Oregon Non-Residential Building Energy Code

OREGON DEPARTMENT OF ENERGY

Fenestration Performance

This Factsheet provides information on how to comply with window and skylight requirements of the Oregon Energy Code. This Factsheet focuses on the Prescriptive Compliance Method.

Window Performance

An important facet of an energy-efficient building envelope is the performance of the windows and skylights. It is also an area of the Oregon Energy Code that is often misunderstood. The Code includes prescriptive requirements for thermal performance (maximum U-factor and Shading Coefficient (SC)) as well as limitations on the maximum glazing fraction. These requirements differ depending on the type of opaque wall assemblies in the building and the climate zone the project is located in (Zone 1 or Zone 2). Requirements apply to windows and skylights, including site-built fenestration, curtain walls and glazed portions of doors with leaf width greater than four feet (including sliding glass doors). It is important to understand that the U-factor requirements are for the entire window assembly including glazing and framing and not just for the glass itself. Using center-of-glass performance for U-value will significantly overestimate the window performance. Unlike the U-factor, the SC may be determined as a center-of-glass value. Prescriptive code requirements are summarized in Table 1 - Prescriptive Fenestration Requirements.

Climate Zone 1 The Code allows a glazing fraction of up to 40% if high thermal performance windows are matched with a well-insulated wall. For example, if the building uses a frame wall with R-13 insulation, windows with overall U-factor of 0.37 or better, and an SC of 0.35 or better, the maximum glazing fraction is 40%. If the building uses masonry walls with integral insulation (CMU with filled cores), and windows with a maximum U-factor of 0.54 and maximum SC of 0.57, the maximum allowable glazing fraction is only 15%. Regardless of the type of wall construction, the window thermal performance requirements vary with the glazing percentage. For any glazing percentage up to 30%, the windows must have a maximum U-factor of 0.54 and a maximum SC of 0.57. For a glazing percentage between 30% and 40% (when wall construction allows), the windows must have a maximum U-factor of 0.37 and a maximum SC of 0.35.

Climate Zone 2 The Code allows a glazing fraction of up to 33% if high thermal performance windows are matched with a well-insulated wall. For example, if the building uses a frame wall with R-19 insulation, window with overall U-value maximum of 0.37, and maximum SC of 0.43, the maximum glazing fraction is 33%. If the building uses masonry walls with integral insulation (CMU with filled cores) and windows with a maximum U-factor of 0.50 and

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Code Language

1312.1.3 Windows and doors. All windows shall comply with this section. Refer to Section 1312.2 for performance requirements.

Exceptions:

1. Code-required fire doors and windows.
2. Windows in exterior walls up to 1 percent of the exterior wall area.

1312.1.3.1 U-factors. U-factors for exterior windows and doors shall include the effects of the window frame and shall be determined using the commercial size category values listed in Chapter 30, 2001 *ASHRAE Handbook of Fundamentals*, Table No. 4, or rated according to the National Fenestration Rating Council (NFRC) 100-2001 Version 2 *Procedure for Determining Fenestration Product Thermal Performance*. U-factors shall be certified through the NFRC Fenestration Thermal Performance Rating Certification and Labeling Program.

1312.1.3.2 Shading coefficient. For calculations, opaque portions of doors shall have a shading coefficient of zero. Shading coefficients for glazing shall be taken from Chapter 30, 2001 *ASHRAE Handbook of Fundamentals*; or manufacturers' test data; or certified according to NFRC 200-2001 Edition *Procedure for Determining Solar Heat Gain Coefficient* (SHGC) at normal incidence. The center of glass values for the shading coefficient at normal incidence may be converted from the SHGC by dividing the SHGC by a factor of 0.87. SHGC shall be certified through the NFRC Certification and Labeling Program.

1312.1.3.3 Certification and labeling. Windows shall be certified and labeled according to the procedures specified in Sections 1312.1.3.1 and 1312.1.3.2.

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Documentation:

To document compliance with this section of code, fill out Compliance Form 3a. Window Schedule information is listed on Worksheet 3d; skylight schedule information is listed on Worksheet 3e.

- Prescriptive Method Form 3b with the appropriate associated worksheets.
- Simplified Trade-Off Approach—submit a disk with the . Code-Comp project file on it. This file can be found in the GDT\Code-Comp\Project directory with a .occ file extension name on it.
- Whole Building Design Approach—Call Oregon Dept. of Energy for information on complying via the Whole Building Design Method.

Code Language continued from **page 1**

Windows shall have a temporary label not to be removed before inspection.

Exception:

Site-built windows shall have a single certificate specifying glazing type, special coatings, spacers, gas fills, center-of-glass and overall U-factor, and center-of-glass shading coefficient for every type of site-built glass used. These certificates shall be maintained on the job site and made available to the inspector.

Examples

Q A small waterfront restaurant along the coast has a west-facing curtain wall with a view of the ocean. The plan for clear glazing would not meet prescriptive window SHGC requirements. Can an overhang be used as a prescriptive alternative to reduce the effective solar heat gain through the window?

A No. The prescriptive code requirement specifies the center-of-glass shading coefficient for the fenestration, and does not account for effects of exterior (or interior) shading. If the other facades have a low window area, the building may still comply using the Simplified Tradeoff Approach.

Q My building uses roof monitors for daylighting. Is this treated as a skylight or window? Is this counted in the window glazing fraction?

A The roof monitor features vertical glazing above the main roofline. The fenestration in a roof monitor should be entered as a window since it is oriented vertically. This should be counted towards the window glazing fraction.

Q How is a sawtooth monitor classified – as a window or as a skylight?

A These feature vertical glazing and a sloped roof surface. It should be entered as a window since it is oriented vertically.

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maximum SC of 0.57, the maximum glazing fraction is only 15%. Regardless of the type of wall construction, the window thermal performance requirements differ based on the glazing percentage. For any glazing percentage up to 25%, the windows must have a maximum U-factor of 0.50 and a maximum SC of 0.57. For a glazing percentage between 25% and 33% (when wall construction allows), the windows must have a maximum U-factor of 0.37 and a maximum SC of 0.43.

Compliant Window Assemblies

There are three allowed sources of window and skylight performance data: tabulated default values in the ASHRAE Handbook of Fundamentals, National Fenestration Council (NFRC) ratings, or documentation of a compliant minimum assembly (MA). The source of information is listed on the Window Schedule (Worksheet 3d) and Skylight Schedule (Worksheet 3e).

ASHRAE Default. Most of the relevant information in the ASHRAE Handbook of Fundamentals is included in Tables 3e and 3f of the Oregon compliance documentation. Table 3e shows default window U-factors for operable windows, fixed windows and curtain wall windows. If this option is used, each specific window component – frame type and operator, glass type (airspace, low-e, argon gas filled, etc) – must be specified on the project plans or in its documented specifications. If the center-of-glass U-factor and shading coefficient is known and specified, it is acceptable to extrapolate the overall window U-factor from this table. Worksheet 3d of the envelope compliance form performs this calculation automatically (if the Excel version is used).

NFRC Rating. The NFRC provides certification for window thermal performance: U-factor and Solar Heat Gain Coefficient. The NFRC 100 test procedure yields a U-factor rating for the entire window assembly, including framing. The NFRC 200 test procedure produces a rating for solar heat gain coefficient (SHGC). The solar heat gain coefficient (SHGC) is a ratio of the solar energy admitted through the window to the amount that falls on the window surface. A low SHGC is important in reducing cooling energy and is especially important on south and west facing glazing. The solar heat gain coefficient can be converted to shading coefficient by dividing SHGC by 0.87. Visible transmittance (also referred to as visible light transmittance or VLT) is also provided for daylight assessment. Windows used for daylighting should have a high VLT and low solar heat gain coefficient (SHGC). Spectrally selective "low e" coatings are ideal for daylighting applications: they allow visible light to pass while reducing solar heat gain. While not explicitly required by code, a best practice for daylighting windows includes a "light to solar gain" ratio (the VLT divided by the SHGC) of 1.25 or greater. If the NFRC method of compliance is chosen, the project plans or specifications must indicate that the window is NFRC certified and meets the minimum required performance levels.

Minimum Assembly. The third method of documenting window performance is to indicate that the window meets the minimum assembly requirements listed in the code. For example, in Climate Zone 1, double-glazed windows with a ½" air space, low-e coating and aluminum frame will meet the minimum assembly require-

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ment for fixed windows in buildings with a maximum glazing fraction of 30%. The same building using operable windows or curtain walls requires a frame with a thermal break. A thermal break is an insulating spacer in the frame that reduces the heat transfer across the frame. Aluminum frames in particular will have a thermal "bridging" effect: heat is transferred through the frame at a high rate. If the glazing fraction exceeds 30% (for buildings with wall types that allow this percentage), the minimum assembly becomes more stringent. An example of a compliant assembly is a double-glazed fixed window with a low-e coating and minimum 1/2" argon-filled space. Operable windows and curtain wall assemblies do not qualify for the minimum assembly path when the glazing fraction is above 30% (25% in Zone 2).

Metal curtain walls, commonly used in high-rise buildings, differ in performance from "fixed" metal-framed windows. The heat transfer is affected by the aluminum spacer between panels and the steel screws used to secure the panel to the frame. Consequently, curtain walls have a relatively poor thermal performance, compared to fixed windows with the same type of glazing.

Skylights

To comply with the Oregon Code prescriptive requirements, the skylight area must be no greater than 6% of the entire roof area over the conditioned space. If the skylight area exceeds this limit, the Simplified Tradeoff Approach must be used. The same limit applies separately to semi-conditioned spaces and mechanical penthouses. Skylight area covers the rough opening area including the skylight framing.

Each skylight must meet performance requirements for U-factor and Shading Coefficient (SC). These requirements can be documented by the same three different methods discussed above: through NFRC-certification, by using the ASHRAE default tables, or by meeting the Minimum Assembly requirement. For Minimum Assembly, any double-glazed skylight with a half-inch airspace will meet the U-factor requirement. There is no Minimum Assembly that meets the SC requirement for skylights. Tinting of one of the panes is typically required to meet the prescriptive SC requirement of 0.47. It is important to note that a window assembly will have a higher U-factor when oriented horizontally. If NFRC rating data is available for vertical fenestration assembly, a conversion can be made to determine an effective U-factor for the same assembly used as a skylight. U-factors for vertically oriented surfaces can be used when the glazing is mounted within 30° of the vertical plans.

Skylight U-Factor (horiz.) = 0.08 + 1.62 x U-Factor (vert.)

Other factors will influence the design and selection of skylights. The visible light transmittance of the skylight, its diffusing properties, and the design of the skylight well all affect how daylighting is distributed to the space.

Site-Built Fenestration

All site-built fenestration must include a certificate specifying the glazing type, type of coatings, spacers and fills, the center-of-glass U-factor, overall window U-factor and center-of-glass shading coefficient for every type of fenestration used. The National Fenestration Rating Council (NFRC) also has developed a rating procedure for site-built fenestration, NFRC 100-SB.

Alterations and Additions

Additions to buildings will comply if they meet the same prescriptive requirements as new buildings. There are two exceptions stated in section 1312.3.1 of the code. First, additions of the same use and occupancy type which increase floor area by no more than the lesser of 10% of the existing building area or 1000 ft^2, if the wall, window and skylight U-factors are equal to or less than the U-factors of the existing building. The second exception is for additions that have skylight or window glazing areas that exceed the prescriptive requirements. For the second exception, the addition will comply only if several requirements are met. The additional floor area cannot exceed the lesser of 15 percent of the existing building's floor area, or 3,000 ft^2. The ceiling height of the addition cannot exceed 20 feet from the ground floor. Also, requirements for center-of-glass U-factor, shading coefficient and exterior wall U-factor must be met, to claim this exception.

Other Compliance Options

If the U-factor or shading coefficient of any of the windows or skylights used in the building fails to meet the prescriptive requirements, the Simplified Tradeoff Approach may be used to demonstrate that the annual heating and cooling loads through the building envelope do not exceed code requirements. Also, buildings with glazing that exceeds the maximum glazing fraction may use the Simplified Tradeoff Approach for compliance. For example, a designer could compensate for using a large window area by specifying high performance windows with very low U-factor and solar heat gain, or by increasing envelope insulation. The CodeComp software is used to document compliance using this approach.

If the building still fails using the Simplified Tradeoff Approach, the Whole Building Approach must be used to demonstrate compliance. The Whole Building Approach requires the use of an approved hourly building energy simulation program – consult the Oregon Department of Energy for details.

Table 1 - Prescriptive Fenestration Requirements

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Examples

Q **My building includes mostly steel framed walls with R-13 batt insulation. However, there is a small area of the building constructed of CMU with vermiculite filled cores. There are no windows in the CMU walls, and 25% glazing fraction for framed walls only. The entire building glazing fraction is 22%. My building is in Zone 1. Does it comply prescriptively?**

A No. The maximum glazing fraction allowed is determined by the "worst case" wall. In this building, the worst case wall is the CMU wall with integral insulation. Therefore, the maximum glazing fraction for the entire building is 15%, regardless of which wall contains the windows.

Additional Information

1. National Fenestration Rating Council, http://www.nfrc.org.
2. The Efficient Windows Collaborative provides information on the benefits and performance characteristics of high performance window assemblies, http://www.efficientwindows.org.
3. Skylight Design Guidelines, developed by Energy Design Resources is an excellent design resource for skylights, http://www.energydesignresources.com.

Find Out More

Copies of Code:

Oregon Building Officials Association
phone: 503-873-1157 fax: 503-373-9389

Technical Support:

Oregon Department of Energy
625 Marion Street NE phone: 503-378-4040
Salem, OR 97301-3737 toll free: 800-221-8035
www.oregon.gov/energy fax: 503-373-7806

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Northwest Energy Efficiency Alliance
www.nwalliance.org

Photo on page 1 c/o Warren Gretz, DOE/NREL

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Non-residential code ENVELOPE fact sheets include:

- Envelope Compliance Approaches
- Fenestration Performance
- Walls
- Roofs

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Wall / Insulation Type	Maximum Glazing Fraction	Window Max. U-Factor	Window Max. Shading Coefficient
Zone 1			
CMU Masonry, w/integral loose fill insulation	Up to 15%	0.540[1]	0.57[1]
Masonry or concrete, w/cont. exterior insulation			
CMU Masonry, w/integral rigid fill insulation	Up to 30%	0.540[1]	0.57[1]
Masonry or concrete, w/interior insulation			
Masonry or concrete, w/cont exterior insulation			
Frame (wood or metal framing)			
Other (provide short description)			
CMU Masonry, w/integral rigid fill insulation	Up to 40%	0.370[2]	0.35[2]
Masonry or concrete, w/interior insulation			
Masonry or concrete, w/cont exterior insulation			
Frame (wood or metal framing)			
Other (provide short description)			
Zone 2			
CMU Masonry, w/integral loose fill insulation	Up to 15%	0.500[3]	0.57[3]
Masonry or concrete, w/cont. exterior insulation			
CMU Masonry, w/integral rigid fill insulation	Up to 25%	0.500[3]	0.57[3]
Masonry or concrete, w/interior insulation			
Masonry or concrete, w/cont exterior insulation			
Frame (wood or metal framing)			
Other (provide short description)			
CMU Masonry, w/integral rigid fill insulation	Up to 33%	0.370[4]	0.43[4]
Masonry or concrete, w/interior insulation			
Masonry or concrete, w/cont exterior insulation			
Frame (wood or metal framing)			
Other (provide short description)			

1. Prescriptive MA (Minimum Assembly) - For Fixed Windows: double-glazed window with a 0.5 inch air space, low-e coating and aluminum frame. MA shading coefficient description is a tinted outboard pane of glass. For Operable Windows or Curtainwall: double-glazed window with a 0.5 inch air space, low-e coating and thermally broken frame. MA shading coefficient description is a tinted outboard pane of glass.
2. Prescriptive MA (Minimum Assembly) - For Fixed Windows: double-glazed window with a 0.5 inch argon filled space, low-e coating (e<= 0.05) and thermal break frame. For Operable Windows or Curtainwall: only use Max U-Factor. MA shading coefficient description is a 0.25-inch thick glass with low-e coating (e<= 0.05) with a tinted outboard pane.
3. Prescriptive MA (Minimum Assembly) - For Fixed Windows: double-glazed window with a 0.5 inch air space, low-e coating and aluminum frame. For Operable Windows or Curtainwall: double-glazed window with a 0.5 inch air space, low-e coating (e<= 0.1) and thermally broken frame. MA maximum shading coefficient description is a tinted outboard pane of glass.
4. Prescriptive MA (Minimum Assembly) - For Fixed Windows, a double-glazed window with a 0.5 inch argon filled space, low-e coating (e<= 0.05) and thermal break frame. For Operable Windows or Curtainwall, only use Max U-Factor. MA shading coefficient description is a 0.25-inch thick glass with low-e coating (e<= 0.05).