobby
  - Atrium
  - Concourse
  - Corridor
  - Storage (incl. nonrefrigerated warehouse)
  - Gymnasium/fitness/exercise area
  - Playing area
  - Gymnasium seating area
  - Convention exhibit/event space
  - Courtroom
  - Automotive service
  - Fire station engine room
  - Manufacturing
  - 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 provided

- 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**

- *Enclosed spaces* in Climate Zones 6-8
- *Enclosed 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* is < 2,500 ft and where lighting is controlled according to sidelighting requirements of Section 9.4.1
Section 5 – 5.5.4.3 and 5.8.2.3  
Fenestration U-Factor

**U-factor** not greater than specified in Tables 5.5-0 through 5.5-8

- **Exception:** *U-factor for skylights* allowed to be increased no greater than
  
  - 0.90 Btu/h•ft² °F in Climate Zone 0-3
  - 0.75 Btu/h•ft² °F in Climate Zone 4-8

Provided they have a glazing material or diffuser with a measured haze value greater than 90% when tested in accordance with ASTM D1003

Have a skylight VT greater than 0.40 and

All general lighting in the daylight area under *skylights* controlled by multi-level photocontrols in accordance with Section 9.4.1.1 (f)

Determined in accordance with NFRC 100

*Skylights* – determine for a slope of 20° above the horizontal

**Exceptions**

- A8.1 acceptable for skylights, A8.2 acceptable for other vertical fenestration, and A7 acceptable for opaque doors
- ANSI/DASMA 105 acceptable for *sectional garage doors and metal coiling doors*
Section 5 – 5.5.4.4
Fenestration SHGC

Vertical fenestration (5.5.4.4.1)
• SHGC values < Table value for appropriate total vertical fenestration area

Exceptions
• For south, east, or west-oriented vertical fenestration only, the SHGC in the proposed building can be reduced by using the multipliers in Table 5.5.4.4.1 for fenestration shaded by permanent projections that will last as long as the building itself
• For south, east, or west-oriented vertical fenestration shaded by partially opaque permanent projections that will last as long as the building itself, can reduce the PF by multiplying by values in Table 5.5.4.4.1
• Street-level exception only applies when using the prescriptive compliance option
• Dynamic glazing cannot be area-weighted with other fenestration and minimum SHGC of dynamic glazing shall be used to show compliance for dynamic glazing
• North-oriented vertical fenestration allowed to have SHGC equal to or less than the area-weighted average SHGC of the south, east, and west-oriented vertical fenestration before any reductions made for permanent projections in Exception 1 and 2 of Section 5.5.4.4.1
Information – Overhangs

Standard credits permanent overhangs by adjustment to SHGC

Size of overhang is determined by projection factor
Determined in accordance with NFRC 200

Exceptions

- *Shading Coefficient (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 an acceptable alternative for determining compliance*
- *SHGC from A8.2 for vertical fenestration is an acceptable alternative for determining compliance*
Skylights
  • $SHGC$ values < Table value for appropriate total skylight area

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

2. 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
Section 5 – 5.5.4.5
Fenestration Orientation

Two options to comply for vertical fenestration:
(a) For Climate Zones 0 - 8
\[ A_W \leq \frac{(A_T)}{4} \text{ and } A_E \leq \frac{(A_T)}{4} \]
OR
(b) For Climate Zones 0 – 3
\[ A_W \times \text{SHGC}_W \leq \frac{(A_T \times \text{SHGC}_C)}{4} \text{ and } A_E \times \text{SHGC}_E \leq \frac{(A_T \times \text{SHGC}_C)}{4} \]

For Climate Zones 4 – 8
\[ A_W \times \text{SHGC}_W \leq \frac{(A_T \times \text{SHGC}_C)}{5} \text{ and } A_E \times \text{SHGC}_E \leq \frac{(A_T \times \text{SHGC}_C)}{5} \]

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 5.5-0 through 5.5-8

Exceptions
- Complies with Exception 3 of Section 5.5.4.4.1
- 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 \( \text{SHGC}_C \)
- Buildings in Climate Zone 8
Section 5 – 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 5.5-0 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 space floor area*
  - with *skylights* complying with 5.5.4.2.3
  - where *sidelighting effective aperture* is $\geq 0.15$
- *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
### Compliance Approaches

**Building System**

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

**Compliance Options**

- Prescriptive Option
- Trade Off Option
- Energy Cost Budget
- Performance Rating Method

**Mandatory Provisions**

(required for all compliance options)
Proposed design must comply with Sections 5.1, 5.4, 5.7, 5.8, and 5.9

Proposed envelope performance factor (EPF) of proposed design is less than or equal to the proposed envelope performance factor of the base design

- 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 meet prescriptive requirements of Section 5.5
Section 5 – 5.7
Submittal Document Labeling of Space-Conditioning Categories

- General – AHJ can require compliance documentation and supplemental information per 4.2.2
- Space Conditioning Categories – if building has semiheated or unconditioned spaces and compliance is sought using semiheated criteria, spaces to be clearly indicated on floor plans
- Visible Transmittance – include test results for skylight glazing or diffusers (per 5.8.2.5)
- **Daylight Areas** – documentation to identify daylight areas on floor plans, including
  - Primary sidelighted areas
  - Secondary sidelighted areas
  - Daylight area under skylights
  - Daylight areas under roof monitor
✓ Labeling of Building Envelope Insulation *(Section 5.8.1.1)*
✓ Compliance with Manufacturers’ Requirements *(Section 5.8.1.2)*
✓ Loose-Fill Insulation Limitation *(Section 5.8.1.3)*
✓ Baffles *(Section 5.8.1.4)*
✓ Substantial Contact *(Section 5.8.1.5)*
✓ Recessed Equipment *(Section 5.8.1.6)*
✓ Insulation Protection *(Section 5.8.1.7)*
✓ Location of Roof Insulation *(Section 5.8.1.8)*
✓ Extent of Insulation *(Section 5.8.1.9)*
✓ Joints in Rigid Insulation *(Section 5.8.1.10)*
Install insulation in a permanent manner in substantial contact with inside surface

Flexible batt insulation in _floor_ cavities

- Supported in a permanent manner by supports no more than 24 in. on center (o.c.)
Recessed *equipment* should not affect insulation thickness

- Lighting fixtures
- HVAC *equipment* (includes *wall* heaters, ducts, and plenums)
- Other

**Except when**

- Total combined area affected (include necessary clearances) is < 1% of *opaque* area of the assembly, OR
- Entire *roof*, *wall*, or *floor* is covered with insulation to the full depth required, OR
- Effects of reduced insulation are included in area-weighted calculations and compressed insulation values from Table A9.4.3

In all cases, air leakage to be limited through or around recessed *equipment* to the *conditioned space* in accordance with Section 5.4.3 (Air leakage)
Insulation Protection

- Cover exterior insulation with protective material
  - Sunlight
  - Moisture
  - Landscaping operations
  - *Equipment* maintenance
  - Wind
- Access to attics and mechanical rooms without damaging or compressing insulation
- Insulation materials in ground contact to have a water absorption rate $\leq 0.3\%$ (*ASTM C272*)
Roof Insulation

- Not installed on a suspended ceiling with removable ceiling panels
- Non-compliant
• Insulation should extend over the full component area to the required *rated R-value of insulation*
  – *U-factor*
  – *C-factor*  OR
  – *F-factor*

Unless otherwise allowed in Section 5.8.1
Where 2 or more layers of rigid insulation board are used in a construction assembly

- the edge joints between each layer of boards to be staggered
Required Inspections:

• *Fenestration and doors*
  – Air leakage testing where applicable conducted by independent third party
  – Operation of *door* and closer or operating mechanism inspected for conformance with the *manufacturer’s instructions*
  – Seals or gaskets installed per *manufacturer’s instructions*

• *Loading dock weatherseals*
  – Ensure that the seals are in good condition
• Opaque building envelope air tightness
  – *Opaque roof, above-grade walls, and below-grade walls, and floors* subject to the following inspections:
    • Use of compliant materials and assemblies per Section 5.4.3.1.3
    • Integration with adjoining *fenestration* and *continuous air barrier* elements

• Fenestration
  – Skylights size and location in relation to designed *primary sidelighted area* and *secondary lighted area* below
  – *Roof monitor* size and location in relation to designed *primary sidelighted area* and *secondary lighted area* below
  – *Dynamic glazing* with *SHGC* and *U-factor* per Section 5.5.4.4.1 and 5.5.4.4.2 and testing of the operation of conformance per manufacturer’s instructions.
  – Permanent *fenestration* projections installation and performance per Section 5.5.4.4.1 and *construction documents*.
• Building Envelope Performance
  – Verified per Section 4.2.5

• Air Leakage
  – In accordance with one of the following methods:
    a. An air barrier design and installation program implemented to include:
       1. Design review conducted to assess compliance with requirements in Sections 5.4.3.1.1, 5.4.3.1.2 and applicable portions of 5.4.3.1.3
       2. Periodic field inspection of continuous air barrier components and assemblies conducted during construction while the air barrier is still accessible for inspection and repair to verify compliance with Sections 5.4.3.1.1, 5.4.3.1.2 and applicable portions of 5.4.3.1.3
       3. Reporting in compliance with Section 4.2.5
• Air Leakage cont’d
  b. A whole-building air leakage verification program implemented to include the following elements:

  1. whole-building pressurization testing performed in accordance with Section 5.4.3.1.3(a) and use of any exceptions documented

  2. Reporting in compliance with Section 4.2.5