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3. Building Envelope

This chapter describes the requirements for efficiency measures used for the building envelope of nonresidential, high-rise residential and hotel/motel occupancy buildings. Heating and cooling loads affect building energy use. Heating and cooling loads reflect the amount of energy needed, such as HVAC equipment size (capacity), to provide sufficient heating and cooling to meet inside temperature setpoints. The principal elements affecting heating loads are infiltration through the building and conduction losses through building envelope components, including walls, roofs, floors, slabs, windows and doors. Cooling loads, however, are dominated by solar gains through windows and skylights, from internal gains due to lighting, plug loads, and occupancy use, and from additional ventilation loads needed for indoor air quality. For example, light entering the building through windows and skylights for daylighting purposes can add to the internal gains incurred by indoor lighting specified for various occupancy uses if both are not properly controlled.

Outside air ventilation and lighting loads are addressed in the Mechanical Systems and Lighting Systems chapters.

The design of the building envelope is usually the responsibility of the architect, but the design team may receive significant input from the contractor, engineer, or other design professionals. The designer is responsible for making sure that the building envelope complies with the standards. In addition, the building official is responsible for making sure that the building envelope is designed and built in conformance with the standards and that design measures shown on construction documents to meet energy requirements are installed properly. This chapter is written for the designer and the building official, as well as other specialists who participate in the design and construction of the building envelope.

3.1 Chapter Organization

This chapter is organized by related topics as follows:

3.1.1 Compliance Options

3.1.2 What's New for 2013

3.1.3 Compliance Overview

3.1.4 Mandatory Measure

3.1.5 Prescriptive Component Envelope Approach

3.1.6 Performance Approach

3.1.7 Envelope Definitions and Features

3.2 Fenestration

3.3 Envelope Assembly

3.4 Relocatable Public School Buildings

3.5 Performance Approach

3.6 Simplified Performance Tradeoff Approach

3.7 Additions and Alterations

3.8 Compliance Documentation

3.1.1 Compliance Options

The standards have both mandatory measures and prescriptive requirements that affect the design and operation of the building. The mandatory measures, prescriptive requirements and operational schedules establish a minimum performance level which can be exceeded by other design measures and construction practices resulting in greater energy savings.

Public Resources Code, Section 25402.1 (b) requires the California Energy Commission to establish a formal process for certification of compliance options of new products, materials, designs or procedures that can improve building efficiency levels established by the Building Energy Efficiency Standards. §10-109 of the standards allows for the introduction of new calculation methods and measures which cannot be properly accounted for in the current approved compliance approaches.

The Energy Commission encourages the use of energy-saving techniques and designs for showing compliance with the standards. The compliance options process allows the Energy Commission to review and gather public input regarding the merits of new compliance techniques, products, materials, designs or procedures to demonstrate compliance for newly constructed buildings and additions and alterations to existing buildings.

Approved compliance options encourage market innovation and allow the Energy Commission to respond to changes in building design, construction, installation, and enforcement.

When the Energy Commission approves a new compliance option it is listed in the Special Cases section of the Energy Commission's website: (http://www.energy.ca.gov/title24/2008standards/special_case_appliance/). Approved compliance options are listed by their respective technology, compliance procedure, product or equipment type and often represent advanced methods for achieving high performance buildings.

3.1.2 What's New for 2013

The 2013 Standards include several important changes to the building envelope component requirements, as described below:

A. An updated equation to calculate the aged solar reflectance for field-applied coatings (cool roof), §110.8(i)2.

B. Minimum mandatory requirements for insulation, §120.7 that apply to:
   a. Roof/ceiling insulation
      i. Metal building
      ii. Wood framed and others
   b. Wall insulation
      i. Metal building
      ii. Metal framed
      iii. Light mass wall
      iv. Heavy mass wall
      v. Wood framed and others
      vi. Spandrel panels and glass curtain walls

c. Floor and soffit insulation
   i. Raised mass floors
   ii. Other floors
   iii. Heated slab floor

C. Building commissioning, §120.8.

D. Prescriptive requirements of §140.3 that apply to:
   a. Cool roofs of low sloped roofs:
      i. A minimum aged solar reflectance of 0.63 and thermal emittance of 0.75 in all climate zones, or solar reflectance index (SRI) of 75 in all climate zones
      ii. Roof/ceiling insulation tradeoff for aged solar reflectance

E. Fenestration
   a. Dynamic Glazing
   b. Visible light transmittance (VT)
   c. Skylights
   d. Window Films

F. Requirements for additions, alterations, and repairs, §141.0 that apply to:
   a. Mandatory insulation requirements for alterations
   b. Maximum U-factor and shading requirements for fenestration in alterations
   c. Roof/ceiling insulation tradeoff for aged solar reflectance of roofing being replaced, recovered or recoated
   d. Requirements applying to altered duct systems
   e. Requirements apply to lighting systems
   f. Window Films

G. Requirements for additions, alterations applying to covered processes, §141.1.

3.1.3 Compliance Overview

The Standards have mandatory requirements, and prescriptive or performance methods for compliance. The standards establish a minimum level of performance which can be exceeded by advanced design and construction practices.

3.1.4 Mandatory Measures

§120.7

When compliance is being demonstrated with either the prescriptive or performance compliance paths, there are mandatory measures that must be installed. The minimum mandatory levels are sometimes superseded by more stringent prescriptive or performance approach requirements. For example, the mandatory measures specify a weighted average U-factor of a metal framed wall insulation to be U-0.105, but if compliance is being demonstrated with the prescriptive approach for a nonresidential building, Table 140.3-B of the standards is used to establish the minimum wall thermal compliance level. In this case, a U-0.098 or U-0.062 metal framed wall assembly insulation (depending on climate zone) must be installed. Conversely, the mandatory measures may be of a higher efficiency than permitted under the performance approach. In these instances, the higher mandatory levels must be installed. For example, a building may comply using the performance computer modeling with only a U-factor of U-0.121 insulation in a metal framed rafter roof, but a U-factor of at least U-0.098 must be installed because that is the mandatory minimum.

3.1.5 Prescriptive Component Envelope Approach

Standards Table 140.3-B, C and D

The prescriptive requirements are the simplest way to comply with the building envelope requirements but offer little flexibility. If each and every prescriptive requirement is met, the building envelope complies with the standards.

This prescriptive compliance approach consists of meeting specific requirements for each envelope component, and minimum mandatory levels of insulation. Prescriptive requirements apply to:

- roofs and ceilings
- exterior roofing products
- exterior walls
- demising walls
- floors and soffits
- fenestration and skylights

Fenestration must meet prescriptive minimum thermal performance values and have a maximum of 40% window-to-wall ratio. Vertical fenestration has a maximum building, and maximum west-facing, area allowance as well as skylights have maximum area limits. Thermal performance values are specified for the maximum U-factor, Solar Heat Gain Coefficient (SHGC) and visible transmittance (VT). The prescriptive envelope requirements are prescribed in §140.3 which includes; Table 140.3-B for nonresidential buildings; Table 140.3-C for high-rise residential buildings and hotel/motel buildings; and Table 140.3-D for relocatable public school buildings.

Under the Envelope Component Approach, each of the envelope assemblies (walls, roofs, floors, windows, and skylights) must comply individually with its requirement. If one component of the envelope does not comply, the Envelope Component Approach cannot be used and another compliance method must be chosen. When using the Envelope Component Approach there can be no trade-offs between components. If one or more of the envelope components cannot meet its requirement, the alternative is to use either the Simplified Performance Tradeoff Approach or the Performance Approach, which allows tradeoffs between building features, in addition to the mandatory requirements.

3.1.6 Performance Approach

§140.1

The performance approach is a more sophisticated compliance method and it offers design flexibility. The performance approach may be used for:

- Envelope-only compliance
- Envelope and lighting compliance
- Envelope and mechanical compliance
- Envelope, lighting and mechanical compliance

The performance approach allows for more energy tradeoffs between building features, such as increasing envelope efficiency in order to allow more lighting power or a less efficient space-conditioning system. See Section 3.5 and Chapter 9 for a more complete discussion of the performance approach.

3.1.7 Envelope Definitions and Features

Elements of the building envelope significantly contribute to the energy efficiency of the building and its design intent. Several features are important to note when a method is chosen to demonstrate compliance. Components of the building shell include the walls, floor, the roof or ceiling, and fenestration. Details for fenestration compliance for windows, skylights and doors are addressed in Section 3.2, Fenestration.

A. Walls and Space(s) Surrounding Occupancy Uses

Envelope and other building component definitions are listed in §100.1.

- Envelope requirements vary by envelope component and are a function of their type of construction, and the space conditions on either side of the envelope surface.
- An exterior partition is an envelope component (roof, wall, floor, window etc.) that separates conditioned space from ambient (outdoor) conditions. A demising partition is an envelope component that separates conditioned space from an unconditioned enclosed space.
- A conditioned space is either directly conditioned or indirectly conditioned (see Section 100.1 for full definition). Indirectly conditioned space is thermally influenced more by adjacent directly conditioned space than it is by ambient (outdoor) conditions. An unconditioned space is enclosed space within a building that is not directly conditioned, or indirectly conditioned.
- A plenum space below an insulated roof and above an uninsulated ceiling is an indirectly conditioned space as there is less thermal resistance to the directly conditioned space below than to the ambient air outside. In comparison, an attic below an uninsulated roof and having insulation on the attic floor is an unconditioned space because there is less thermal resistance to the outside than across the insulated ceiling to the conditioned space below.
- An exterior wall is considered separately from a demising wall or demising partition and has more stringent thermal requirements.
- Sloping surfaces are considered either a wall or a roof, depending on their slope (see Figure 3-1). If the surface has a slope of less than 60° from horizontal, it is considered a roof; a slope of 60° or more is a wall. This definition extends to fenestration products, including windows in walls and any skylights in roofs.
- Floors and roof/ceilings do not differentiate between demising and exterior. Thus an exterior roof/ceiling "is an exterior partition, or a demising partition, that has a slope less than 60 degrees from horizontal, that has conditioned space below," ambient conditions or unconditioned space above "and that is not an exterior door or skylight."
- Similarly an "exterior floor/soffit is a horizontal exterior partition, or a horizontal demising partition, under conditioned space" and above an unconditioned space or above ambient (outdoor) conditions.
- Windows are considered part of the wall because the slope is over 60°. Where the slope is less than 60 degrees, the glazing indicated as a window is considered a skylight.

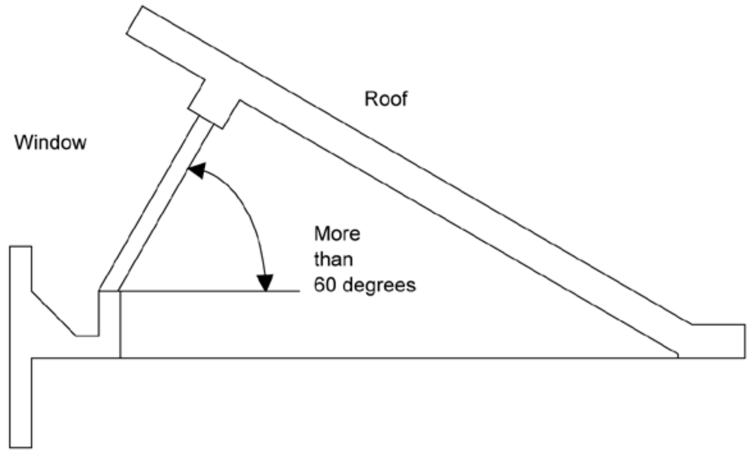


Figure 3-1 – Slope of a Wall or Window (Roof or Skylight slope is less than 60°)

B. Roofing Products (Cool Roof)

Roofing products with a high solar reflectance and thermal emittance are referred to as “cool roofs.” These roofing types absorb less solar heat and give off more heat to their surroundings than traditional roofing material. These roofs are cooler and thus help reduce air conditioning loads by reflecting and emitting energy from the sun. Roof radiative properties are rated and listed by the Cool Roof Rating Council (CRRC) (http://www.coolroofs.org/).

Light-colored high reflectance surfaces reflect solar energy (visible light, invisible infrared and ultraviolet radiation) and stay cooler than darker surfaces that absorb the sun’s energy and become hot. Thermal emittance refers to the ability of heat to escape from a surface once heat energy is absorbed. Both solar reflectance and thermal emittance are measured from 0 to 1; the higher the value, the "cooler" the roof. There are numerous roofing materials in a wide range of colors that have relatively good cool roof properties. Surfaces with low emittance (usually shiny metallic surfaces) contribute to the transmission of heat into components under the roof surface. Excess heat can increase the building’s air conditioning load resulting in increased air conditioning energy needed for maintaining occupant comfort. High-emitting roof surfaces reject absorbed heat quickly (upward and out of the building) than darker roof surfaces with low-emitting properties.

The standards prescribe cool roof radiative properties differently for low-sloped and steep-sloped roofs (§140.3(a)1A). A low-sloped roof is defined as a surface with a pitch less than or equal to 2:12 (9.5 degrees from the horizon), while a steep-sloped roof is a surface with a pitch greater than 2:12 (9.5 degrees from the horizon). Because heat solar gain is based on the sun’s angle of incidence on a surface, low-sloped roofs receive more solar radiation than steep-sloped roofs in the summer when the sun is high in the sky.

The standards specify radiative properties that represent minimum “cool roof performance” qualities of roofing products. Performance values are established based on “initial” testing of the roofing product and for their “aged” value which accounts for the effects of weathering due to different climate conditions over time:

- Solar reflectance: The fraction of solar energy that is reflected by the roof surface.
- Thermal emittance: The fraction of thermal energy that is emitted from the roof surface
- Solar Reflectance Index (SRI): The relative surface temperature of a surface with respect to standard white (SRI=100) and standard black (SRI=0) under the standard

solar and ambient condition. This combined metric is a function of both solar reflectance and thermal emittance. One can achieve the same SRI if the roofing product has a higher solar transmittance but a lower thermal reflectance.

C. Infiltration and Air Leakage

Infiltration is the *unintentional* replacement of conditioned air with unconditioned air through leaks or cracks in the building envelope. Poor construction detailing at interfacing points of different construction materials, particularly in extreme climates, can have a significant impact on heating and cooling loads. Air leakage can occur through holes and cracks in the building envelope and around doors and fenestration areas. Ventilation is the *intentional* replacement of conditioned air with unconditioned air through open windows or mechanical ventilation.

Reducing air leakage in the building envelope can result in significant energy savings, especially in climates with more severe winter and summer conditions. It also can result in improved building comfort, reduced moisture intrusion, and fewer air pollutants.

An **air barrier** that inhibits air leakage is critical to good building design and is a prescriptive requirement for some climate zones (see Section 3.3.2, Prescriptive Envelope Requirements, G. Air Barrier).

D. Thermal Properties of Opaque Envelope Components

Typical opaque envelope assemblies are made up of a variety of components, such as wood or metal framing, masonry or concrete, insulation, various membranes for moisture and/or fire protection, and may have a variety of interior and exterior sheathings even before the final exterior façade is placed. Correctly calculating assembly U-factors is critical to the selection of equipment to meet the building's heating and cooling loads. Performance compliance software automatically calculates the thermal effects of component layers making up the overall envelope assembly, but software programs may utilize different user input hierarchies. The Reference Appendices, Joint Appendix JA4, "U-factor, C-factor, and Thermal Mass Data," provides detailed thermal data for many wall, roof/ceiling, and floor assemblies. However, this reference cannot cover every possible permutation of materials, thickness, etc. that might be used in a building; thus, the Energy Commission has developed the EZ-FRAME2013 program for calculating material properties of a typical envelope assemblies that may not be found from the JA4 reference data.

Key terms of assembly thermal performance are:

- **Btu** (British thermal unit): The amount of heat required to raise the temperature of 1 lb. of water 1 ^{o}F.
- **Btuh or Btu/hr** (British thermal unit per hour): The rate of heat flow during an hour's time. The term is used to rate the output of heating or cooling equipment or the load that equipment must be capable of handling; that is, the capacity needed for satisfactory operation under stated conditions.
- **R or R-value** (Thermal resistance): the ability of a material or combination of materials to retard heat flow. As the resistance increases, the heat flow is reduced. The higher the **'R'**, the greater the insulating value. R-value is the reciprocal of the conductance, **'C'**.

  R-value = hr x ft^2 x ^{o}F/Btu
  R = inches of thickness/k

- **U or U-factor** (Thermal transmittance or coefficient of heat transmission): The rate of heat transfer across an envelope assembly per degree of temperature difference on either side of the envelope component. U-factor is a function of the materials and their thickness. U-factor includes air film resistances on inside and outside surfaces. U-factor applies to heat flow through an assembly or system, whereas **'C'**, having the same dimensional units applies to individual materials. The lower the **'U'**, the higher the insulating value.

  U-factor = Btu/(hr x ft^2 x ºF)

- **k or k-value** (Thermal conductivity): The property of a material to conduct heat in The number of Btu that pass through a homogeneous material 1 inch thick and 1 sf. in area in an hour with a temperature difference of 1 ^{o}F between the two surfaces. The lower the **'k',** the greater the insulating value.

  k = Btu x in/(hr x ft^2 x °F)

- **C or C-value** (Thermal conductance): The number of Btu that pass through a material of any thickness and 1 sf. in area in an hour with a temperature difference of 1 ^{o}F between the two surfaces. The time rate of heat flow through unit area of a body induced by a unit temperature difference between the body surfaces. The C-value does not include the air film resistances on each side of the assembly. The term is usually applied to homogeneous materials but may be used with heterogeneous materials such as concrete block. If **'k'** is known, the **'C**' can be determined by dividing **'k'** by inches of thickness. The lower the 'C', the greater the insulating value.

  C = Btu/(hr. x ft^2 x °F) or C = k/inches of thickness

- **HC** (Heat capacity – thermal mass): The ability to store heat in units of Btu/ft^2 and is a property of a given envelope component's specific heat, density and thickness. High thermal mass building components, such as tilt-up concrete walls, can store heat gains and release stored heat later in the day or night. The thermal storage capability of high mass walls, floors, and roof/ceilings can slow heat transfer and shift heating and cooling energy affecting building loads throughout a 24-hour period depending on the building's design, location and occupancy use.

3.2 Fenestration

Choosing the proper windows, glazed doors, and skylights is one of the most important decisions for any high-performance project. The use of high performance fenestration can actually reduce energy consumption by decreasing the lighting and heating and cooling loads in nonresidential and high-rise residential buildings. The size, orientation, and types of fenestration products can dramatically affect overall energy performance. The National Fenestration Rating Council (NFRC) can help facility managers, specifiers, designers and others make informed purchasing and design decisions about fenestration products. To help select windows with the desired energy performance for institutional projects, NFRC developed a performance base calculation, the Component Modeling Approach, or CMA. The benefits of using CMA are discussed later in this chapter.

3.2.1 Mandatory Measures

The mandatory measures for windows, glazed doors, and skylights address the air-tightness of the units (air leakage), how their U-factor and Solar Heat Gain Coefficient (SHGC) are determined, as well as Visible Transmittance (VT).

Any fenestration product or glazed door, other than field-fabricated fenestration products and field-fabricated glazed doors, may be installed only if the manufacturer has certified to the Energy Commission by using a default label, or if an independent certifying organization approved by the Energy Commission has certified that the product complies with all of the applicable requirements of this subsection.

3.2.2 Certification and Labeling

§10-111 and §110.6
Reference Nonresidential Appendices NA6

The Administrative Regulations §10-111 and §110.6 of the Standards require that fenestration products have labels that list the U-factor, SHGC, VT and the method used to determine those values. The label must also certify that the fenestration product meets the requirements for air leakage from §110.6(a)1 of the Standards. See Table 3-1 (Maximum Air Infiltration Rates) of this chapter.

Minimum visible transmittance (VT) is now a prescriptive requirement for windows and skylights. The NFRC 200 test method is only appropriate for flat clear glazing and does not cover curved glazing, or diffusing glazing. For these special types of fenestration, including dome skylights, use ASTM E972 to rate the visible transmittance. Manufacturer specification sheets and/or product data sheets are acceptable for verifying compliance to ASTM E972. Tubular skylights use NFRC 200 or NFRC 203.

VT for diffusing skylights, which are not covered by NFRC 200 or NFRC 203, are tested using ASTM E972. Manufacturers, specifiers, or the responsible party must include proof of VT testing using the E972 method by including a VT test report or a manufacture cut-sheet with all energy compliance documentation.

A. Manufactured (Factory-Assembled) Fenestration Label Certificates

Each manufactured (factory-assembled) fenestration product must have a clearly visible temporary label attached to it, which is not to be removed before inspection by the enforcement agency. Manufactured fenestration products are to be rated and labeled for U-factor, SHG and VT by the manufacturer.

The manufacturer can choose to have the fenestration product rated and labeled in accordance with NFRC Rating Procedure (NFRC 100 for U-factors and NFRC 200 for SHGC and VT) see Figure 3-2. If the manufactured fenestration product is rated using the NFRC Rating Procedure, it must also be permanently labeled in accordance with NFRC procedures.

Where possible, it is best to select a NFRC-rated fenestration product , and to do so before completing compliance documents, as this enables the use of NFRC-certified data for compliance purposes.

Figure 3-2 - NFRC Manufactured Label

B. Default Temporary Label

Fenestration product manufacturers can choose to use default performance values listed in Tables in §110.6 of the Standards for U-factors and SHGC in lieu of testing. For fenestration products requiring a VT value, assume a value of 1.0 as specified in the Reference Nonresidential Appendix NA6. If default values are used, the manufacturer must attach a temporary label to each window (see Figure 3-3) and manufacturer specification sheets or cut-sheets must be included with compliance documentation. A NRCC-ENV-05-E will be required to document the thermal performance if no default temporary labels are attached to the window units.
Although there is no exact format for the default temporary label, it must be large enough to be clearly visible from 4 ft., such that the enforcement agency field inspectors may read it easily and it must include all information required by the regulations.

The minimum suggested label size is 4 in. x 4 in. and the label must have the words at the bottom of the label as noted in the example shown in Figure 3-3.

> *"Product meets the air infiltration requirements of §110.6(a)1, U-factor criteria of §110.6(a)2, SHGC criteria of §110.6(a)3 and VT criteria of §110.6(a)4 of the 2013 California Building Energy Efficiency Standards for Residential and Nonresidential Buildings."*

If the product claims the default U-factor for a thermal-break product, the manufacturer must certify that the thermal-break criteria are met. To do this, the manufacturer should mark the checkboxes for the following features:

1. Air space 7/16 in. or greater;
2. For skylights, the label must indicate the product was rated with a Built-in Curb;
3. Meets Thermal-Break Default Criteria.

2013 California Energy Commission Default Label **XYZ Manufacturing Co.**		
Key Features:	☐ Doors	☐ Double-Pane
	☐ Skylight	☐ Glass Block
Frame Type	**Product Type:**	**Product Glazing Type:**
☐ Metal	☐ Operable	☐ Clear
☐ Non-Metal	☐ Fixed	☐ Tinted
☐ Metal, Thermal Break	☐ Greenhouse/Garden Window	☐ Single-Pane
☐ Air space 7/16 in. or greater ☐ With built-in curb ☐ Meets Thermal-Break Default Criteria	----------	To calculate VT see NA6
California Energy Commission Default U-factor =	**California Energy Commission** Default SHGC =	**California Energy Commission** Calculated VT =
Product meets the air infiltration requirements of §110.6(a)1, U-factor criteria of §110.6(a)2, SHGC criteria of §110.6(a)3 and VT criteria of §110.6(a)4 of the 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings.		

Figure 3-3 – Sample Default Temporary Label

The person taking responsibility for fenestration compliance can choose to attach Default Temporary Labels to each fenestration product as described previously instead of providing a Default Label Certificate for each product line.

Alternatively, for diffusing skylight's VT not covered by NFRC 200 or NFRC 203, a test report should be included using the ASTM E972 method or a manufacturer's cut-sheet that specifically describes the method used to calculate the VT. Manufactures, specifiers, or the responsible party should include the report with their energy documentation.

C. Field-Fabricated Fenestration

Field-fabricated fenestration is not the same as site-built fenestration. Field-fabricated fenestration is a very limited category of fenestration that is made at the construction site out of materials that were not previously formed or cut with the intention of being used to fabricate a fenestration product. No attached labeling is required for field-fabricated fenestration products, only a NRCC-ENV-05-E. Field-fabricated fenestration and field-fabricated exterior doors may be installed only if the compliance performance documentation has demonstrated compliance. The field inspector is responsible for ensuring field-fabricated fenestration meets the specific; U-factor, SHGC and VT as listed on the NRCC-ENV-05-E. Thermal break values do not apply to field-fabricated fenestration products. Further explanation of Field-Fabricated Fenestration as well as required performance values can be found in Section 3.2 of this chapter.

D. Site-Built Label Certificates

The designer should select a U-factor, SHGC, and VT for the fenestration system that meets the design objectives and occupancy needs for the building. Site-built fenestration is field-assembled using specific factory-cut or factory-formed framing and glazing units that are manufactured with the intention of being assembled at the construction site or glazing contractor's shop. Site-built certificates should be filed at the contractor's project office during construction or in the building manager's office, see the CMA sample on Figures 3-4 and 3-4A and discussion of CMA in subsection F below. Note: The red circles in the figures indicate the field inspector's area to inspect and compare to the energy compliance and building plans.

NATIONAL FENESTRATION RATING COUNCIL LABEL CERTIFICATE

PROJECT INFORMATION

LABEL CERTIFICATE ID: *XYZ-001* **Issuance Date:** mm/dd/yyyy

This is to be completed by an NFRC Approved Calculation Entity (ACE), based on information provided by the Specifying Authority and calculated in accordance with NFRC procedures.

PROJECT LOCATION:

Address: ____

City: ____, **State,** ____, **Zip code:** ____.

Contact person: ____, **Title:** ____.

Phone: ____, **Facsimile:** ____, **Email:** ____.

Project name (optional): ____, **Designer (optional):** ____.

Figure 3-4 - NFRC - CMA Label Certificate Page 1

PRODUCT LISTING

FOR CODE COMPLIANCE

LABEL CERTIFICATE ID: *XYZ-001* **Issuance Date:** mm/dd/yyyy

NFRC CERTIFIED PRODUCT RATING INFORMATION:*

The NFRC Certified Product Rating Information listed here is to be used to verify that the ratings meet applicable energy code requirements.

PRODUCT LISTING:

						CERTIFIED Performance Rating at NFRC Model Size		
CPD ID	Total Area ft^2	Name	Framing Ref	Glazing Ref	Spacer Ref	U** Btu/hr·ft^2·°F	SHGC** -	VT** -
P-PL-010	88.89	PL-2200 / PL-2210	FA-PL2210	GA-TT-001	SA-AM-001	0.53	0.58	0.66
P-PL-005	192.67	PL-3400 / PL-3401	FA-PL3401	GA-TT-001	SA-AM-002	0.56	0.57	0.65
P-PL-012	382.22	PL-5700 / PL-5720	FA-PL5720	GA-TO-002	SA-AM-001	0.52	0.21	0.30
P-PL-002	60.00	PL-1100 / PL-1152	FA-PL1152	GA-TT-001	SA-AM-001	0.42	0.51	0.62
P-PL-022	525.00	PL-9900 / PL-9915	FA-PL9915	GA-TO-003	SA-AM-002	0.45	0.15	0.19

Figure 3-4A - NFRC - CMA Label Certificate Page 2

1. For site-built fenestration totaling 1,000 ft^2 or greater, the glazing contractor or specifier must generate a NFRC label certificate from either approach listed below:

   A. A NFRC label certificate generated by the CMA computer program; or

   B. Default to the U-factor values from Table 110.6-A and the SHGC values from 110.6-B and for Visible transmittance values, use the method specified in NA6.

2. For site-built fenestration totaling less than 1,000 ft^2 or any area of replacement of site-built fenestration, which includes vertical windows, glazed doors, and skylights, compliance must be demonstrated using any of the approaches listed below:

   A. NFRC Label Certificate generated by the CMA computer program; or

   B. Use the center-of-glass values from the manufactures product literature to determine the total U-factor, SHGC and VT. See Reference Nonresidential Appendix NA6 - the *Alternative Default Fenestration Procedure;* or

   C. Default to the U-factor values from Table 110.6-A and SHGC values from Table 110.6-B. For VT values, use the method specified in NA6.

Note: NA6 calculations are based on center-of-glass (COG) values from the manufacturer. For example, when using a manufacturer's SHGC center-of-glass specification of 0.27, the NA6 calculation results in an overall SGHC value of 0.312, which then may be rounded to 0.31. Rounding to the nearest hundredth decimal place is acceptable to determine the overall fenestration efficiency value with either the prescriptive or performance approach.

E. Fenestration Certificate NRCC-ENV-05-E (formally FC-1)

For non-rated products and where no default label certificates are placed on the fenestration product, use the Fenestration Certificate NRCC-ENV-05-E to document thermal performances of each fenestration product that results in a different U-factor, SHGC, and VT. Alternatively, one certificate will suffice when all the windows are the same.

The NRCC-ENV-05-E should indicate the total amount of non-NFRC rated fenestration products throughout the project. The locations and orientations where products are being installed should be indicated on the drawings and in a fenestration schedule that lists all fenestration products.

The NRCC-ENV-05-E should clearly identify the appropriate table or equation that is used to determine the default U-factor and SHGC and, if applicable, the center of glass $SHGC_C$ used in calculating the $SHGC_{fen}$. Manufacturer's documentation of these product characteristics, which list the center-of-glass values, must be attached to the NRCC-ENV-05-E and located at the job site for verification.

F. Component Modeling Approach (CMA) and Software Tool (CMAST)

NFRC has developed the CMA to make the rating process quicker and simpler and serve as an energy ratings certification program for windows and other fenestration products used in non-residential (commercial) projects. Launched in January 2008 specifically for California's Title 24 Part 6, the CMA Software Tool, also called CMAST, allows users to assemble fenestration products in a virtual environment. CMAST draws data for NFRC-approved components from online libraries choosing from pre-approved glazing, frame and spacer components. CMA users are able to obtain preliminary ratings for various configurations of their designs. CMA is a fair, accurate and credible method based on NFRC 100 and 200 program documents, which are verified by third-party rating procedures.

Architects and others can use this tool to:

1. Help design energy-efficient windows, curtain wall systems and skylights for high performance building projects;
2. Determine whether a product meets a project's specifications and local/state building energy codes;
3. Model different fenestration designs to compare energy performance.

Once the user is satisfied with the product, he or she creates a Bid Report containing the data for all fenestration products to be reviewed. This report can serve as an initial indication that the products comply with the project's energy-related requirements and building energy codes. The physical windows are then built, either on-site or in a factory. The final products are reviewed and are rated by an NFRC-Approved Calculation Entity (ACE) then a license agreement is signed with NFRC.

At this point, NFRC issues a CMA Label Certificate for the project. This Label Certificate, unlike NFRC's residential window label that is applied to individual units, is a single document that lists the certified fenestration ratings at the NFRC standard testing size for the entire building project. Once approved, the CMA Label Certificate is available online immediately. This single certificate serves as code compliance documentation for fenestration energy performance, and the certified products may be applied to future projects without repeating the certification process.

Benefits of CMA/CMAST

CMA provides facility managers, specifiers, building owners and design teams with a simple method for designing and certifying the energy performance of fenestration systems for their buildings. However, there are several additional advantages gained by using the CMA:

1. CMA's online tool, CMAST, has the ability to create a file with values for use in building energy analysis software programs, such as Energy Plus and DOE-2.
2. The program can export detailed information for angular-dependent SHGC and VT values, seamlessly transferring the data to the analytical software.
3. A 2010 study[1] conducted in California demonstrated that fenestration modeled with the CMA program can provide an increase in compliance margins by as much as 11.7 percent over the Energy Commission's default calculation methods.
4. CMA can help demonstrate above-code performance which is useful for environmental rating programs such as LEED™ or local green building programs.

Use of the CMA can help lead to a more efficient building, and also enable cost-savings due to more accurate fenestration performances and potential energy benefits from above-code utility incentives. Further details are available at www.NFRC.org/.

1 Study conducted by the Heschong Mahone Group

Example 3-1

Question

A 150,000 ft² "big box" retail store has 800 ft² of site-built vertical fenestration located at the entrance. An operable double pane aluminum storefront framing system is used, without a thermal break. What are the acceptable methods for determining the fenestration U- factor and SHGC? What are the labeling requirements assuming a center of glass U-factor of 0.50 and SHGC of 0.70 and a center glass visible transmittance of 0.75?

Answer

For site-built fenestration less than 1,000 ft^2 then one of the following three methods may be used:
1. The easiest method for site-built fenestration is to rate the fenestration using the Component Modeling Approach (CMA or CMAST) which will yield the most efficient values possible.
2. The second option is to use the default U-factor and SHGC values in equations in Reference Nonresidential Appendix NA6 as described in the following bullets:

- The Alternate U-factor may be calculated from the Reference Nonresidential Appendix NA6, Equation NA6-1, $U_T = C_1 + C_2 X U_C$. From Table NA-1 for metal frame site-built fenestration, C_1= 0.311 and C_2 = 0.872, therefore the overall U-factor is calculated to be 0.311 + 0.872 x 0.50 = 0.747.
- Likewise, the SHGC is determined from the Reference Nonresidential Appendix, NA6, Equation NA6-2, $SHGC_T$ = 0.08 + 0.86 x $SHGC_C$. Therefore, the SHGC is calculated to be 0.08 + 0.86 x 0.70 = 0.68.
- For VT, from Appendix NA6, the visible transmittance of the frame is 0.88 for a curtain wall, so the $VT_T = VT_{F\ X} VT_C$ = 0.88 X 0.75 = 0.66.

3. The third option for determining U-factor and SHGC is to select values from Default Standards Table 110.6-A and 110.6-B. From these tables, the U-factor is 0.79 and the SHGC is 0.70. A CEC Default Label Certificate, NRCC-ENV-05-E, should be completed for each fenestration product unless the responsible party chooses to attach a Default Temporary Labels to each fenestration unit throughout the building.

Example 3-2

Question

What constitutes a "double-pane" window?

Answer

Double-pane (or dual-pane) glazing is made of two panes of glass (or other glazing material) separated by a space [generally ¼ inch (6 mm) to ¾ inch (18 mm)] filled with air or other inert gases. Two panes of glazing laminated together do not constitute double-pane glazing, but are treated as single pane.

G. Air Leakage

§110.6(a)1, 110.7

Manufactured and site-built fenestration such as doors and windows must be tested and shown to have infiltration rates not exceeding the values shown in Table 3-1. For field-fabricated products or an exterior door, except for unframed glass doors and fire doors, the Standards require that the unit be caulked, gasketed, weather-stripped or otherwise sealed. Field-fabricated fenestration and field-fabricated exterior doors are not required to comply with Table 3-1.

Table 3-1 – Maximum Air Infiltration Rates

Class	Type	Rate
Windows (cfm/ft²) of window area	All	0.3
Residential Doors (cfm/ft²) of door area	Swinging, Sliding	0.3
All Other Doors (cfm/ft²) of door area	Sliding, Swinging (single door)	0.3
	Swinging (double door)	1.0

3.2.3 Dynamic Glazing

A. Chromatic Glazing

Chromatic type fenestration has the ability to change its performance properties, allowing the occupant to control manually or automatically their environment by tinting or darkening a window with the flip of a switch or by raising and lowering a shade positioned between panes of glass. Some windows and doors change their performance automatically in response to a control or environmental signal. These high-performance windows, which are sometimes referred to as “smart windows,” provide a variety of benefits, including reduced energy costs due to controlled daylighting and unwanted heat gain or heat loss. While still a relatively new technology, they are expected to grow substantially in the coming years. Look for the NFRC certified Dynamic Glazing Label to compare and contrast the energy performance for these new products. See the example of a NFRC Dynamic Glazing Label in Figure 3-5 below. Its unique rating identifiers help consumers understand the “dynamics” of the product, and allow comparison with other similar fenestration products.

Figure 3-5 - Dynamic Glazing NFRC Label

The label references the following information:

1. U-factor measures the rate of heat loss through a product. Therefore, the lower the U-factor, the lower the amount of heat loss. In cold climates where heating

bills are a concern, choosing products with lower U-factors will reduce the amount of heat that escapes from inside the house.

2. The Solar Heat Gain Coefficient (SHGC) measures the rate of heat gain from solar energy passing through a product. Therefore, the lower the SHGC, the less amount of solar heat gain. In hot climates where air conditioning bills are a concern, choosing products with a lower SHGC will reduce the amount of heat that comes in from the outside.
3. Visible Transmittance (VT) measures the amount of light that comes through a product. The higher the VT rating, the more light is allowed through a window or door.
4. The Variable Arrow – If the product can operate at intermediate states, a dual directional arrow, (↔), with the word “Variable” underneath will appear on the label. Some dynamic glazing is able to adjust to intermediate states allowing for a performance level between the endpoints. The low value rating is displayed to the left (in the closed position) and the high value rating is displayed to the right (in the Open position). This lets the consumer know the best and worst case performance of the product at a glance, as well as what the default or de-energized performance level will be.
5. Air Leakage (AL) is a measurement of heat loss and gain by infiltration through cracks in the window assembly, which affects occupant comfort. The lower the AL, the less air will pass through cracks in the window assembly.

To receive chromatic glazing credit the following must be met:

1. Optional Prescriptive - Default to Standard Tables 140.3-B and 140.3-C, U-factor and SHGC;
2. Performance Approach Compliance - maximum credit allowance for best rating;
3. Automatic controls must be used to receive best rating values; or
4. NFRC Dynamic Glazing Compliance Label is required; otherwise, default to Standard Tables 110.6-A and 110.6-B values.

3.2.4 Window Films

Developed in the early 1950’s, window films are mostly made of polyester substrate that is durable, tough, and highly flexible. It absorbs little moisture and has both high and low temperature resistances. Polyester film offers crystal clarity and can be pre-treated to accept different types of coatings for energy control and long term performance. Window films are made with a special scratch resistant coating on one side and with a mounting adhesive layer on the other side. The adhesive is normally applied to the interior surface (room side) of the glass, unless a film is specifically designed to go on the exterior window surface.

Polyester film can be metalized and easily laminated to other layers of polyester film. It can be tinted or dyed, or metalized through vacuum coating, sputtering, or reactive deposition to produce an array of colored and spectrally selective films either clear or in color; often the color comes from the metallic coating rather than from tinting or dying.

There are three basic categories of window films:

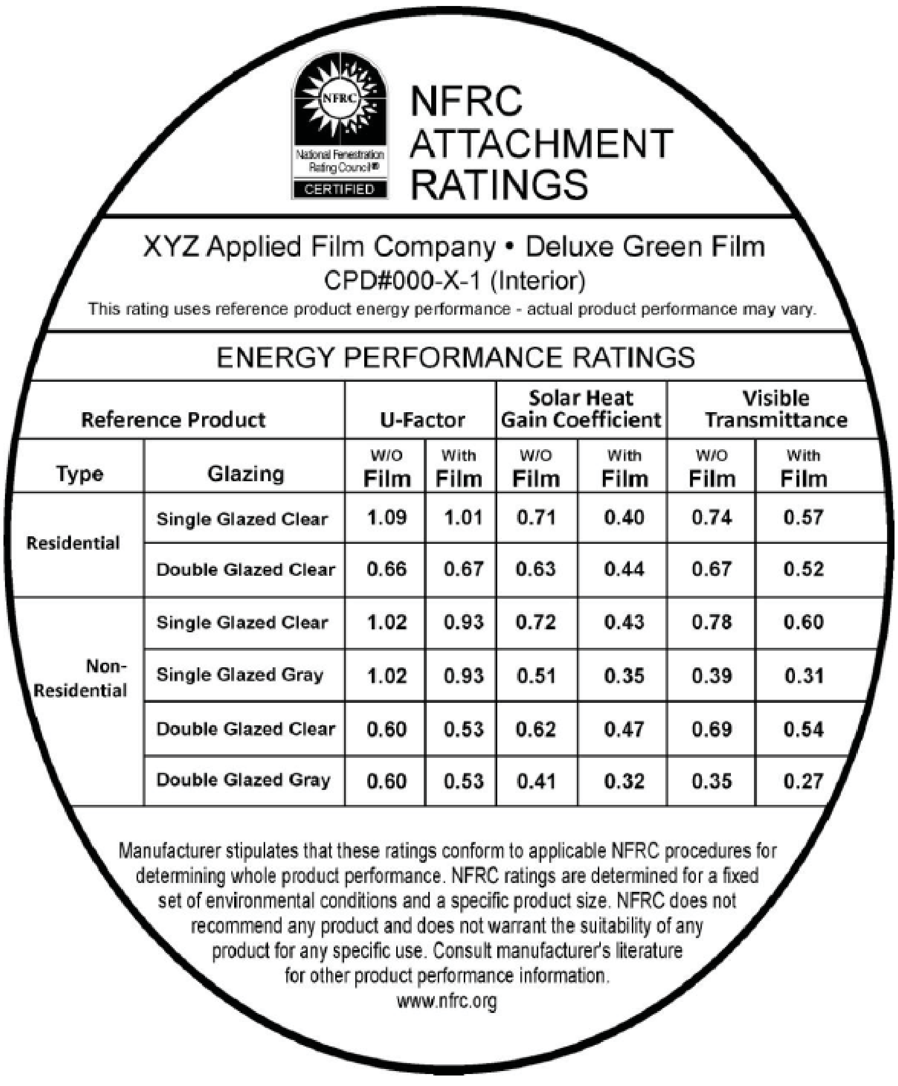
1. Clear (Non-Reflective)
2. Tinted or dyed (Non-Reflective)
3. Metalized (Reflective), which can be metalized though vacuum coating, sputtering, or reactive deposition, and may be clear or colored

Clear films are used as safety or security films and to reduce ultraviolet (UV) light which contributes to fading of finished surfaces and furnishings. However, they are not normally used for solar control or energy savings.

Tinted or dyed window films reduce both heat and light transmission, mostly through increased absorptance and can be used in applications where the primary benefit desired is glare control with energy savings as secondary benefit.

Metalized (reflective) films are the preferred window film in most energy saving applications, since they reduce transmission primarily through reflectance, and are manufactured to selectively reflect heat more than visible light.

Look for the NFRC certified- Attachment Ratings Energy- Performance Label, which helps consumers understand the contrast in energy performance of Window Films. An example of a Window Film Energy Performance Label is shown in Figure 3-6 below.



NFRC ATTACHMENT RATINGS

National Fenestration Rating Council® CERTIFIED

XYZ Applied Film Company • Deluxe Green Film

CPD#000-X-1 (Interior)

This rating uses reference product energy performance - actual product performance may vary.

ENERGY PERFORMANCE RATINGS

Reference Product		U-Factor		Solar Heat Gain Coefficient		Visible Transmittance	
Type	Glazing	W/O Film	With Film	W/O Film	With Film	W/O Film	With Film
Residential	Single Glazed Clear	1.09	1.01	0.71	0.40	0.74	0.57
	Double Glazed Clear	0.66	0.67	0.63	0.44	0.67	0.52
Non-Residential	Single Glazed Clear	1.02	0.93	0.72	0.43	0.78	0.60
	Single Glazed Gray	1.02	0.93	0.51	0.35	0.39	0.31
	Double Glazed Clear	0.60	0.53	0.62	0.47	0.69	0.54
	Double Glazed Gray	0.60	0.53	0.41	0.32	0.35	0.27

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information.

www.nfrc.org

Figure 3-6 - Window Film Energy Performance Label

A. Window Film Compliance

To receive window film credit the following must be met:

1. The Performance Approach must be used;
2. Only use the Alteration to Existing building compliance method;
   a. NFRC Window Film Energy Performance Label is required for each different film; otherwise, use the default Table 110.6-A and 110.6-B values;
   b. Window Films to be used shall have a 10 year warranty or better

B. Window Prescriptive Requirements

There are four aspects of the envelope component approach for windows:

1. Maximum total area plus west-facing
2. Maximum U-factor
3. Maximum Relative Solar Heat Gain (RSHG)
4. Minimum visible transmittance (VT)

3.2.5 Window Area

§140.3(a)5.A.

Under the envelope component approach, the total window area may not exceed 40 percent of the gross exterior wall area (encompassing total conditioned space) for the building. Likewise, the west-facing window area may not exceed 40 percent of the west-facing gross wall area (encompassing total conditioned space for the building) or 6 feet times the west-facing display perimeter, whichever is greater. This maximum area requirement will affect those buildings with very large glass areas, such as high-rise offices, automobile showrooms or airport terminals.

Optionally, the maximum area may be determined by multiplying the length of the display perimeter (see definition below in this section) by 6 ft in height and use the larger of the product of that multiplication or 40 percent of gross exterior wall area.

Glazing in a demising wall does not count toward the total building allowance. There is no limit to the amount of glazing allowed in demising walls, but it must meet the prescriptive U-factor, relative solar heat gain (RSHG), and visible light transmission (VT) requirements for the climate zone.

As a practical matter, window area is generally taken from the rough opening dimensions. To the extent this opening is slightly larger than the frame; the rough opening area will be slightly larger than the formally-defined window area.

For glazed doors, also use the rough opening area, except where the door glass area is less than 50 percent of the door, in which case the glazing area may be either the entire door area, or the glass area plus two inches added to all four sides of the glass (to represent the “window frame”) for a window in a door. Calculate the window area from the rough opening dimensions and divide by the gross exterior wall area, which does not include demising walls. Glazing area in demising walls has no limit and any glazing in demising walls is not counted as part of the exterior wall/window ratio.

Display perimeter is the length of an exterior wall in a Group B; Group F, Division 1; or Group M occupancy that immediately abuts a public sidewalk, measured at the sidewalk level for each story that abuts a public sidewalk. This generally refers to retail display windows, although other occupancies such as offices can also have a display perimeter. Public sidewalks are accessible to the public at large (no obstructions, limits to access, or intervening non-public spaces). The display perimeter is used for a special calculation of window area (§140.3(a)5A). Demising walls are not counted as part of the display perimeter.

In general, any orientation within 45° of true north, east, south or west will be assigned to that orientation. The orientation can be determined from an accurate site plan. Figure 3-7 demonstrates how surface orientations are determined and what to do if the surface is oriented exactly at 45° of a cardinal orientation. For example, an east-facing surface cannot face exactly northeast, but it can face exactly southeast. If the surface were facing exactly northeast, it would be considered north-facing.

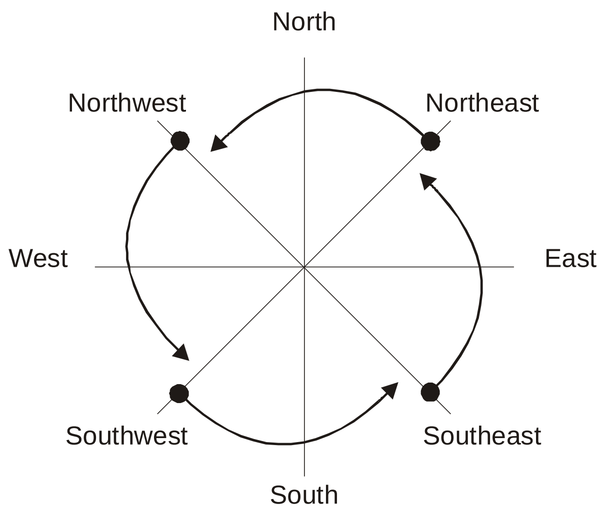


Figure 3-7 – Four Surface Orientations

3.2.6 Window U-factor

§140.3(a)5B

Fenestration products are required to use default U-factors and solar heat gain coefficients (see Tables 110.6-A and B of the standards) or have their performance characteristics certified by NFRC. However, each window must meet the prescriptively required maximum U-factor criteria (see 2 below) for each climate zone. For nonresidential buildings, the U-factor criterion is 0.36 Btu/h-°F-ft² for fixed windows, 0.46 operable windows, 0.41, for curtain wall or store front and 0.45 for glazed doors. In general, most NFRC-rated double-glazed windows with a low-e coating and a thermally broken frame will comply with the U-factor criterion; however, other window constructions may also comply. See www.NFRC.org, Certified Product Directory database or use Equation NA6-1in Reference Nonresidential Appendix NA6.

Table 3-2 – Window Prescriptive Requirements U-factors

	All Climate Zones				
Space Type	**Criterion**	**Fixed Window**	**Operable Window**	**Curtainwall / Storefront**	**Glazed Doors**
Nonresidential	U-factor	0.36	0.46	0.41	0.45
	Relative Solar Heat Gain 0-40% WWR	0.25	0.22	0.26	0.23
	Min VT	0.42	0.32	0.46	0.17
	All Climate Zones				
Residential High-rise	U-factor	0.36	0.46	0.41	0.45
	Relative Solar Heat Gain 0-40% WWR	0.25	0.22	0.26	0.23
	Min VT	0.42	0.32	0.46	0.17
(From Standards Tables 140.3-B and 140.3-C)					

3.2.7 Window Relative Solar Heat Gain (RSHG)

§140.3(a)5C

Relative solar heat gain (RSHGC) is essentially the same as SHGC, except for the external shading correction. It is calculated by multiplying the SHGC of the fenestration product by an overhang factor. If an overhang does not exist, then the overhang factor is 1.0. Relative solar heat gain is only applicable when using the prescriptive compliance approach.

Tables 140.3-B and 140.3-C of the Energy Standards (Table 3-2 above) specify the max area-weighted average RSHGC excluding the effects of interior shading.

Overhang factors may either be calculated or taken from Table 3-18 below and depend upon the ratio of the overhang horizontal length (H) and the overhang vertical height (V). These dimensions are measured from the vertical and horizontal planes passing through the bottom edge of the window glazing, as shown in Figure 3-14. An overhang factor may be used if the overhang extends beyond both sides of the window jamb a distance equal to the overhang projection (§140.3(a)5Cii). If the overhang is continuous along the side of a building, this restriction will usually be met. If there are overhangs for individual windows, each must be shown to extend far enough from each side of the window. See subsection 3.2.9 for more information on RSHG.

3.2.8 Visible Light Transmittance (VT)

New for the 2013 Standards is a requirement for visible light transmittance. Fenestration must meet the climate zone specific prescriptive requirement of having an area-weighted average VT of 0.42 or greater for fixed windows, 0.32 or greater for operable windows, 0.46 or greater for curtain walls and 0.17 or greater for glazed doors. Products with spectrally selective “low-e” coatings (also known as single, double or triple silver low-e) are available to meet this requirement. For a more detailed discussion of VT see subsection 2.3.11, Determining Visible Transmittance (VT).

A combination of high VT glazing in the upper part of a window (clerestory) and lower VT glazing at the lower part of the window (view window) can be used, as long as the area-weighted average meets the prescriptive requirement. This allows daylight to enter the space through the high VT glazing making a better daylighting design.

The standards also allow a slight variance if the window-to-wall ratio (WWR) is greater than 40%. For this case, assume 0.40 for the WWR in the equation below, or if the glazing can comply with the prescriptive requirements if the area-weighted average VT meets the following minimum requirement:

Visible Light Transmittance Equation: $VT \geq 0.11 / WWR$.

In this equation VT is the visible transmittance of the framed window, and WWR is the gross window-to-wall ratio.

The graph below shows the allowed area weighted average min. VT's by gross WWR for four types of windows.

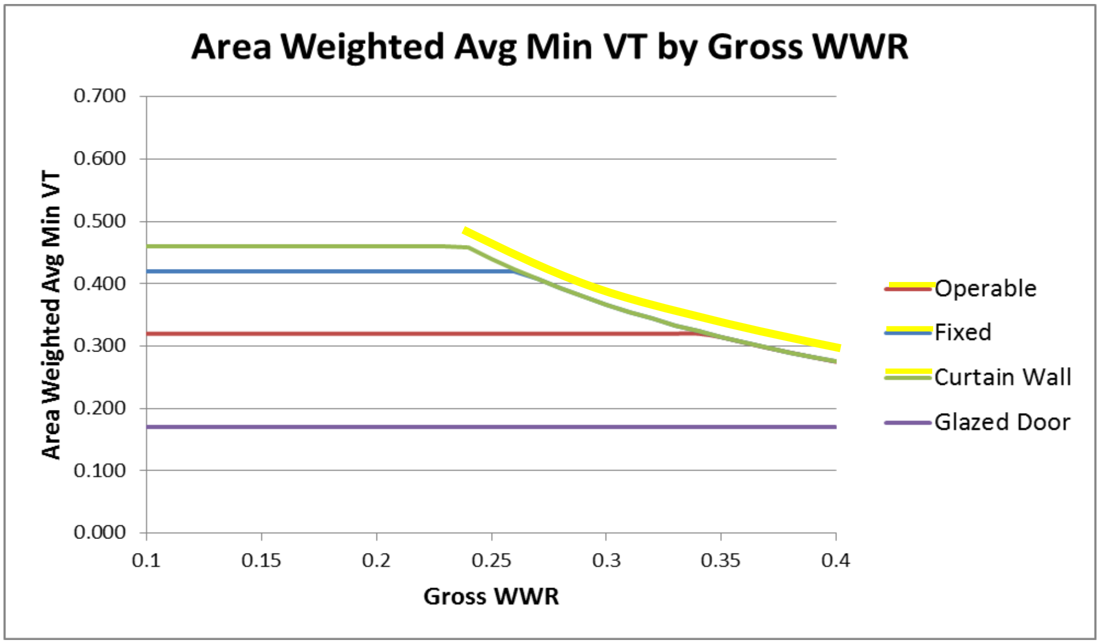


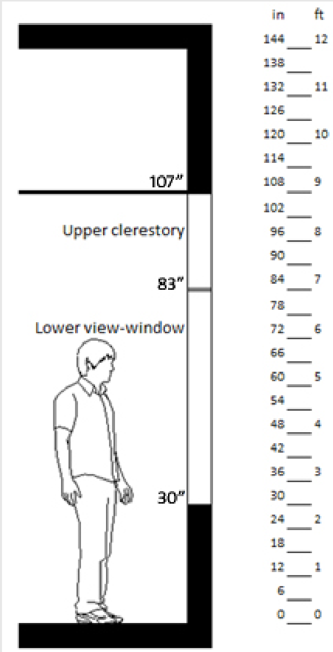
Figure 3-8 – Area Weighted Average Minimum VT by Gross Window to Wall Ratio

The average VT requirements apply separately to chromogenic (dynamic or color changing) glazing and non-chromogenic glazing. For chromogenic glazing, higher ranges of VT can be used to meet the prescriptive requirements. However, all glazing that is not chromogenic must separately meet the area-weighted VT prescriptive requirements.

Example 3-3

Question

A space has a gross window-to-wall ratio of 30% and has a fixed window with a sill height of 2'6" (30") and a head height of 8'11" (107"), which runs 10' wide (120"). The window has a break at 6'11" (83") such that the upper portion or clerestory portion of the window is 2' (24") tall and can have a glazing different from that in the lower portion (view window). Can a designer use 0.30 VT glazing in the view window?



Answer

Possibly, if a higher VT glazing is used in the clerestory. Since a WWR of 30% is less than the threshold of 40%, the area weight average minimum VT is read from Figure 3-8.

The area weighted minimum VT we need for this window is 0.420.

I.e. (View window Area x View window VT) + (Clerestory Area x Clerestory VT) / Total Window Area = 0.420

In our case:

Clerestory area = 24” height x 120” width = 2,880 in^2

View window area = (83” - 30”) height x 120” width = 6,360 in^2

Total window area = (107” - 30”) height x 120” width = 9,240 in^2

If the designer wants to use a 0.30 VT glazing in the view window then View window VT = 0.30(6360 x 0.3) + (2880 x VT_{CL})/9240 = 0.420

Solving the above equation for Clerestory VT we get:

Clerestory VT = 0.685

So, to use a 0.3 VT glazing in the view window the designer must use a 0.685 VT or higher window in the clerestory.

3.2.9 Skylight Prescriptive Envelope Requirements

As with windows, there are four aspects of the envelope component approach for skylights:

- Maximum area
- Maximum U-factor
- Maximum solar heat gain coefficient
- Minimum Visible Transmittance (VT)

Table 3-3 - Skylight Requirements (Area-weighted Performance Rating)

		All Climate Zones		
		Glass, Curb Mounted	Glass, Deck-Mounted	Plastic, Curb-Mounted
Nonresidential	U-factor	0.58	0.46	0.88
	SHGC	0.25	0.25	NR
	VT	0.49	0.49	0.64
	Maximum SRR%	5%		
High-Rise Residential	U-factor	0.58	0.46	0.88
	SHGC	0.25	0.25	NR
	VT	0.49	0.49	0.64
	Maximum SRR%	5%		

Excerpt from Standards Tables 140.3-B and 140.3-C, Skylight Roof Ratio, SRR

3.2.10 Skylight Area

§140.3(a)6A

The area limit for skylights is 5 percent of the gross exterior roof area or skylight roof ratio (SRR). The limit increases to 10 percent for buildings with an atrium over 55 ft high (see Reference Joint Appendix JA1 definition). The 55 feet height is also the height threshold at which the California Building Code requires a mechanical smoke-control system for atriums (CBC Sec. 909). This means that the 10 percent skylight allowance is not allowed for atriums unless they also meet this smoke control requirement. All skylights must meet the maximum U-factor criteria.

Note an atrium is defined in Reference Joint Appendix JA1 as:

"a large-volume indoor space created by openings between two or more stories but is not used for an enclosed stairway, elevator hoistway, escalator opening, or utility shaft for plumbing, electrical, air-conditioning or other equipment."

There are two ways that skylights can be mounted into a roof system, either flush-mounted or curb-mounted. In order to create a positive water flow around them, skylights are often mounted on "curbs" set above the roof plane. These curbs, rising 6 to 12 inches (15 to 30 centimeters) above the roof, create additional heat loss surfaces, right where the warmest air of the building tends to collect.

Skylight area of unit skylights is the area of the rough opening of a skylight. The rough framed opening is used in the NFRC U-factor ratings (NFRC U-factor ratings for manufactured skylights with integrated curbs include glazing, framing, and the curb) procedure; it is also the basis of the default U-factors in Reference Appendix NA6. For skylights, the U-factor represents the heat loss per unit of rough framed opening (the denominator). However, the heat loss (the numerator) includes losses through the glazing, the frame, and the part of the curb that is integral with the skylight and included in the skylight test. Portions of roof that serve as curbs that mount the skylight above the level of the roof (see Figure 3-9) are part of the opaque building envelope.

Site-built monumental or architectural skylights that are equipped with integral built-in or site-built curbs (not part of the roof construction) are often used for atrium roofs, malls, and other applications that need large skylights and are treated differently. In such cases the skylight area is the surface area of the glazing and frame/curb (not the area of the rough framed opening), regardless of the geometry of the skylight (i.e., could be flat pyramid, bubble, barrel vault, or other three-dimensional shape). For special cases such as clerestory, rooftop monitor or tubular skylights, see Chapter 5 of this manual.

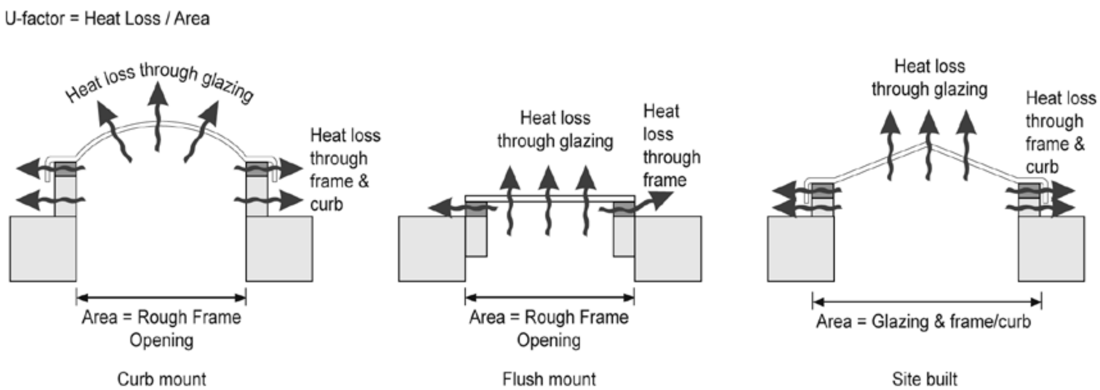


Figure 3-9 – Skylight Area

When skylights are specified, the designer must also show the Skylit Daylight Zones on the building plans. When the total installed general lighting power in the Skylit Daylight Zones in a room is greater than 120W, the general lighting in these Daylit Zones is controlled by automatic daylighting controls. See Chapter 5 of this manual for a detailed discussion of the Daylight Zones.

3.2.11 Skylight U-factor

§140.3(a)6B

For skylights, the U-factor and solar heat gain coefficient (SHGC) criteria are different, depending on whether the skylight glazing material is plastic or glass. For glass skylights, the U-factor criteria depend on whether or not the skylight is intended to be mounted on a curb. It is assumed that all plastic skylights are mounted on a curb (see Standards Tables 140.3-B, 140.3-C, and 140.3-D for U-factor requirements). As discussed above, the U-factor for skylights includes heat losses through the glazing, the frame and the integral curb (when one exists). In many cases, an NFRC rating does not exist for projecting plastic skylights. In this case, the designer can make use of the default fenestration U-factors in Standards Table 110.6-A.

If a glass skylight is installed and it is not possible to determine whether the skylight was rated with a curb, compliance shall be determined by assuming that the skylight must meet the requirements for skylights with a curb. All plastic skylight types are assumed to meet the requirements for plastic skylights with a curb.

3.2.12 Skylight SHGC

§140.3(a)6C

Skylights are regulated only for SHGC, not RSHG, because skylights cannot have overhangs. The SHGC criteria vary with the skylight to roof ratio (SRR). The SHGC requirements apply to all skylight to roof ratios. See Tables 140.3-B, 140.3-C, and 140.3-D for SHGC requirements in the Standards. The designer can make use of default solar heat gain coefficients in Standards Table 110.6-B or use the Nonresidential Reference Appendix NA6 if all site-built fenestration (skylights and vertical fenestration) is less than 1,000 ft².

3.2.13 Daylighting Prescriptive Requirements for Skylights in Large Enclosed Spaces

§140.3(c)

Appropriately-sized skylight systems, when combined with daylighting controls, can dramatically reduce the energy consumption of a building. Daylighting control requirements under skylights are discussed in Chapter 5 of this manual. With too little skylight area, insufficient light is available to turn off electric lighting; with too much skylight area, solar gains and heat losses through skylights negate the lighting savings with heating and cooling loads.

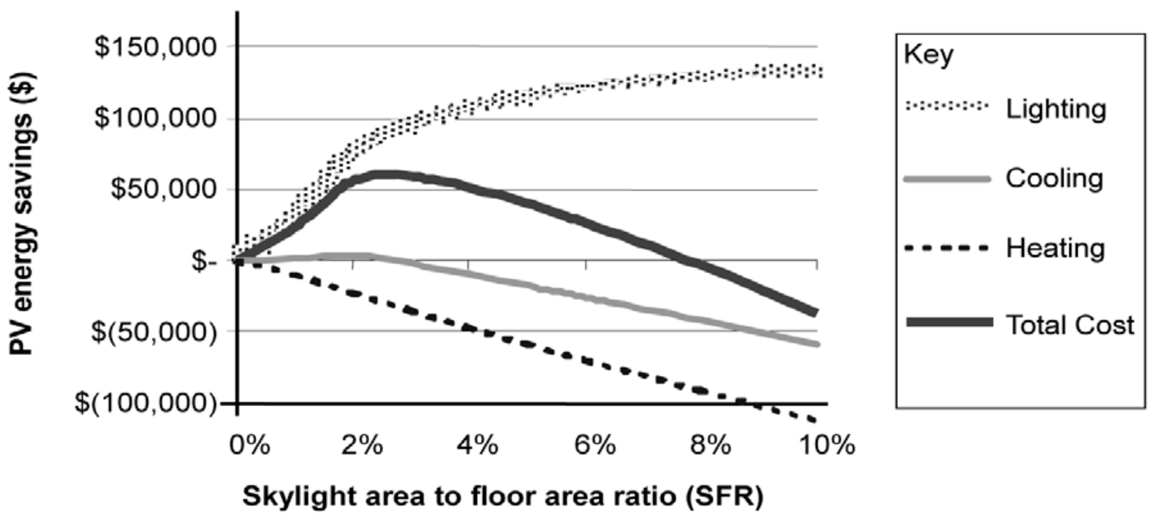


Figure 3-10 – Present Value Savings of Skylight 50,000 ft² Warehouse in Sacramento

Skylights and automatic daylighting controls are most cost-effective in large open spaces and are prescriptively required in enclosed spaces (rooms) that are larger than 5,000 ft², directly under a roof and have ceiling heights greater than 15 ft., and have lighting power densities greater than 0.5 W/ft². The standards require a total of at least 75% of the floor area be within Skylit Daylit Zones or Primary Sidelit Zones.

The definitions of Daylit Zones are contained in §130.1(d) and applies to the circuiting of daylighting controls near windows and skylights. These definitions are applied to the calculation of Daylit Zones areas to show compliance with these minimum daylighting requirements. However, the application of these daylit definitions for purposes of complying with the 75% floor area requirements do not need to account for the presence of partitions, stacks or racks.

The rationale for these relaxed definitions are that the design of the envelope may be developed before there is any knowledge of the location of the partial height partitions or shelves as is often the case for core and shell buildings. Thus, the architectural Daylit Zone requirement of 75% of the space area indicates the possibility of the architectural space being mostly daylit. By not accounting for partial ceiling height partitions and racks, the standards are consistent in addressing architectural daylit areas regardless of whether the design is core and the shell or a complete design development including interior design. This approach does not require the addition of extra skylights or windows if racks and partial height partitions are added later.

The Daylit Zone and controls specifications in §130.1(d) describe which luminaires are controlled and this specification must consider the daylit obstructing effects of tall racks, shelves and partitions. There is a greater likelihood that the electrical design will occur later than the architectural design and, thus, greater planning for these obstructions can be built into the lighting circuiting design.

The demanding lighting control needs in auditoriums, churches, museums and movie theaters, and the need to minimize heat gains through the roofs of refrigerated warehouses, render these few occupancies exempt from the skylight requirement. Gymnasiums do not qualify for this exemption unless there is a stage or there is a determination that this space will be used to hold theatrical events.

Since skylights with controls reduce electric lighting, they are mandatory on all nonresidential occupancies that meet the above criteria, whether the space is conditioned or unconditioned. See further discussion in subsection 3.2.6, B. Controls.

In qualifying high ceiling large buildings, the core of many of these spaces will be daylighted with skylights. Skylighting 75% of the floor area is achieved by evenly spacing skylights across the roof of the building. A space can be fully skylighted by having skylights spaced so that the edges of the skylights are not further apart than 1.4 times the ceiling height. Thus, in a space having a ceiling height of 20 feet, the space will be fully skylighted if the skylights are spaced so there is no more than 28 feet of opaque ceiling between the skylights.

The total skylight area on the roof of a building is prescriptively limited to a maximum of 5% of the gross roof area (§140.3(a)6. Studies have found that energy savings can be optimized if the product of the Visible Transmittance (VT) of the skylight and the skylight to daylit area ratio is greater than 2% (this accounts for a light well factor of 75% and a skylight dirt depreciation factor of 85%).[1] If one fully daylights the space with skylights and the skylights meet a prescriptive requirement of 49% VT, then approximately a minimum skylight area that is at least 3% of the roof area is typically needed to optimize energy cost savings (see Figure 3-11).

[1] Energy Design Resources Skylighting Guidelines http://www.energydesignresources.com/resources/publications/design-guidelines/design-guidelines-skylighting-guidelines.aspx

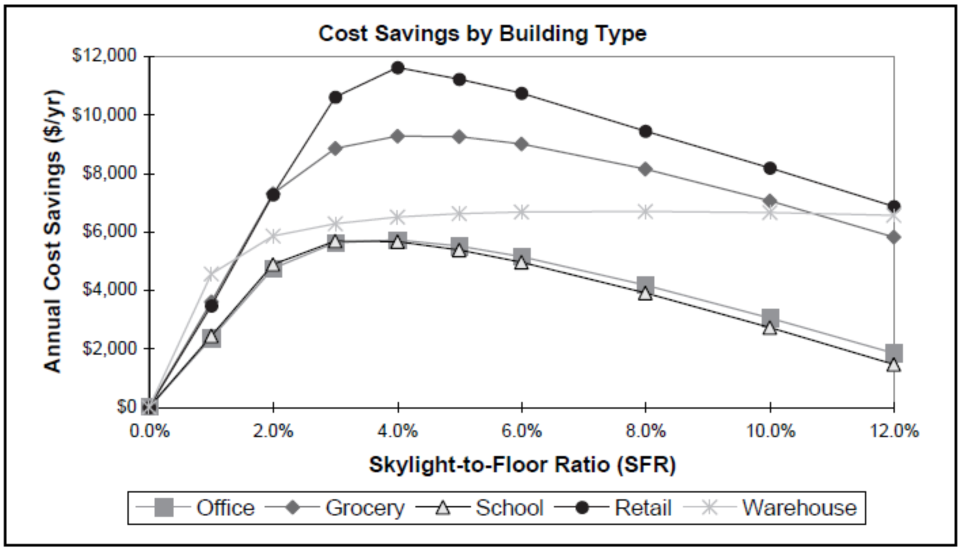


Figure 3-11 – Skylighting Savings by Skylight-to-Floor Ratio and Building Type in San Bernardino, CA (Climate Zone 10) [2]

Example 3-4

What is the maximum spacing and recommended range for skylights in a 40,000 ft^2 warehouse with 30 foot tall ceiling and a roof deck?

From the definition of *Skylit Daylit Zone* in Section 130.1(d), the maximum spacing of skylights that will result in the space being fully skylit is:

Maximum skylight spacing = 1.4 x Ceiling Height + Skylight width

By spacing skylights closer together results in more lighting uniformity and thus better lighting quality – but costs more as more skylights are needed. However as a first approximation one can space the skylights 1.4 times the ceiling height. For this example, skylights can be spaced 1.4 x 30 = 42 feet. In general the design will also be dictated by the size of roof decking materials (such as 4' by 8' plywood decking) and the spacing of roof purlins so the edge of the skylights line up with roof purlins. For this example we assume that roof deck material is 4' by 8' and skylights are spaced on 40 foot centers.

Each skylight is serving a 40 x 40 ft area of 1,600ft^2. A standard skylight size for warehouses is often 4 ft by 8 ft (so it displaces one piece of roof decking). The ratio of skylight area to daylit area is 2% (32/1600 = 0.02). Assuming this is a plastic skylight and it has a minimally compliant visible light transmittance of 0.64 the product of skylight transmittance and skylight area to daylit area ratio is;

(0.64)(32/1,600) = 0.013 = 1.3%

This is a little less than the 2% rule of thumb described earlier for the product of skylight transmittance and skylight area to daylit area ratio. If one installed an 8 ft by 8 ft skylight (two 4 ft by 8 ft skylights) on a 40 foot spacing would yield a 2.6% product of skylight transmittance and skylight area to daylit area ratio and provide sufficient daylight. With 64 square feet of skylight area for each 1,600 square feet of roof area, the skylight to roof area ratio (SRR) is 4% which is less than the maximum SRR of 5% allowed by Section 140.3(a) and thus also complies with the maximum skylight requirement.

[2] Figure 5-9 *Skylighting Guidelines*.

An alternate (and improved) approach would be to space 4 ft x 8 ft skylights closer together which would provide more uniform daylight distribution in the space and could more closely approach the desired minimum VT skylight area product. A 32 foot center to center spacing of skylights results in (32 x 32) = 1,024 square feet of daylit area per skylight. By taking the product of the skylight VT and the skylight area and dividing by 0.02 (the desired ratio) yields the approximate area the skylight should serve. In this case, with a VT of 0.64 and a skylight area of 32 square feet, each skylight should serve around:

$$(0.64 \times 32 / 0.02) = 1{,}024 \text{ ft}^2.$$

For a minimally compliant 4 ft by 8 ft plastic skylight with a visible light transmittance of 0.64, the product of skylight transmittance and skylight area to daylit area ratio is:

$$(0.64)(32/1{,}024) = 0.020 = 2.0\%$$

Energy savings can be better optimized than this rule of thumb approach by using a whole building energy performance analysis tool that optimizes the trade-offs between daylight, heat losses and gains, and electric lighting energy consumption.

3.2.14 Skylight Characteristics

§140.3(c)

Skylights installed to comply with the minimum skylight area for large enclosed spaces shall meet the requirements in §140.3(a)6 and §140.3(c):

1. Have a glazing material or diffuser that has a measured haze value greater than 90 percent, tested according to ASTM D1003 (notwithstanding its scope) or other test method approved by the Energy Commission.
2. If the space is conditioned, meet the requirements in §140.3(a)6.

In general, the standards require the use of double-glazed skylights. When the skylights are above unconditioned spaces, there is no limitation placed on the maximum skylight area or its U-factor or SHGC.

If the space is unconditioned, single-glazed skylights will comply with the code requirements as long as they are sufficiently diffusing (i.e. the glazing or diffuser material has a haze rating greater 90 percent) and their visible transmittance is above the VT requirements in Table 140.3-B or C. Products that have such a rating include prismatic diffusers, laminated glass with diffusing interlayer’s, pigmented plastics, etc. The purpose of this requirement is to assure the light is diffused over all sun angles. Note, any unconditioned space that later becomes conditioned must meet the new construction envelope requirements. Therefore, if the space may become conditioned in the future, it is recommended that the envelope meet the conditioned envelope thermal requirements.

Other methods of diffusion that result in sufficient diffusion of light over the course of the entire year would also be acceptable in lieu of using diffusing glazing. Acceptable alternatives are baffles or reflecting surfaces that ensure direct beam light is reflected off of a diffuse surface prior to entering the space over all sun angles encountered during the course of a year. This alternative method of diffusion would have to be documented by the designer and approved by the code authority in your jurisdiction.

3.2.15 Controls

§130.1(d)

Electric lighting in the Skylight Daylit Zones shall meet the mandatory control requirements in §130.1(d). See Chapter 5 for more information about lighting control requirements and for more information about daylighting control requirements.

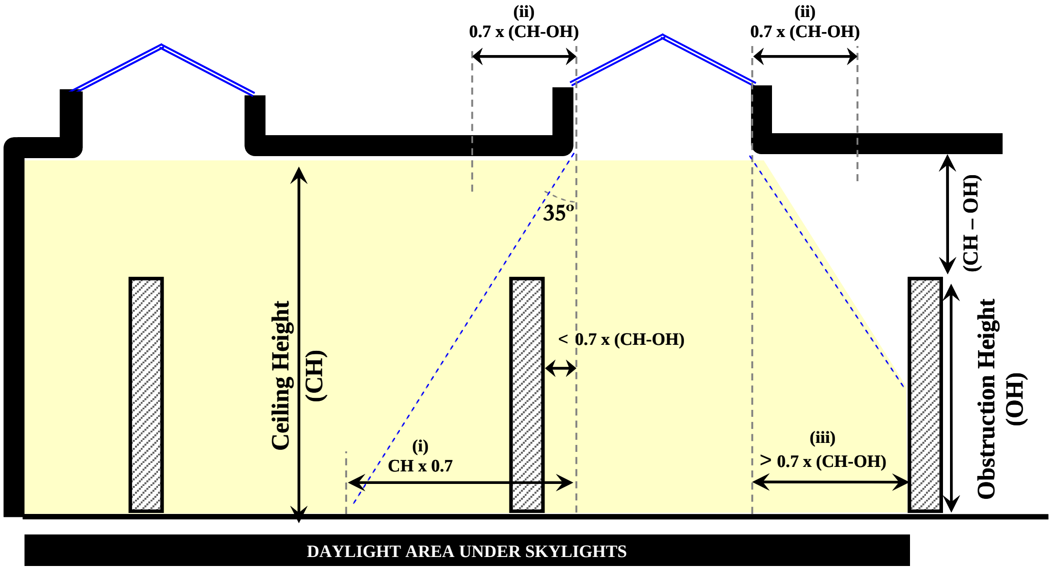


Figure 3-12 – Daylit Area under Skylights

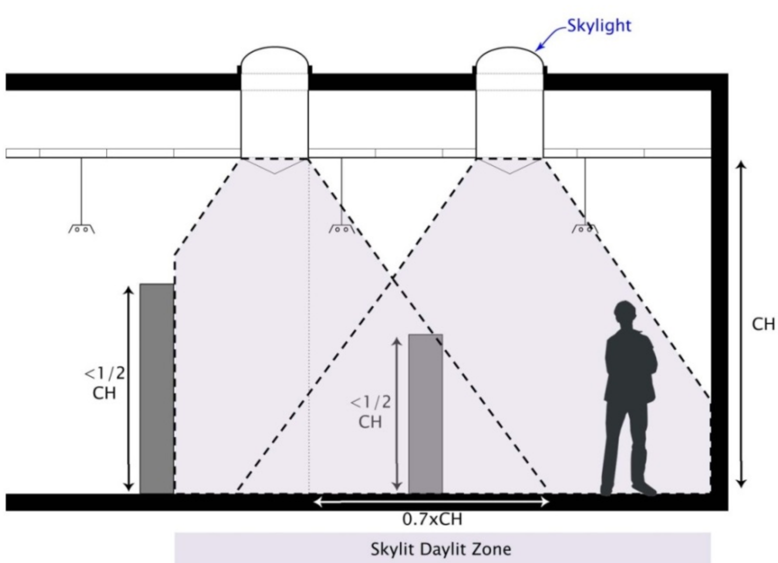


Figure 3-13– Daylit Area Tradeoff between Skylights and Windows

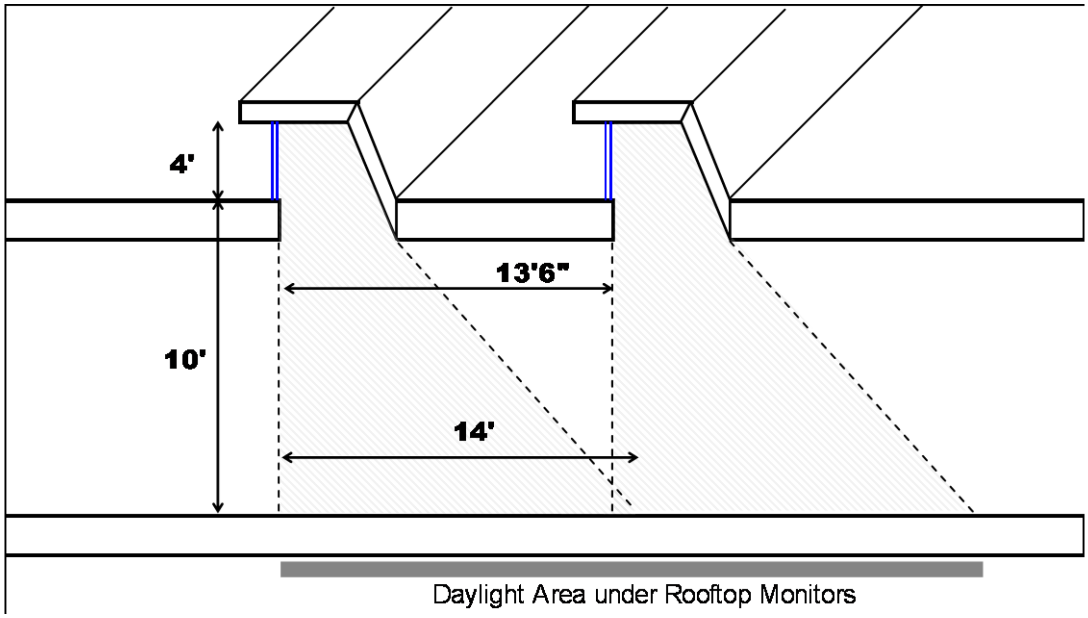


Figure 3-14 – Daylit Area under Rooftop Monitors

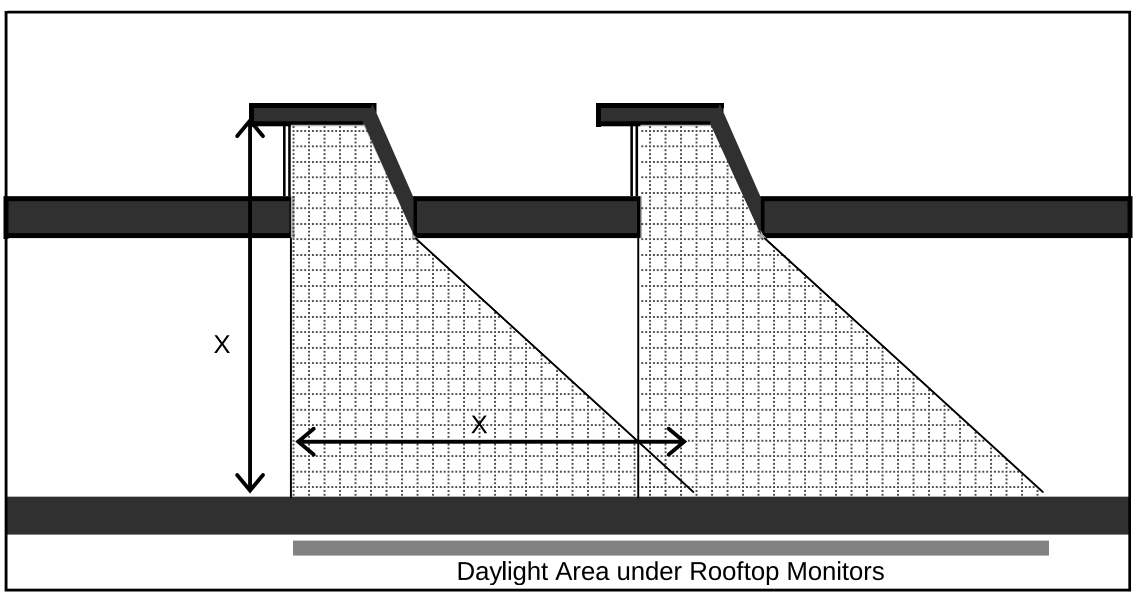


Figure 3-15 – Daylit Area under Rooftop Monitors

3.2.16 Determining Fenestration U-factors

§110.6 and §141.0(b)3

The U-factor for a fenestration product describes the rate of heat flow through the entire unit, not just the glass or plastic glazing material. The U-factor includes the heat flow effects of the glass, the frame, and the edge-of-glass conditions (there also may be spacers, sealants and other elements that affect heat conduction). For skylights mounted on a curb that is part of the roof construction, the total heat flow considered in determining the U-factor includes losses through the frame, glazing and other components, but not through the curb that is part of the roof construction.

Standards Tables 140.3-B, 140.3-C, and 140.3-D, lists skylight product that includes a curb, and the effects of this curb are included in the product U-factor rating. This curb included in the product rating is separate from the curb that is a part of the roof construction. For projecting windows (greenhouse windows), the total heat flow includes the side panels, base and roof of the projecting window assembly. However, the area used to determine the U-factor for skylights and projecting windows is the rough-framed opening. Using the rough-framed opening eases the process of making load calculations and verifying compliance, since the rough-framed opening is easier to calculate than the actual surface area of the projecting window or skylight.

Reference Joint Appendix JA1 lists many of the terms and product characteristics that relate to fenestration U-factors. In particular, see the definitions for window, skylight, window area, skylight area, site-built fenestration, and field-fabricated fenestration.

Table 3-4 shows acceptable procedures for determining fenestration U-factors for four classes of fenestration: manufactured windows, manufactured skylights, site-built fenestration, and field-fabricated fenestration.

Table 3-4 – Acceptable Methods for Determining U-factors

	Fenestration Category				
SHGC Determination Method	Manufactured Windows	Manufactured Skylights	Site-Built Fenestration (Vertical& Skylight)	Field-Fabricated Fenestration	Glass Block
NFRC's Component Modeling Approach (CMA)	✓	✓	✓	N/A	N/A
NFRC-100	✓	✓	✓	N/A	N/A
Standards Default Table 110.6-A	✓	✓	✓	✓	✓
NA6[1]	N/A	N/A	✓	N/A	N/A

The Alternative Default U-factors from Nonresidential Reference Nonresidential Appendix NA6 may only be used for site-built vertical and skylights having less than 1,000 ft^2.

The preferred methods for determining fenestration U-factor are those in NFRC 100 for manufactured windows and for site-built fenestration. For manufactured windows, the default U-factors in Standards Table 110.6-A (reproduced in Table 3-6 Table 3-6below) must be used if NFRC-determined U-factors are not available. These U-factors represent the high side of the range of possible values, thereby encouraging designers to obtain ratings through NFRC procedures, when they are available.

NFRC U-factors are becoming more common for skylights; increasingly, more manufacturers are getting NFRC labels for their skylights, including tubular skylights (which includes U-factor), and SHGC. If NFRC data is not available, the Alternative Default U-factor equation from Reference Nonresidential Appendix NA6, Equation NA6-1 may be used for skylights. This equation is derived from NFRC-100 and represent average typical values, as opposed to the values published in Table 110.6-A in the Standards that are on the high side of the range of typical values.

The recommended method for determining the U-factor of site-built fenestration systems (curtain walls and storefront systems) is the NFRC 100 procedure. This requires that site-build fenestration, including curtain walls, go through the NFRC process for obtaining label certificates for site-built products. If the building has less than 1,000 ft² of site-built fenestration area, which includes windows, glazed doors, and skylights, then U-factors used for compliance for site-built products may instead be calculated from Equation NA6-1 from the Reference Nonresidential Appendix NA6, or Standards default values from Table 110.6-A.

For buildings with more than 1,000 ft² of site-built fenestration area, there are two compliance choices with regard to U-factor and labeling of site-built fenestration:

Go through the NFRC process and obtain a label certificate. This is the option described in §10-111(a)1A.

Provide a default label certificate using the default U-factors from Standards Table 110.6-A. This option results in very conservative U-factors.

3.2.17 Field-Fabricated Fenestration Product or Exterior Door

Field-fabricated fenestration is fenestration assembled on site that does not qualify as site-built fenestration. It includes windows where wood frames are constructed from raw materials at the building site, salvaged windows that do not have an NFRC label or rating, and other similar fenestration items.

For field-fabricated fenestration, the U-factor and Solar Heat Gain Coefficient are default values that can be found in Table 3-5 and Table 3-6 below. Values are determined by frame type, fenestration type and glazing composition.

Exterior doors are doors through an exterior partition. They may be opaque or have glazed area that is less than or equal to one-half of the door area. U-factors for opaque exterior doors are listed in Reference Joint Appendix JA4, Table 4.5.1. Doors with glazing for more than one-half of the door area are treated as fenestration products and must meet all requirements and ratings associated with fenestration.

When a door has glazing of less than one-half the door area, the portion of the door with fenestration must be treated as part of the envelope fenestration independent of the remainder of the door area.

A field-fabricated product may become a site-built product if all the requirements for receiving a label certificate required of site-built products are met.

Table 3-5 – Default Fenestration Product U-factors

FRAME	PRODUCT TYPE	SINGLE PANE[3, 4]	DOUBLE PANE[1, 3, 4]	GLASS BLOCK[2,3]
Metal	Operable	1.28	0.79	0.87
	Fixed	1.19	0.71	0.72
	Greenhouse/garden window	2.26	1.40	N.A.
	Doors	1.25	0.77	N.A.
	Skylight	1.98	1.30	N.A.
Metal, Thermal Break	Operable	N.A.	0.66	N.A.
	Fixed	N.A.	0.55	N.A.
	Greenhouse/garden window	N.A.	1.12	N.A.
	Doors	N.A.	0.59	N.A.
	Skylight	N.A.	1.11	N.A.
Nonmetal	Operable	0.99	0.58	0.60
	Fixed	1.04	0.55	0.57
	Doors	0.99	0.53	N.A.
	Greenhouse/garden windows	1.94	1.06	N.A.
	Skylight	1.47	0.84	N.A.

[1] For all dual-glazed fenestration products, adjust the listed U-factors as follows:

a. Add 0.05 for products with dividers between panes if spacer is less than 7/16 inch wide.

b. Add 0.05 to any product with true divided lite (dividers through the panes).

[2] Translucent or transparent panels shall use glass block values when not rated by NFRC 100.

[3] Visible Transmittance (VT) shall be calculated by using Reference Nonresidential Appendix NA6.

[4] Windows with window film applied that is not rated by NFRC 100 shall use the default values from this table.

Table 3-6 – Default Solar Heat Gain Coefficient (SHGC) (Table 110.6-B of the Energy Standards)

FRAME TYPE	PRODUCT	GLAZING	FENESTRATION PRODUCT SHGC		
			SINGLE PANE[2,3]	DOUBLE PANE[2,3]	GLASS BLOCK[1,2]
Metal	Operable	Clear	0.80	0.70	0.70
	Fixed	Clear	0.83	0.73	0.73
	Operable	Tinted	0.67	0.59	N.A.
	Fixed	Tinted	0.68	0.60	N.A.
Metal, Thermal Break	Operable	Clear	N.A.	0.63	N.A.
	Fixed	Clear	N.A.	0.69	N.A.
	Operable	Tinted	N.A.	0.53	N.A.
	Fixed	Tinted	N.A.	0.57	N.A.
Nonmetal	Operable	Clear	0.74	0.65	0.70
	Fixed	Clear	0.76	0.67	0.67
	Operable	Tinted	0.60	0.53	N.A.
	Fixed	Tinted	0.63	0.55	N.A.

[1]Translucent or transparent panels shall use glass block values when not rated by NFRC 200.

[2]Visible Transmittance (VT) shall be calculated by using Reference Nonresidential Appendix NA6.

[3]Windows with window film applied that is not rated by NFRC 200 shall use this table's default values.

3.2.18 Determining Relative Solar Heat Gain Coefficient (RSHGC)

§140.3(a)5C

Relative solar heat gain (RSHG) is essentially the same as SHGC, except for the external shading correction. It is calculated by multiplying the SHGC of the fenestration product by an overhang factor. If an overhang does not exist, then the overhang factor is 1.0.

Overhang factors may either be calculated or taken from Table 3-7 below and depend upon the ratio of the overhang horizontal length (H) and the overhang vertical height (V). These dimensions are measured from the vertical and horizontal planes passing through the bottom edge of the window glazing, as shown in Figure 3-16. An overhang factor may be used if the overhang extends beyond both sides of the window jamb a distance equal to the overhang projection (§140.3(a)5Cii). The overhang projection is equal to the overhang length (H) as shown in Figure 3-16. If the overhang is continuous along the side of a building, this restriction will usually be met. If there are overhangs for individual windows, each must be shown to extend far enough from each side of the window.

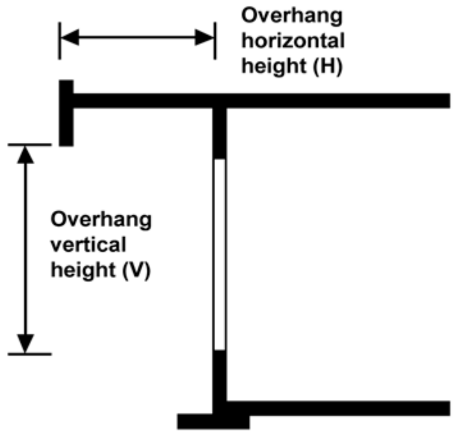


Figure 3-16 – Overhang Dimensions

Equation 3-1 – Relative Solar Heat Gain

RSHG = $SHGC_{win}$ x OHF

Where

RSHG = Relative solar heat gain.

$SHGC_{win}$ = Solar heat gain coefficient of the window.

$$OHF = OverhangFactor = 1 + \frac{aH}{V} + b\left(\frac{H}{V}\right)^2$$

Where:

H = Horizontal projection of the overhang from the surface of the window in ft, but no greater than V.

V = Vertical distance from the windowsill to the bottom of the overhang, in ft.

a = -0.41 for north-facing windows, -1.22 for south-facing windows, and -0.92 for east- and west-facing windows.

b =0.20 for north-facing windows, 0.66 for south-facing windows, and 0.35 for east- and west-facing windows.

Table 3-7 – Overhang Factors

H/V	North	South	East/West
0.00	1.00	1.00	1.00
0.10	0.96	0.88	0.91
0.20	0.93	0.78	0.83
0.30	0.90	0.69	0.76
0.40	0.87	0.62	0.69
0.50	0.85	0.56	0.63
0.60	0.83	0.51	0.57
0.70	0.81	0.47	0.53
0.80	0.80	0.45	0.49
0.90	0.79	0.44	0.46
1.00 or greater	0.79	0.44	0.43

To use Table 3-7, measure the horizontal projection of the overhang (H) and the vertical height from the bottom of the glazing to the shading cut-off point of the overhang (V). Then calculate H/V. Enter the table at that point. If the calculated H/V falls between two values in the table choose the next higher value to the calculated H/V value. Move across to the column that corresponds to the orientation of the window and find the overhang factor. Note, that any value of H/V greater than one has the same overhang factor (for a given orientation) shown in the last row of the table.

Figure 3-17 graphs the overhang factors of the various orientations as a function of H/V. It shows that overhangs have only a minor effect on the north (maximum reduction in SHGC is only about 20 percent). East, west and south overhangs can achieve reductions of 55–60 percent. The benefits of the overhang level off as the overhang becomes large. (*Note:* this graph is presented only to illustrate the benefits of overhangs.)

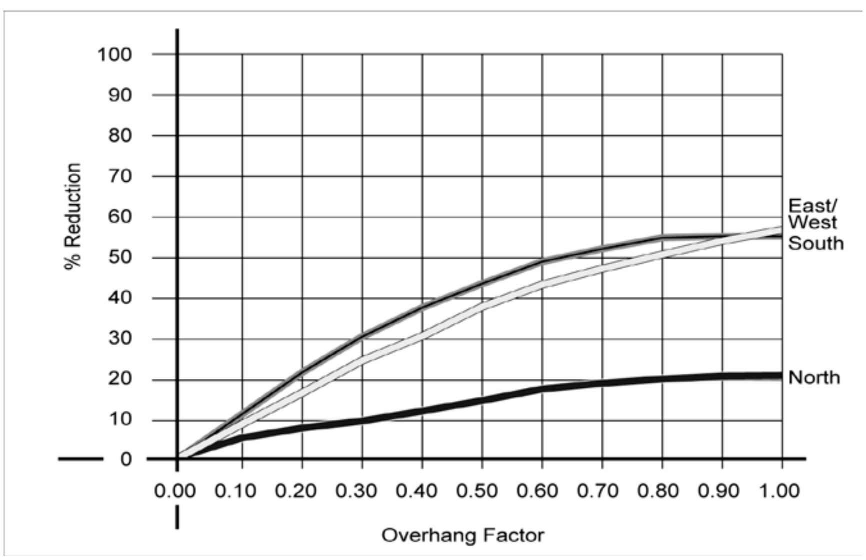


Figure 3-17 – Graph of Overhang Factors

Example 3-5

Question

An east-facing window has glass with a solar heat gain coefficient of 0.71. It has a fixed overhanging eave that extends 3 ft out from the plane of the glass (H = 3), and is 6 ft above the bottom of the glass (V = 6). The overhang extends more than 3 ft beyond each side of the glass and the top of the window is less than 2 ft vertically below the overhang. What is the RSHG for this window?

Answer

First, calculate H/V. This value is 3 / 6 = 0.50. Next, find the overhang factor from

Table 3-7. For east-facing windows, this value is 0.63. Finally, multiply it by the solar heat gain coefficient to obtain the RSHG: 0.63 x 0.71 = 0.45.

3.2.19 Determining Solar Heat Gain Coefficients

§141(c)5

The solar heat gain coefficient (SHGC) is the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation; the lower the SHGC, the less solar heat is gained. For SHGC measurements, the solar radiant energy includes infrared, visible light and ultraviolet. A low SHGC reduces solar heat gains, thereby reducing the amount of air conditioning energy needed to maintain comfort in the building. A low SHGC may also increase the amount of heat needed to maintain comfort in the winter. The technical definition of SHGC is the ratio of solar energy entering the window (or fenestration product) to the amount that is incident on the outside of the window. As with U-factors, the window frame, sash and other opaque components, and type of glazing affect SHGC.

There are four acceptable methods for determining SHGC for use with the Standards (see Table 3-8). The preferred methods are two NFRC procedures: NFRC 200 for manufactured fenestration, which includes manufactured skylights; and NFRC 100 for site-built fenestration, which includes site-built skylights. The NFRC standard for rating the SHGC of tubular daylighting devices (TDDs or tubular skylights) is appropriate only for attic configurations where the insulation layer is directly on top of the ceiling. For spaces with insulated roofs, use the NFRC or default rating of the top dome only.

A third method is to use the SHGC Defaults from Standards Table 110.6-B. These values are on the high side and do not account for special coatings and other technologies that may be part of a proposed fenestration product.

The fourth method, applicable only to skylights and site-built fenestration in buildings with less than 1,000 ft² of site-built fenestration, is to use Equation NA6-2 in the Reference Nonresidential Appendix NA6. This equation calculates an overall SHGC for the fenestration ($SHGC_t$) assuming a default framing factor and using the center-of-glass SHGC value ($SHGC_c$) for the glazing from the manufacturer’s literature.

Note: Buildings that have 1,000 ft² or more of site-built fenestration cannot use the Alternative Default Fenestration Procedure, Equation NA6-1 or NA6-2.

Windows are not allowed SHGC credit for any interior shading such as draperies or blinds. Only exterior shading devices such as shade screens permanently attached to the building or structural components of the building can be modeled through performance standards compliance. Manually operable shading devices cannot be modeled. Only overhangs can be credited using the relative solar heat gain procedure for prescriptive compliance.

Table 3-8 – Methods for Determining SHGC

	Fenestration Category				
SHGC Determination Method	Manufactured Windows	Manufactured Skylights	Site-Built Fenestration (Vertical& Skylight)	Field-Fabricated Fenestration	Glass Block
NFRC's Component Modeling Approach (CMA)	✓	✓	✓	N/A	N/A
NFRC-200	✓	✓	✓	N/A	N/A
Standards Default Table 110.6-B	✓	✓	✓	✓	✓
NA6[1]	N/A	N/A	✓	N/A	N/A

[1]The Alternative Default U-factors from Reference Nonresidential Appendix NA6 may only be used for site-built vertical and skylights having less than 1,000ft^2.

3.2.20 Determining Visible Transmittance (VT)

Visible Transmittance (VT) is a property of glazing materials that has a varying relationship to SHGC. VT is the ratio of light that passes through the glazing material to the light that is incident on the outside of the glazing. Light is the portion of solar energy that is visible to the human eye. VT is an important characteristic of glazing materials, because it affects the amount of daylight that enters the space and how well views through windows are rendered. Glazing materials with a very low VT have little daylighting benefit and views appear dark, even on bright days. The ideal glazing material for most of California's summer climates would have a high VT and a low SHGC. Such a glazing material allows solar radiation in the visible spectrum to pass while blocking radiation in the infrared and ultraviolet spectrums. Materials that have this quality are labeled "spectrally selective" and have a VT that is up to 2.2 times the SHGC. The center-of-glass VT for a given insulated glass (IG) is found in manufacturer literature, through the NFRC product directory or by use of the Component Modeling Approach (CMA).

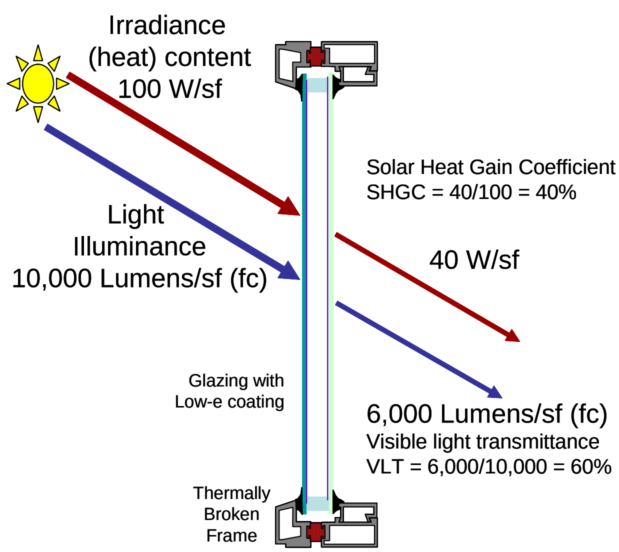


Figure 3-18 – Solar Heat Gain Coefficient and Visible Transmittance

The prescriptive requirements of Tables 140.3-B and 140.3-C of the standards prescribe specific VT values for all climate zones and glass types. The visible light transmittance is used in the performance method in the calculation of the interior illumination levels and lighting energy savings due to daylight controls. This is discussed in more detail in Chapter 5 of this manual.

3.2.21 Site-Built Fenestration Roles and Responsibilities

§110.6, §10-111

Manufactured fenestration products are factory-assembled as a unit, and the manufacturer is able to assume the burden of testing and labeling. However, with site-built fenestration, multiple parties are responsible. Architects and/or engineers design the basic glazing system by specifying the components, the geometry of the components, and sometimes, the method of assembly. An extrusion manufacturer provides the mullions and frames that support the glazing and is responsible for thermal breaks. A glazing manufacturer provides the glazing units, cut to size and fabricated as insulated glass (IG) units. The glazing manufacturer is responsible for tempering or heat strengthening, the tint of the glass, any special coatings, the spacers, and the sealants. A glazing contractor (usually a subcontractor to the general contractor) puts the system together at the construction site or their shop and is responsible for many quality aspects. Predetermining the energy performance of site-built fenestration as a system is more challenging than for manufactured units.

One of the parties (architect, glazing contractor, extrusion manufacturer, IG fabricator, or glass manufacturer) must take responsibility for testing and labeling of the site-built fenestration system under the most recent NFRC 100 procedure. The responsible party must obtain a label certificate as described in §10-111 of the Standards.

It is typical for the glazing contractor to assume responsibility for the team and to coordinate the certification and labeling process. A common procedure is for the design team to include language in the contract with the general contractor that requires that the general contractor be responsible; the general contractor typically assigns this responsibility to the glazing contractor, once the responsible party has established a relationship with an NFRC.

It is not necessary to complete the NFRC testing and labeling prior to completing the compliance documentation and filing the building permit application. However, plans examiners should verify that the fenestration performance shown in the plans and specifications and used in the compliance calculations is “reasonable” and achievable. This requires some judgment and knowledge on the part of the plans examiner. Generally, designers will know the type of glass that they plan to use and whether or not the frame has a thermal break or is thermally improved. This information is adequate to consult the default values for U-factor and SHGC in Reference Nonresidential Appendix NA6.

After the construction contract is awarded, the glazing contractor or other appropriate party assumes responsibility for acquiring the NFRC Label Certificate. Each label certificate has the same information as the NFRC temporary label for manufactured products, but includes other information specific to the project such as the name of the glazing manufacturer, the extrusion contractor, the places in the building where the product line is used, and other details. The label certificate remains on file in the construction office for the building inspector to view. After construction is complete, the label certificate should be filed in the building office with the as-built drawings and other operations and maintenance data. This will give building managers the information needed for repairs or replacements.

Example 3-6

Question

(Reserved)

Answer

(Reserved)

Example 3-7

Question

The envelope and space conditioning system of an office building with 120,000 ft² of conditioned floor area is being altered. The building has 24,000 ft² of vertical fenestration. Which of the following scenarios does the NFRC label certificate requirement apply to?

1. Existing glazing remains in place during the alteration.

2. Existing glazing is removed, stored during the alteration period and then re-installed (glazing is not altered in any way).

3. Existing glazing is removed and replaced with new site-built glazing with the same dimensions and performance specifications.

4. Existing glazing on the north façade (total area 800 ft²) is removed and replaced with site-built fenestration.

Answer

NFRC label certificate or California Energy Commission default values requirements do not apply to scenarios 1 and 2 but do apply to scenario 3.

1. Requirement does not apply because the glazing remains unchanged and in place.

2. *Exception* to §110.6(a)1 applies in this case (this exception applies to fenestration products removed and reinstalled as part of a building alteration or addition).

3. Use either NFRC Label Certificate or use Table 110.6-A default values; applies in this case as 24,000 ft² (more than the threshold value of 1,000 ft²) of new fenestration is being installed.

4. Since the site-built fenestration area is less than 1,000 ft², use either the NFRC label certificate, the applicable default U-factor or SHGC set forth in Reference Nonresidential Appendix NA6, or California Energy Commission default values.

3.3 Envelope Assembly

This section of the building envelope chapter addresses the requirements for thermal control of the opaque portion of the building shell or envelope.

3.3.1 Mandatory Measures

A. Certification of Insulation Materials

§110.8(a), §140.3(a)1B

The California Quality Standards for Insulating Materials, which became effective on January 1, 1982, ensure that insulation sold or installed in the state performs according to the stated R-value and meets minimum quality, health, and safety standards.

Manufacturers must certify that insulating materials comply with *California Quality Standards for Insulating Materials* (CCR, Title 24, Part 12, Chapters 12-13), which ensure that insulation sold in the state performs according to stated R-values and meets minimum quality, health, and safety standards. Builders may not install insulating materials, unless the product has been certified by the Department of Consumer Affairs, Bureau of Home Furnishing and Thermal Insulation. Builders and enforcement agencies shall use the Department of Consumer Affairs *Directory of Certified Insulation Material* to verify the certification of the insulating material. If an insulating product is not listed in the most recent edition of the directory, contact the Department of Consumer Affairs, Bureau of Home Furnishing and Thermal Insulation Program, at (916) 999-2041 or by E-mail: HomeProducts@dca.ca.gov.

Where applicable, the R-value of cavity and/or continuous insulation, or the overall assembly U-factor may be used to demonstrate compliance with required insulation levels. Reference insulation values are provided in the Reference Appendix, Reference Joint Appendix JA4, where assembly U-factors is shown for various assemblies and their individual components. U-factors represent the actual thermal conductance of the assembly, including air film coefficients, framing factors and all layers used to construct the assembly. Assemblies not listed in JA4 tables may calculate U-factors using the EZ Frame 2013 assembly calculator.

B. Urea Formaldehyde Foam Insulation

§110.8(b)

The mandatory measures restrict the use of urea formaldehyde foam insulation. The restrictions are intended to limit human exposure to formaldehyde, which is a volatile organic chemical known to be harmful to humans.

If foam insulation is used that has urea formaldehyde, it must be installed on the exterior side of the wall (not in the cavity of framed walls), and a continuous barrier must be placed in the wall construction to isolate the insulation from the interior of the space. The barrier must be 4-mil (0.1 mm) thick polyethylene or equivalent.

C. Flame Spread Rating of Insulation

§110.8(c)

The *California Quality Standards for Insulating Materials* also require that all exposed installations of faced mineral fiber and mineral aggregate insulations use fire retardant facings that have been tested and certified not to exceed a flame spread of 25 and a smoke development rating of 450. Insulation facings that do not touch a ceiling, wall, floor surface, and faced batts on the underside of roofs with an air space between the ceiling and facing are considered exposed applications.

Flame spread ratings and smoke density ratings are shown on the insulation or packaging material or may be obtained from the manufacturer.

D. Insulation Placement on Roof/Ceilings

§110.8(e)

Insulation installed on the top of suspended (T-bar) ceilings with removable ceiling panels may not be used to comply with the Standards unless the installation meets the criteria described in the *Exception* to §110.8(e)3 below. Insulation may be installed in this location for other purposes such as for sound control, but it will have no value in terms of meeting roof/ceiling insulation requirements of the Standards.

Acceptable insulation installations include placing the insulation in direct contact with a continuous roof or ceiling that is sealed to limit infiltration and exfiltration as specified in §110.7; including but not limited to placing insulation either above or below the roof deck or on top of a drywall ceiling.

When insulation is installed at the roof in nonresidential buildings, the space between the ceiling and the roof is considered to be either directly or indirectly conditioned space. Therefore, this space must not include fixed vents or openings to the outdoors or to unconditioned spaces. This space is not considered an attic for the purposes of complying with CBC attic ventilation requirements. Vents that do not penetrate the roof deck and that are designed for wind resistance for roof membranes are acceptable.

Exception to §110.8(e)3: Insulation placed in direct contact with a suspended ceiling with removable ceiling panels shall be an acceptable method when the total combined conditioned spaces with a combined floor area is no greater than 2,000 ft² in an otherwise unconditioned building., and the average height of the space between the ceiling and the roof over these conditioned spaces is greater than 12 ft.

E. Insulation for Demising Walls

§110.8(f)

Demising walls separating conditioned space from enclosed unconditioned space must be insulated with a minimum of R-13 insulation if the wall is a wood or metal framed assembly. This requirement applies to buildings meeting compliance under the prescriptive or performance approach. This requirement assures at least some insulation in a wall where an adjoining space may remain unconditioned indefinitely. Demising walls that are constructed of brick, concrete masonry units, or solid concrete are not required to be insulated.

F. Insulation Requirements for Heated Slab Floors

§110.8(g)

Heated slab-on-grade floors must be insulated according to the requirements in Table 110.8-A of the Standards. The top of the insulation must be protected with a rigid shield to prevent intrusion of insects into the building foundation and the insulation must be capable of withstanding water intrusion.

A common location for the slab insulation is on the perimeter of the foundation. Insulation that extends downward to the top of the footing is acceptable. Otherwise, the insulation must extend downward from the level of the top of the slab, down 16 inches (40 cm) or to the frost line, whichever is greater.

For below-grade slabs, vertical insulation shall be extended from the top of the foundation wall to the bottom of the foundation (or the top of the footing) or to the frost line, whichever is greater.

Another option is to install the insulation inside the foundation wall and between the heated slab. In this case insulation must extend downwards to the top of the footing and then extend horizontally inwards, under the slab, a distance of 4 ft towards the center of the slab. R-5 vertical insulation is required in all climates except climate zone 16, which requires R-10 of vertical insulation and R-7 horizontal insulation.

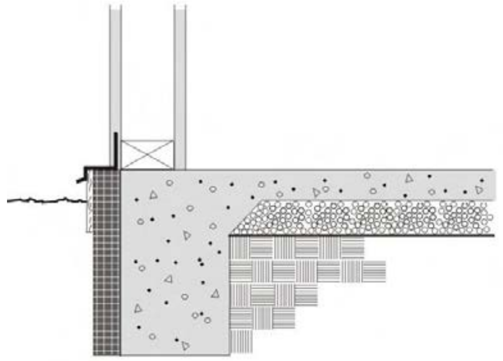


Figure 3-19 – Perimeter slab insulation

Table 3-9 - Slab Insulation Requirements for Heated Slab Floors

Insulation Location	Insulation Orientation	Installation Requirements	Climate Zone	Insulation R-Value
Outside edge of heated slab, either inside or outside the foundation wall	Vertical	From the level of the top of the slab, down 16 inches or to the frost line, whichever is greater? Insulation may stop at the top of the footing where this is less than the required depth. For below grade slabs, vertical insulation shall be extended from the top of the foundation wall to the bottom of the foundation (or the top of the footing) or to the frost line, whichever is greater.	1 – 15	5
			16	10
Between heated slab and outside foundation wall	Vertical and Horizontal	Vertical insulation from top of slab at inside edge of outside wall down to the top of the horizontal insulation. Horizontal insulation from the outside edge of the vertical insulation extending 4 feet toward the center of the slab in a direction normal to the outside of the building in plan view.	1 – 15	5
			16	10 vertical and 7 horizontal

G. Wet Insulation Systems

§110.8(h)

Wet insulation systems are roofing systems where the insulation is installed above the roof's waterproof membrane. Water can penetrate this insulation material and have an effect on the energy performance of the roofing assembly in wet and cool climates. In climate zones 1 and 16, the insulating R-value of continuous insulation materials installed above the roof's waterproof membrane must be multiplied by 0.8 before choosing the table column in Reference Joint Appendix JA4 for determining assembly U-factor. See the footnotes for Tables 4.2.1 through 4.2.7 in the Reference Joint Appendix JA4.

H. Roofing Products Solar Reflectance and thermal Emittance

§110.8(i)

Roofing products be tested and labeled by the Cool Roof Rating Council (CRRC) and that liquid-applied products meet minimum standards for performance and durability per §110.8(i)4 of the Standards. Note that installing cool roofs is *not* a mandatory measure. However, to receive compliance credit, a roofing product's reflectance and thermal emittance must be tested and certified according to CRRC procedures. If a CRRC rating is not obtained for roofing products, default values for reflectance and emittance must be used.

I. Rating and Labeling

§10-113

When a cool roof is installed to meet the prescriptive requirement or are used for compliance credit, the products must be tested and labeled by the Cool Roof Rating Council (CRRC) as specified in §10-113 of the Standards. The CRRC is the supervisory entity responsible for certifying cool roof products. The CRRC test procedure is documented in CRRC-1, the CRRC Product Rating Program Manual. This test procedure includes tests for both solar reflectance and thermal emittance.

An example of an approved CRRC product label

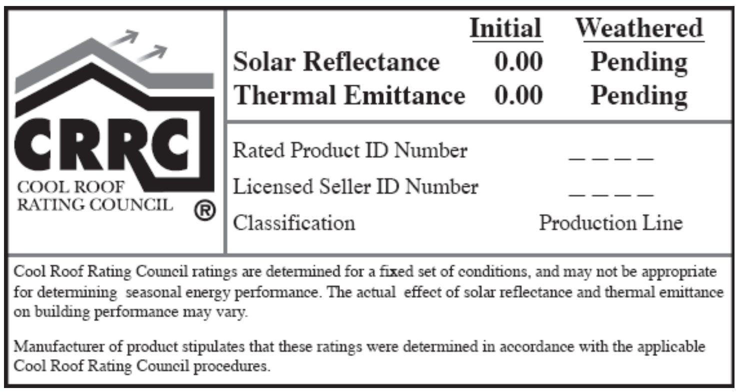


Figure 3-20 – Sample CRRC Product label and information

J. Solar Reflectance, Thermal Emittance, and Solar Reflectance Index (SRI)

§110.8(i)1,2, and 3

To demonstrate compliance with the Standards, all cool roofing products must be certified and labeled according to CRRC procedures. The CRRC certification includes solar reflectance and thermal emittance. There are two kinds of solar reflectance:

1. Initial and 3-year Aged Solar Reflectance and Thermal Emittance

All requirements of the Standards are based on the 3-year aged solar reflectance. However, if the aged value for the reflectance is not available in the CRRC's Rated Product Directory, then the aged value shall be derived from the CRRC initial value. The equation below can be used to calculated the aged rated solar reflectance until the appropriate aged rated value for the reflectance is posted in the directory.

$$\text{Aged Reflectance}_{calculated}=(0.2+\beta[\rho_{initial}-0.2])$$

Where,

$\rho_{initial}$ = Initial Reflectance listed in the CRRC Rated Product Directory

β= 0.65 for Field Applied Coating, or 0.70 for Not a Field Applied Coating

The Standards do not distinguish between initial and aged thermal emittance, meaning that either value can be used to demonstrate compliance with the Standards. If a manufacturer fails to obtain CRRC certificate for their roofing products, the following default aged solar reflectance and thermal emittance values must be used for compliance:

a. For asphalt shingles, 0.08/0.75
b. For all other roofing products, 0.10/0.75

K. Solar Reflectance Index (SRI)

The temperature of a surface depends on the solar radiation incident, surface's reflectance, and emittance. The SRI measures the relative steady-state surface temperature of a surface with respect to standard white (SRI=100) and standard black (SRI=0) under the standard solar and ambient condition. A calculator has been produced by the staff at Lawrence Berkeley National Laboratory, which calculates the SRI by designating the Solar Reflectance and Thermal emittance of the desired roofing material. The calculator can be found at http://www.energy.ca.gov/title24/2013standards. SRI calculations must be based on moderate wind velocity of 2-6 meters per second. To calculate the SRI, the 3-year aged value of the roofing product must be used. By using the SRI calculator a cool roof may comply with an emittance lower than 0.85, as long as the aged reflectance is higher and vice versa.

L. Field Applied Liquid Coatings

§110.8(i)4, Table 110.8-C

Liquid roof coatings applied to low-sloped roofs in the field as the top surface of a roof covering shall comply with the following mandatory requirements and descriptions. There are a number of liquid products, including elastomeric coatings and white acrylic coatings that qualify for Field Applied Liquid Coatings. The Standards specify minimum performance and durability requirements for field-applied liquid coatings. Please note that these requirements do not apply to industrial coatings that are factory-applied, such as metal roof panels. The requirements address elongation, tensile strength, permeance, and accelerated weathering. The requirements depend on the type of coating and are described in greater detail below.

M. Aluminum-Pigmented Asphalt Roof Coatings

Aluminum-pigmented coatings are silver-colored coatings that are commonly applied to modified bitumen and other roofing products. The coating has aluminum pigments that float to the top surface of the coating while it is setting, providing a shiny and reflective surface. Because of the shiny surface and the physical properties of aluminum, these coatings have a thermal emittance below 0.75, which is the minimum rating for prescriptive compliance. The overall envelope TDV energy approach is typically used to achieve compliance with these coatings.

This class of field-applied liquid coatings shall be applied across the entire surface of the roof and meet the dry mil thickness or coverage recommended by the coating manufacturer, taking into consideration the substrate on which the coating will be applied to. Also, the aluminum-pigmented asphalt roof coatings shall be manufactured in accordance with ASTM D2824.[3] Standard Specification is also required for Aluminum-Pigmented Asphalt Roof Coatings, Nonfibered, Asbestos Fibered, and Fibered without Asbestos that are suitable for application

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[3] ASTM D2824 / D2824M-13, Standard Specification for Aluminum-Pigmented Asphalt Roof Coatings, Nonfibered, and Fibered without Asbestos, ASTM International, West Conshohocken, PA, 2013, www.astm.org.
Scope: This specification covers asphalt-based, aluminum roof coatings suitable for application to roofing or masonry surfaces by brush or spray. The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combined values from the two systems may result in non-conformance with the standard. The following precautionary caveat pertains only to the test method portion, Section 8, of this specification: This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

to roofing or masonry surfaces by brush or spray. Use ASTM D6848, Standard Specification for Aluminum Pigmented Emulsified Asphalt used as a Protective Coating for Roofing; installed in accordance with ASTM D3805,[4] Standard Guide for Application of Aluminum-Pigmented Asphalt Roof Coatings.

N. Cement-Based Roof Coatings

This class of coatings consists of a layer of cement and has been used for a number of years in the central valley of California and in other regions. These coatings may be applied to almost any type of roofing product. Cement-based coatings shall be applied across the entire roof surface to meet the dry mil thickness or coverage recommended by the manufacturer. Also, cement-based coatings shall be manufactured to contain no less than 20% Portland Cement and meet the requirements of ASTM D822, ASTM C1583 and ASTM D5870.

O. Other Field-Applied Liquid Coatings

Other field-applied liquid coatings include elastomeric and acrylic-based coatings. These coatings must be applied across the entire surface of the roof surface to meet the dry mil thickness or coverage recommended by the coating manufacturer, taking into consideration the substrate on which the coating will be applied. The field-applied liquid coatings must be tested to meet a number of performance and durability requirements as specified in Table 110.8-C of the Standards or the minimum performance requirements of ASTM C836, D3468, D6083, or D6694, whichever are appropriate to the coating material.

P. Infiltration and Air leakage

§110.7

All joints and other openings in the building envelope that are potential sources of air leakage must be caulked, gasketed, weather-stripped, or otherwise sealed to limit air leakage into or out of the building. This applies to penetrations for pipes and conduits, ducts, vents, and other openings. It means that all gaps between wall panels, around doors, and other construction joints must be well sealed. Ceiling joints, lighting fixtures, plumbing openings, doors, and windows should all be considered as potential sources of unnecessary energy loss due to infiltration.

No special construction requirements are necessary for suspended (T-bar) ceilings, provided they meet the requirements of §110.8(e). Standard construction is typically adequate for meeting the infiltration/exfiltration requirements unless an air barrier is required (see Section 3.3.5 G).

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[4] ASTM D3805 / D3805M-97(2009), Standard Guide for Application of Aluminum-Pigmented Asphalt Roof Coatings, ASTM International, West Conshohocken, PA, 2009, www.astm.org.

Scope: This guide covers the application methods for Specification D 2824 Aluminum-Pigmented Asphalt Roof Coatings, Non-Fibered (Type I), Asbestos Fibered (Type II), and Fibered without Asbestos (Type III), for application on asphalt built-up roof membranes, modified bitumen roof membranes, bituminous base flashings, concrete surfaces, metal surfaces, emulsion coatings, and solvent-based coatings. This guide does not apply to the selection of a specific aluminum-pigmented asphalt roof coating type for use on specific projects. The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combined values from the two systems may result in non-conformance with the standard. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Q. Mandatory Insulation Requirements (Newly Constructed Buildings)

§120.7

Newly constructed nonresidential, high-rise residential and hotel/motel buildings must meet mandatory insulation requirements for opaque portions of the building that separate conditioned spaces from unconditioned spaces or ambient air. The U-factor for each assembly type shall not exceed the values listed below. Determining the total weight-averaged U-factor is allowed for all assembly types except for light and heavy mass walls. Joint Appendix JA-4 of the Reference Appendices illustrates the allowed procedure for calculating U-factors. The representative constructions that meet these requirements are shown in parentheses. U-factors allow greater flexibility in the design choice of individual components making up a given assembly that meet the maximum U-factor requirement and design conditions of the envelope.

R. Roof/Ceiling Insulation

1. Metal Building: Weighted average U-factor of U-0.098 (R-19 screw down roof, no thermal blocks).
2. Wood Framed and Others: Weighted average U-factor of U-0.075 (2x4 rafter, R-19 insulation).

S. Wall Insulation

1. Metal Building: Weighted average U-factor U-0.113 (single layer of R-13 batt insulation).
2. Metal Framed: Weighted average U-factor U-0.105 (R-8 continuous insulation).
3. Light Mass Walls: 6 inches or greater Hollow Core Concrete Masonry Unit having a U-factor not to exceed 0.440 (partially grouted with insulated cells).
4. Heavy Mass Walls: 8 inches or greater Hollow Core Concrete Masonry Unit having a U-factor not to exceed 0.690 (solid grout concrete, normal weight, 125 lb/ft^3).
5. Wood Framed and Others: Weighted average U-factor of U-0.110 (R-11 batt insulation).

Glass Spandrel Panels and Glass Curtain Wall: Weighted average U-factor of U-0.280.

T. Floor and Soffit Insulation

1. Raised Mass Floors: A minimum of 3 inches of lightweight concrete over a metal deck or the weighted average U-factor of the floor assembly shall not exceed U-0.269.
2. Other Floors: Weighted average U-factor of U-0.071.
3. Heated Slab Floor: A heated slab floor shall be insulated to meet the requirements of §110.8(g).

U. Mandatory Insulation Requirements (Altered Buildings)

§141.0

Altered buildings must meet mandatory insulation requirements for opaque portions of the building that separate conditioned spaces from unconditioned spaces or ambient air. For alterations, different mandatory insulation requirements for the building envelope apply than for newly constructed buildings (§141.0(b)1). The weighted U-factor for each assembly type shall not exceed the values listed below. Joint Appendix JA-4 of the Reference Appendices illustrates the allowed procedure for calculating U-factors. U-factors allow greater flexibility in the design choice of individual components making up a given assembly that meet the maximum U-factor requirement and design conditions of the envelope.

V. Wall Insulation

1. Metal Building: Minimum R-13 or maximum weighted average U-factor U-0.113.
2. Metal Framed: Minimum R-13 or maximum weighted average U-factor U-0.217.
3. Wood Framed and Others: Minimum R-11 or maximum weighted average U-factor U-0.110.
4. Glass Spandrel Panels and Glass Curtain Wall: Minimum R-4 or maximum weighted average U-factor U-0.280.
5. Light and Heavy Mass Walls: No minimum R-value required.

W. Floor and Soffit Insulation

1. Raised Framed Floors: Minimum R-11 or maximum weighted average U-factor U-0.071.
2. Raised Mass Floors in High-rise Residential and Hotel/Motel Guest Rooms: Minimum R-6 or maximum weighted average U-factor U-0.111.
3. Raised Mass Floors in other Occupancies: No minimum R-value required.

3.3.2 Prescriptive Envelope Requirements

The prescriptive requirements include minimum insulation levels for roofs/ceilings, walls, and floors. The requirements are expressed as a maximum U-factor. The U-factor criterion are given for different classes of construction such as wood framed, metal framed, metal building, and mass assembles. The assembly U-factor and descriptions of a particular roof/ceiling, wall or floor can be found in the appropriate tables listed in Reference Joint Appendix JA4 or by using the EZFrame2013 assembly calculator. Mandatory minimum insulation levels must always be met, regardless of prescriptive insulation levels prescribed by the standards.

When an assembly of the proposed building does not precisely match one of the choices in Reference Joint Appendix JA4, choose the best match which captures: (1) the overall type of assembly (e.g., masonry, wood frame, metal frame); and (2) an insulation level in the Reference Joint Appendix JA4 assembly which is the same or less than the proposed assembly; or use the EZFrame2013 assembly calculator.

Insulation requirements vary by climate zone and occupancy type. Table 140.3-B of the standards specifies insulation levels for nonresidential buildings, including relocatable public school buildings. Table 140.3-C of the standards specifies insulation requirements for high-rise residential buildings and hotel/motel guest rooms. Requirements for nonresidential buildings are more stringent than for high-rise residential buildings and hotel/motel guest rooms because these buildings are assumed to be heated and cooled continuously. Table 140.3-D of the standards specifies insulation levels for relocatable public school buildings where the manufacturer certifies their use in all California climate zones; these criteria are not climate dependent.

A. Exterior Roofs and Ceilings

§140.3(a)1B

Under the prescriptive requirements, exterior roofs or ceilings must have an assembly U-factor equal to or lower than the U-factor criterion for nonresidential, high-rise residential buildings and relocatable public school buildings (see 3-11). The U-factor values for exterior roofs and ceilings can be derived from Reference Joint Appendix JA4 and must be used to determine compliance with the maximum assembly U-factor requirements. Alternatively, the EZFrame2013 assembly calculator can be used to determine U-factors for assemblies and/or components not listed in JA4 tables.

Table 3-10 – Roof/Ceiling U-Factor Requirements

Building Type		Climate Zones							
		1	2	3	4	5	6	7	8
Nonresidential	Metal Bldg	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
	Wood-framing & Other framing type	0.049	0.039	0.039	0.039	0.049	0.075	0.067	0.067
High-rise Residential	Metal Bldg	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
	Wood-framing & Other framing type	0.034	0.028	0.039	0.028	0.039	0.039	0.039	0.025
Relocatable Public School Buildings	Metal Bldg	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
	Wood-framing & Other framing type	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
Building Type		**Climate Zones**							
		9	10	11	12	13	14	15	16
Nonresidential	Metal Bldg	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
	Wood-framing & Other framing type	0.049	0.039	0.039	0.039	0.039	0.039	0.039	0.039
High-rise Residential	Metal Bldg	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
	Wood-framing & Other framing type	0.034	0.028	0.039	0.028	0.028	0.028	0.028	0.028
Relocatable Public School Buildings	Metal Bldg	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
	Wood-framing & Other framing type	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039

Summary from Standards Tables 140.3-B, 140.3-C and 140.3-D

Figure 3-21 shows acceptable means of meeting the U-factor criteria for metal roofs. For screw down metal roofs with no thermal blocks, continuous insulation will be required to meet the U-factor requirement.

The mandatory measures prohibit insulation from being installed directly over suspended ceilings (see previous section), except for limited circumstances.

The U-factor must be selected from Reference Joint Appendix JA4. Alternatively, the EZFrame2013 assembly calculator can be used to determine U-factors for assemblies and/or components not listed in JA4 tables.

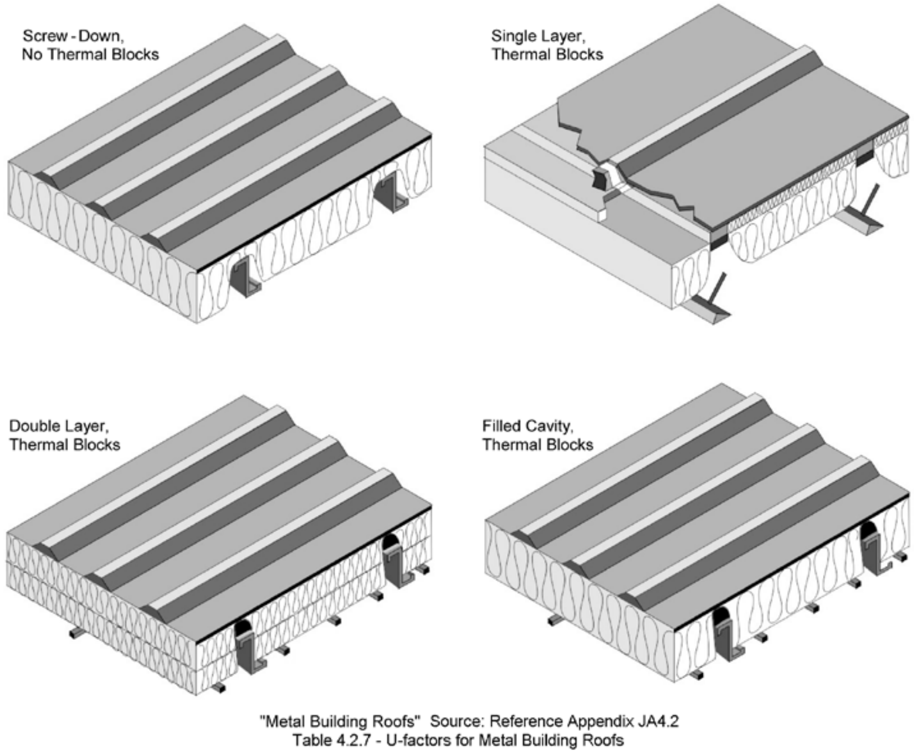


Figure 3-21 – Acceptable Metal-to-Metal Roof Constructions

B. Roofing Products (Cool Roof)

The prescriptive requirements call for roofing products to meet the solar reflectance and thermal emittance in both low-sloped and steep-sloped roof applications for nonresidential buildings. A qualifying roofing product under the prescriptive approach for a nonresidential building must have an aged solar reflectance and thermal emittance greater than or equal to that the values indicated in Table 3-11 below. Table 3-12 is for high-rise residential buildings and hotel/motel guest rooms and Table 3-13 is for relocatable public school buildings where manufacturer certifies use in all climate zones.

Table 3-11 – Prescriptive Criteria for Roofing Products for Nonresidential Buildings

			Climate Zones															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Roofing Products	Low-sloped	Aged Reflectance	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0. 63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
		Emittance	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
		SRI	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	Steep Sloped	Aged Reflectance	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
		Emittance	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
		SRI	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

Table 3-12 – Prescriptive Criteria for Roofing Products for High-rise Residential Buildings and Guest Rooms of Hotel/Motel Buildings

			Climate Zones															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Roofing Products	Low-sloped	Aged Reflectance	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
		Emittance	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
		SRI	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	Steep Sloped	Aged Reflectance	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
		Emittance	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
		SRI	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

Table 3-13 – Prescriptive Criteria for Roofing Products for Relocatable Public School Buildings, Where Manufacturer Certifies Use in All Climate Zones

Roofing Products	**Aged Reflectance/Emittance**
Low-Sloped	0.63/0.75
SRI	75
Steep-Sloped	0.20/0.75
SRI	16

If the aged value for the solar reflectance is not available in the CRRC's Rated Product Directory, then the equation in Section 3.3.1H can be used until the aged rated value for the reflectance is posted in the directory.

There are five exceptions to the minimum prescriptive requirements for solar reflectance and thermal emittance or the SRI:

1. Wood framed roofs in climate zones 3 and 5 are exempt if the roof assembly has a U-factor of 0.039 or lower.
2. Metal building roofs in climate zones 3 and 5 are also exempted if the roof assembly has a U-factor 0.048 or lower.
3. Roof area covered by building-integrated photovoltaic panels and building integrated solar thermal panels is not required to meet the cool roof requirements.
4. If the roof construction has a thermal mass like gravel, concrete pavers, stone or other materials with a weight of at least 25 lb/ft², over the roof membrane, then it is exempt from the above requirements for solar reflectance and thermal emittance or SRI.

Where a low-sloped nonresidential roof's aged reflectance is less than the prescribed requirement, insulation trade-offs are available. By increasing a roof's insulation level a roofing product with a lower reflectance than the prescriptive requirements can be used to meet the Cool Roof requirements. The appropriate U-factor can be determined from Table 3-14 for nonresidential buildings based on roof type, climate zone and aged reflectance of less than 0.63.

Table 3-14- (Standards Table 140.3) Roof / Ceiling Insulation Tradeoff for Aged Solar Reflectance

Nonresidential					
Aged Solar Reflectance	Metal Building Climate Zone 1-16 U-factor	Wood framed and Other Climate Zone 1 & 5 U-factor	Wood Framed and Other Climate Zone 2-4, 9-16 U-factor	Wood Framed and Other, Climate Zone 6 U-factor	Wood Framed and Other Climate Zone 7 & 8 U-factor
0.62-0.60	0.061	0.045	0.036	0.065	0.059
0.59-0.55	0.054	0.041	0.034	0.058	0.053
0.54-0.50	0.049	0.038	0.032	0.052	0.048
0.49-0.45	0.047	0.035	0.030	0.047	0.044
0.44-0.40	0.043	0.033	0.028	0.043	0.040
0.39-0.35	0.039	0.031	0.027	0.039	0.037
0.34-0.30	0.035	0.029	0.025	0.037	0.035
0.29-0.25	0.033	0.027	0.024	0.034	0.032

C. Exterior Walls

§140.3(a)2

Under the prescriptive requirements, exterior walls must have an assembly U-factor equal to or lower than the U-factor criterion for nonresidential, high-rise residential buildings and relocatable public school buildings (see Table 3-15 below).

The U-factor for exterior walls from Reference Joint Appendix JA4 must be used to determine compliance with the maximum assembly U-factor requirements. The Standards no longer allow using the R-value of the cavity or continuous insulation to demonstrate compliance with the insulation values of the Reference Joint Appendix JA4; only U-factors may be used to demonstrate compliance.

For metal framed walls with insulation between the framing section, continuous insulation may need to be added to meet the U-factor requirements of the Standards.

For light mass walls, insulation is not required for buildings in south coast climates but is required for other climates. For heavy mass walls, insulation is not required for buildings in central coast or south coast climates but is required for other climates.

Table 3-15 – Wall U-Factor Requirements

Building Type		1	2	3	4	5	6	7	8
Non-residential	Metal Bldg	0.113	0.061	0.113	0.061	0.061	0.113	0.113	0.061
	Metal- Frame	0.098	0.062	0.082	0.062	0.062	0.098	0.098	0.062
	Mass Light	0.196	0.170	0.278	0.227	0.44	0.44	0.44	0.44
	Mass Heavy	0.253	0.650	0.650	0.650	0.650	0.690	0.690	0.690
	Wood-Frame	0.102	0.059	0.110	0.059	0.102	0.110	0.110	0.102
Residential High-rise	Metal-Frame	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061
	Metal Bldg	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
	Mass Light	0.170	0.170	0.170	0.170	0.170	0.227	0.227	0.227
	Mass Heavy	0.160	0.160	0.160	0.184	0.211	0.690	0.690	0.690
	Wood-Frame	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
Relocatable Public School Buildings	Wood-Frame	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
	Metal-Frame	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
	Metal Bldg	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
	Mass Light– 7.0≤ HC	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
	Other	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059

Building Type		9	10	11	12	13	14	15	16
Non-residential	Metal Bldg	0.061	0.061	0.061	0.061	0.061	0.061	0.057	0.061
	Metal-Frame	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
	Mass Light	0.44	0.170	0.170	0.170	0.170	0.170	0.170	0.170
	Mass Heavy	0.690	0.650	0.184	0.253	0.211	0.184	0.184	0.160
	Wood-Frame	0.059	0.059	0.059	0.059	0.059	0.059	0.042	0.059
Residential High-rise	Metal Bldg	0.061	0.061	0.057	0.057	0.057	0.057	0.057	0.057
	Metal-Frame	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
	Mass Light	0.196	0.170	0.170	0.170	0.170	0.170	0.170	0.170
	Mass Heavy	0.690	0.690	0.184	0.253	0.211	0.184	0.184	0.160
	Wood-Frame	0.059	0.059	0.042	0.059	0.059	0.042	0.042	0.042
Relocatable Public School Buildings	Wood-Frame	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
	Metal-Frame	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
	Metal Bldg	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
	Mass Light – 7.0≤ HC	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
	Other	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059

The U-factor criteria for walls depend on the class of construction. U-factors used for compliance must be selected from Reference Joint Appendix JA4. Alternatively, the EZFrame2013 assembly calculator can be used to determine U-factors for assemblies and/or components not listed in JA4 tables.

There are seven classes of wall constructions: wood frame, metal frame, metal building walls, light mass, heavy mass, furred walls, and others see (Table 3-15). The “other” category is used for any wall type that does not fit into one of the other six wall classes. The following provides additional information about each type of wall system:

1. **Wood framed walls:** As defined by the 2010 California Building Code, Type IV buildings typically have wood framed walls. Framing members typically consist of 2x4 or 2x6 framing members spaced at 24 in. or 16 in. OC. Composite framing members and engineered wood products also qualify as wood framed walls if the framing members are non-metallic. Structurally insulated panels (SIPS) are another construction type that qualifies as wood framed. SIPS panels typically consist of rigid foam insulation sandwiched between two layers of oriented strand board (OSB). Reference Joint Appendix JA4, Table 4.3.1 has data for conventional wood framed walls and Table 4.3.2 has data for SIPS panels.

2. **Metal framed walls:** Many nonresidential buildings and high-rise residential buildings require non-combustible construction, and this is achieved with metal framed walls. Often metal framed walls are not structural and are used as infill panels in rigid framed steel or concrete buildings. Batt insulation is less effective for metal framed walls (compared to wood framed walls) because the metal framing members are more conductive. In most cases, continuous insulation is required to meet prescriptive U-factor requirements. From Reference Joint Appendix JA4, Table 4.3.3 has data for metal framed walls.

3. **Metal building walls:** Metal building walls consist of a metal building skin that is directly attached to metal framing members. The framing members are typically positioned in a horizontal direction and spaced at about 4 ft. A typical method of insulating metal buildings walls is to drape the insulation over the horizontal framing members and to compress the insulation when the metal exterior panel is installed.

4. **Low-mass walls:** Low-mass walls have a heat capacity (HC) greater or equal to 7.0 but less than 15.0 Btu/°F-ft². See the definition below for heat capacity. From Reference Joint Appendix JA4, Tables 4.3.5 and 4.3.6 have U-factor, C-factor, and heat capacity data for hollow unit masonry walls, solid unit masonry and concrete walls, and concrete sandwich panels.

5. **High-mass walls:** Have an HC equal to or greater than 15.0 Btu/°F-ft². See Reference Joint Appendix JA4 for HC data on mass walls.

   Note: For low- and high-mass walls the **heat capacit**y is the amount of heat required to raise the temperature of the material by one degree F. By storing heat, materials with a high heat capacity, or thermal mass, have a tendency to dampen temperature swings throughout the day. For this reason, U-factor criteria are less stringent for mass walls than for framed construction.

6. **Furred walls:** Are a specialty wall commonly applied to a mass wall type. See figure below. The Reference Joint Appendix JA4 Table 4.3.5, 4.3.6 or other masonry tables list alternative walls. Additional continuous insulation layers are selected from Reference Joint Appendix JA4 Table 4.3.13 and calculated using either Equation 4-1 or 4-4 from the JA4.

Figure 3-22 – Brick wall with furring details

7. **Spandrel panels** and **glass curtain walls:** These wall types consist of metalized or glass panels often hung on outside of structural framing to create exterior wall elements around fenestration and between floors. See Reference Joint Appendix JA4, Table 4.3.8 for U-factor data.

8. **Continuous Insulation:** For some climate zones, mass walls require continuous insulation to meet the U-factor requirements. When this is the case, the effect of the continuous insulation is estimated by Equation 4-1 in Reference Joint Appendix JA4.

   $U_{prop} = 1 / [(1/U_{col,A}) + R_{cont,insul}]$

Example 3-3

Question

An 8 inches (20 cm) medium-weight concrete block wall with uninsulated cores has 1 inch (25 mm) thick exterior polystyrene insulation with an R-value of R-5. What is the U-factor for this assembly?

Answer

From Reference Joint Appendix Table 4.3.5, the U-factor for the block wall is 0.53. From Equation 4-1, the U-factor is calculated as:

$U = 1 / [(1/0.53) + 5] = 0.145$

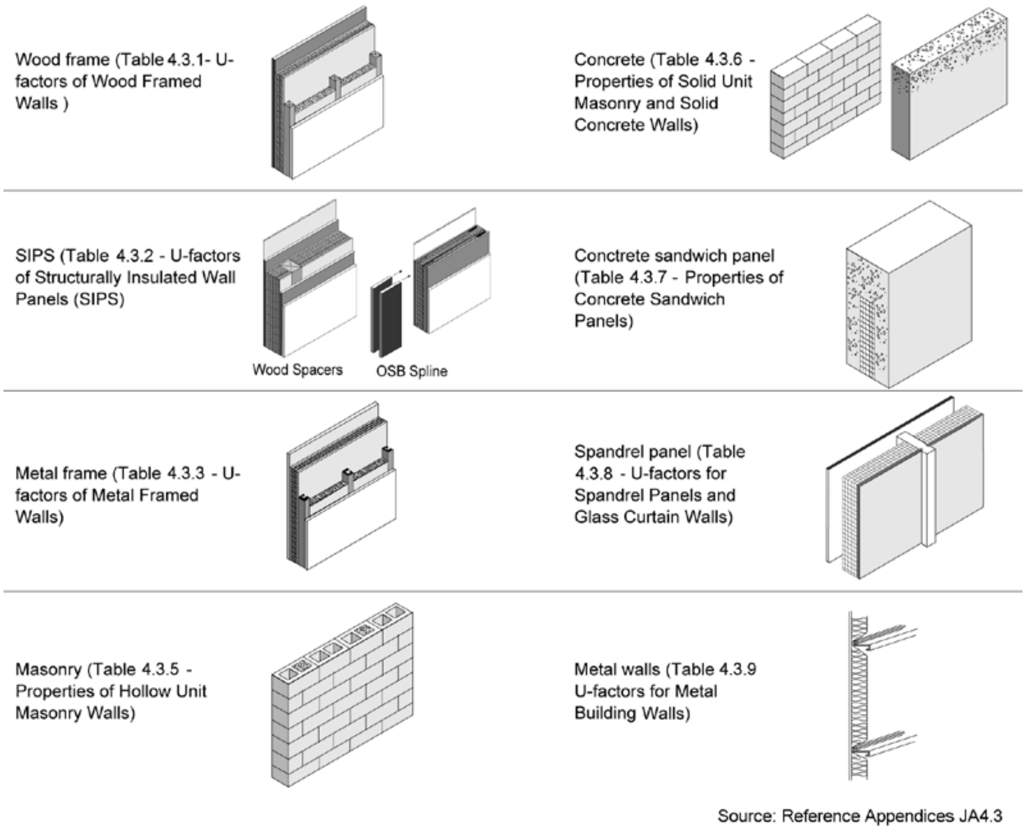


Figure 3-23 – Classes of Wall Constructions

Framed or block walls can also have insulation installed between interior or exterior furring strips. The effective continuous R-value of the furring/insulation layer is shown in Table 4.3.13 of Reference Joint Appendix JA4.

D. Demising Walls

§110.8(f), §140.3(a)3 and Exception to §140.3(a)5A

Demising walls, separating conditioned space from enclosed unconditioned space, must be insulated with a minimum of R-13 insulation if the wall is a framed assembly. If it is not a framed assembly, then no insulation is required. This applies only to the opaque portion of the wall.

The rationale for insulating demising walls is that the space on the other side may remain unconditioned indefinitely. For example, the first tenant in a warehouse building cannot know whether the future neighbor will use the adjoining space as unheated warehouse space or as an office. This requirement assures at least some insulation in the wall.

E. Exterior Floors and Soffits

§140.3(a)4

Under the prescriptive requirements, exterior floors and insulated soffits must have an assembly U-factor equal to or lower than the U-factor criterion for nonresidential, high-rise residential buildings and relocatable public school buildings in Table 3- below. The U-factor for exterior floors and soffits from Reference Joint Appendix JA4 shall be used to determine compliance with the maximum assembly U-factor requirements. The Standards no longer allow using the R-value of the cavity or continuous insulation to demonstrate compliance with the insulation values of the Reference Joint Appendix JA4; only U-factors may be used to demonstrate compliance. For metal framed floors, batt insulation between framing section may need continuous insulation to be modeled and installed on the interior or exterior to meet the U-factor requirements of the Standards.

The U-factor criteria depend on whether the floor is a mass floor or not. A mass floor is one constructed of concrete and for which the HC is greater than or equal to 7.0 Btu/°F-ft².

Table 3-16 – Floor/Soffit U-Factor Requirements

Building Type	**Door Type**	**Climate Zones**							
		1	2	3	4	5	6	7	8
Nonresidential	Mass	0.092	0.092	0.269	0.269	0.269	0.269	0.269	0.269
	Other	0.048	0.039	0.071	0.071	0.071	0.071	0.071	0.071
High-rise Residential	Mass	0.045	0.045	0.058	0.058	0.058	0.069	0.092	0.092
	Other	0.034	0.034	0.039	0.039	0.039	0.039	0.071	0.039
Relocatable Public School Buildings	Wood-Framed and Other	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
Building Type	**Door Type**	**Climate Zones**							
		9	10	11	12	13	14	15	16
Nonresidential	Mass	0.269	0.269	0.092	0.092	0.092	0.092	0.092	0.058
	Other	0.071	0.071	0.039	0.071	0.071	0.039	0.039	0.039
High-rise Residential	Mass	0.092	0.069	0.058	0.058	0.058	0.045	0.058	0.037
	Other	0.039	0.039	0.039	0.039	0.039	0.034	0.039	0.034
Relocatable Public School Buildings	Wood-Framed and Other	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048

The U-factor criteria for concrete raised floors depend on whether the floor is a mass floor or not. A mass floor is one constructed of concrete and for which the heat capacity is greater than or equal to 7.0 Btu/°F-ft².

Insulation levels for nonresidential concrete raised floors with HC ≥ 7.0 using U-factor for compliance, from Reference Joint Appendix JA4, Table 4.4.6, are equivalent to no insulation in climate zones 3-10 and associated U-factors to continuous insulation of R-8 in climate zones 1, 2, 11 through 15, and R-15 in climate zone 16.

To determine the U-factor insulation levels for high-rise residential concrete raised floors, use the U-factors that are associated with R-8 continuous insulation in climate zones 7 through 9; R-15 in climate zones 3-5 and 11-13; with additional insulation required in the desert and mountain climate zones 1, 2, 14, and 16.

Table 4.4.6 from Reference Joint Appendix JA4 is used with mass floors while Tables 4.4.1 through 4.4.5 are used for non-mass floors. See also Figure 3-25.

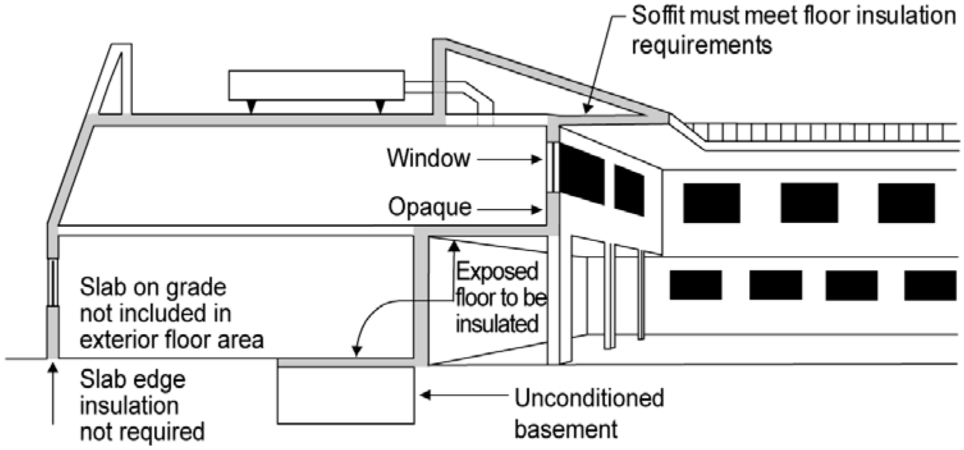


Figure 3-24 – Requirements for Floor/Soffit Surfaces

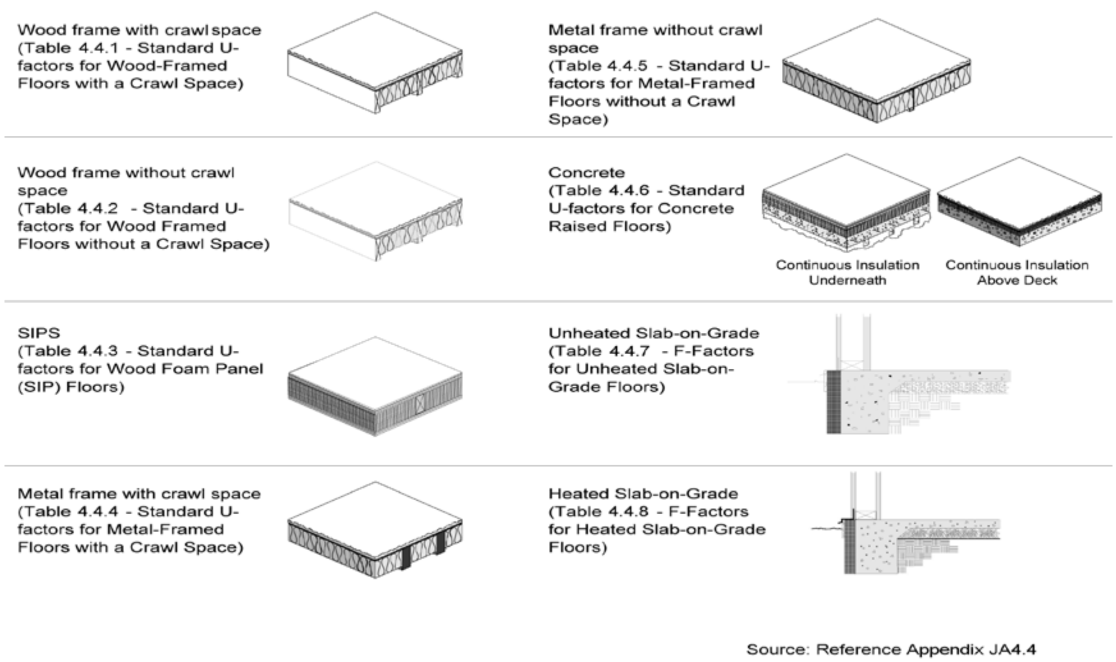


Figure 3-25 – Classes of Floor Constructions

F. Exterior Doors

§140.3(a)7

The Standards provide new prescriptive requirements for exterior doors. The Standards establish U-factor requirements for swinging and non-swinging doors. A maximum U-factor of 0.70 is allowed for swinging doors. For non-swinging doors the criteria depends on the climate zone as shown in the Table 3-17 below.

When glazing area exceeds one-half of the entire door area, it is then defined as a fenestration product in the Standards, and the entire door area is modeled as a fenestration unit. If the glazing area is less than half the door area, the glazing must be modeled as the glass area plus 2 inches in each direction of the opaque door surface (to account for a frame). However, exterior doors are a part of the gross exterior wall area and must be considered when calculating the window-wall-ratio. Table 3- from Reference Joint Appendix JA4 has U-factors for exterior doors.

Table 3-17 – Door Requirements Summary (Standards Table 140.3-B and 140.3-C)

Building Type	**Door Type**	**Climate Zones**							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Nonresidential	Non-Swinging	0.50	1.45	1.45	1.45	1.45	1.45	1.45	1.45
	Swinging	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
High-rise Residential	Non-Swinging	0.50	1.45	1.45	1.45	1.45	1.45	1.45	1.45
	Swinging	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Relocatable Public School Buildings	Non-Swinging	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	Swinging	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Building Type	**Door Type**	**Climate Zones**							
		9	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Nonresidential	Non-Swinging	1.45	1.45	1.45	1.45	1.45	1.45	1.45	0.50
	Swinging	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
High-rise Residential	Non-Swinging	1.45	1.45	1.45	1.45	1.45	1.45	1.45	0.50
	Swinging	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Relocatable Public School Buildings	Non-Swinging	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	Swinging	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70

Example 3-8

Question

According to the provisions of the Standards, are cool roofs optional for nonresidential buildings or high-rise residential buildings?

Answer

The answer depends on the compliance approach you chose. For prescriptive compliance, compliance with solar reflectance and thermal emittance, or SRI is required where indicated in Standards Tables 140.3-B, C, and D. In the performance approach, reflectance and emittance values less than the minimum prescriptive requirements may be used; however, any deficit that results from this choice must be made up by improving other energy efficiency features in the building, which include envelope, space-conditioning system , and lighting systems.

Example 3-4

Question

Must all roofing materials used in California, whether cool roof or not, be certified by the CRRC and labeled accordingly?

Answer

No, but it does depend on the compliance approach you are using. A roof repair, such as for a leak, does not require the roofing product to be cool roof and/or certified by the CRRC.

If you are altering your roof, such as a new reroof, then either the prescriptive envelope component approach or the performance approach can be used for compliance.

In these compliance cases, the answer is yes; the roof must be certified and labeled by CRRC for nonresidential roofs. Note that if you are using the performance approach to receive compliance credit, you can either obtain a CRRC certification, OR use a default solar reflectance of 0.10 and thermal emittance of 0.75. Note that using default values instead of CRRC certificates may result in a significant energy penalty that must be made up by increasing energy efficiency in other building features. Also note that the default reflectance for asphalt roofs is different than tile and metal roofing products; see Example 3-8.

Example 3-5

(Reserved)

Example 3-6

Question

Can I use solar reflectance and thermal emittance data generated by any nationally recognized and well-respected laboratory in lieu of CRRC ratings? Can in-house testing by the manufacturer be used to qualify my product?

Answer

Only CRRC ratings from the product directory list can be used to establish cool roof product qualification for Standards compliance. The CRRC process requires use of a CRRC-accredited laboratory [under most circumstances, an "Accredited Independent Testing Laboratory (AITL) defined by the CRRC program]. Any testing laboratory can become an AITL by following the CRRC accreditation process and satisfying the requirements. The roster of CRRC-accredited laboratories is posted on the CRRC website (http://www.coolroofs.org).

Example 3-7

Question

The aged reflectance for the material I want to use for my roof is currently not available in the CRRC Rated Product Directory. Can I use the initial reflectance that is listed?

Answer

Yes. You have to use the equation $0.2+\beta[\rho_{initial} – 0.2])$ where ($\rho_{initial}$ = Initial Reflectance listed in the CRRC Rated Product Directory) to calculate the aged reflectance value until the aged value is available in the directory at some future time.

B= 0.65 for Field Applied Coating, or 0.70 for all other products other than Field Applied Coatings

Example 3-8

Question

Can the reflectance and emittance requirements of Energy Star Cool Roofs be substituted for Standards requirements?

Answer

No. Only roofing products which are listed by the CRRC in their Rated Product Directory can be used to the Standards. CRRC currently is the only organization which have met the criteria set in §10-113.

Example 3-9

Question

Can I claim to have a cool roof, or can I get anything higher than a default reflectance, if my roof does not meet the field-applied coating performance requirements of the Standards?

Answer

No, you cannot claim to have a cool roof and you cannot claim higher energy credits if your roof does not meet the coating performance requirements of the Standards for field-applied coatings.

Example 3-10

Question

How does a product get CRRC cool roof certification?

Answer

Any party wishing to have a product or products certified by CRRC should contact the CRRC - toll-free (866) 465-2523 from inside the US or (510) 482-4420, ext. 215 or email info@coolroofs.org. In addition, CRRC publishes the procedures in "CRRC-1 Program Manual," available for free on http://www.coolroofs.org or by calling the CRRC. However, working with CRRC staff is strongly recommended.

Example 3-11

Question

Do alterations to the roof of an unconditioned building trigger cool roof requirements?

Answer

No, alterations to the roof of an unconditioned building do not trigger cool roof requirements. In general, the lighting requirements are the only requirements applicable for both newly constructed and altered unconditioned buildings; this includes §140.3(c), the skylight requirements. Building envelope (other than skylight requirements) and space-conditioning requirements do not apply to unconditioned buildings.

Example 3-12

Question

What happens if I have a low-sloped roof on most of my buildings and steep-sloped roof on another portion of the roof? Do I have to meet the two different sets of rules in §140.3(a)1Ai and ii?

Answer

Yes, your building would have to meet both the low-sloped requirement and the steep-sloped roof requirements for the respective area.

Example 3-13

Question

I am installing a garden roof (roofs whose top surface is composed of soil and plant) on top of an office building. Although garden roofs are not cool roofs by their reflectance properties, will they be allowed under the Standards?

Answer

Yes, the Energy Commission considers a garden roof as a roof with thermal mass on it.

Under *Exception* 4 to §140.3(a)1Ai, if a garden roof has a dry unit weight of 25 lb/ft² then the garden roof is equivalent to cool roof.

G. Air Barrier

§140.3(a)9

Table 140.3-B of the standards specifies requirements for air barriers in climate zones 10-16. Air barrier requirements apply to nonresidential buildings, but not relocatable public school buildings. These requirements reduce the overall building air leakage rate in climate zones that benefit from this design measure. The reduction in air leakage can be met with a continuous air barrier that seals all joints and openings in the building envelope and is composed of:

A. Materials having a maximum air permeance of 0.004 cfm/ft^2 (see Table 3-18 below), or

B. Assemblies of materials and components having an average air leakage not exceeding 0.05 cfm/ft^2, or

C. An entire building having an air leakage rate not exceeding 0.40 cfm/ft^2

Table 3-18 – Materials Deemed to Comply As Air Barrier

	MATERIALS AND THICKNESS		**MATERIALS AND THICKNESS**
1	Plywood – min. 3/8 inches thickness	9	Built up roofing membrane
2	Oriented strand board – min. 3/8 inches thickness	10	Modified bituminous roof membrane
3	Extruded polystyrene insulation board – min. ½ inches thickness	11	Fully adhered single-ply roof membrane
4	Foil-back polyisocyanurate insulation board – min. ½ inches thickness	12	A Portland cement or Portland sand parge, or a gypsum plaster, each with min. 5/8 inches thickness
5	Closed cell spray foam with a minimum density of 2.0 pcf and a min. 1½ inches thickness	13	Cast-in-place concrete, or precast concrete
6	Open cell spray foam with a density no less than 0.4 pcf and no greater than 1.5 pcf, and a min. 5½ inches thickness	14	Fully grouted concrete block masonry
7	Exterior or interior gypsum board min. 1/2 inches thickness	15	Sheet steel or sheet aluminum
8	Cement board – min. 1/2 inches thickness	____	____

3.4 Relocatable Public School Buildings

Standards Table 140.3-D

Reference Nonresidential Appendix NA4

Public school building design is defined by two prescriptive requirements (listed in Tables 140.3-B and 140.3-D of the Standards). Table 140.3-B covers prescriptive requirements for climate-specific relocatable public school buildings; Table 140.3-D covers prescriptive requirements for relocatable public school buildings that can be installed in any climate. Building envelopes must meet the prescriptive requirements in §140.3. For additional design requirements, refer to §140.3 and Reference Nonresidential Appendix NA4. Manufacturers must certify compliance and provide documentation according to the chosen method of compliance. Performance compliance calculations must be performed for multiple orientations, each model using the same proposed design energy features rotated through 12 different orientations and different climate zones (Reference Nonresidential Appendix NA4). Also see §140.3(a)8 and §141.0(b)2.

3.4.1 Performance Approach

§140.1 Performance *Reference Nonresidential Appendix NA4*

When the manufacturer/builder certifies a relocatable public school building for use in any climate zone, the building must be designed and built to meet the energy budget for the most severe climate zones (as specified in the Reference Nonresidential Appendix NA4), assuming the prescriptive envelope criteria in Table 140.3-D.

When the manufacturer/builder certifies that the relocatable building is manufactured for use in specific climate zones and that the relocatable building cannot be lawfully used in other climate zones, the energy budget must be met for each climate zone that the manufacturer/building certifies, assuming the prescriptive envelope criteria in Table 140.3-B, including the non-north window RSHG and skylight SHGC requirements for each climate zone. The energy budget and the energy use of the proposed building must be determined using the multiple orientation approach specified in the Reference Nonresidential Appendix NA4. The manufacturer/builder shall meet the requirements for identification labels specified in §140.3(a)8.

Manufacturers may certify the relocatable classrooms for multiple orientations or for compliance for all climate zones statewide. Since relocatable public school buildings could be positioned in any orientation, it is necessary to perform compliance calculations for multiple orientations. Each model with the same proposed design energy features shall be rotated through 12 different orientations: either in climate zones 14, 15, and 16 for relocatables showing statewide compliance; or, in the specific climate zones that the manufacturer proposes for the relocatable be allowed to be installed (i.e., the building with the same proposed design energy features), the relocatable model is rotated in 30 degree increments. The relocatable model shall comply in each case. Approved compliance software programs shall automate the rotation of the building and reporting of the compliance results to insure it is done correctly and uniformly and to avoid unnecessary documentation.

Under the performance approach, energy use of the building is modeled by compliance software approved by the Energy Commission. The compliance software does an hourly simulation of the proposed building, including a detailed accounting of envelope heat transfers using the assemblies and fenestration input, and including the precise geometry of exterior overhangs or side fins. The most accurate tradeoffs between different envelope components – and between the envelope, the space-conditioning system and the installed lighting design – are therefore accounted for and compared with the standard design version of the building. The proposed design has to have TDV energy less than or equal to the standard design. This section presents some basic details on the modeling of building envelope components. Program users and those checking for enforcement should consult the most current version of the user's manuals and associated compliance supplements for specific instructions on the operation of the program. All compliance software, however, are required to have the same basic modeling capabilities. A discussion on the performance approach, and fixed and restricted inputs, is included in Chapter 9.

The following modeling capabilities are required by all approved nonresidential compliance software. These modeling features affect the thermal loads seen by the HVAC system model.

3.4.2 Opaque Surface Mass Characteristics

Heat absorption, retention and thermal transfer characteristics associated with the heat capacity of exterior opaque mass surfaces such as walls, roofs and floors are modeled. Typical inputs are spacing, thickness, Standard U-factor, JA4 Table references, Framed Cavity R-value and Proposed Assembly U-factor. The heat capacity of concrete masonry unit walls and solid concrete walls is provided in Tables 4.3.5 and 4.3.6 of Reference Joint Appendix JA4. Effective R-values for interior and exterior insulation are provided in Table 4.3.13 of Reference Joint Appendix JA4.

3.4.3 Opaque Surface

Heat gains and heat losses are modeled through opaque surfaces of the building envelope. The following inputs or acceptable alternative inputs are used by this modeling capability:

A. Surface areas by opaque surface type.

B. Surface orientation and slope.

C. Thermal conductance of the surface. The construction assembly U-factor is chosen from tabulated values in Reference Joint Appendix JA4.

D. Surface absorptance. Surface absorptance is a restricted input (except for roofs).

Note, for roofs, surface absorptance and emittance are variable inputs in the proposed design for roofs to provide a ‘cool roof credit’ in climate zones where a cool roof is not required. The roof reference design is set with a cool roof surface absorptance for nonresidential buildings in all climate zones. The difference in surface absorptance creates a credit that can be used with the whole building performance method. Cool roofs have both a high reflectance and a high emittance. The high reflectance keeps much of the sun’s energy from being absorbed and becoming a component of heat transfer. The high emittance ensures that when the roof does warm up, its heat can escape through radiation to the sky. To model the proposed design as a cool roof, the roofing product must be listed in the Rated Product Directory of the Cool Roof Rating Council. If the roof is not rated, a default aged reflectance of 0.08 is used for asphalt or composition shingles and 0.10 for other roofing products. If the proposed design does not have a cool roof, the performance method may be used to trade off with other measures, such as increased insulation or HVAC equipment efficiency, so that the TDV energy of the proposed design does not exceed that of the standard design.

3.4.4 Fenestration Heat Transfer

Heat transfer through all fenestration surfaces of the building envelope are modeled using the following inputs:

A. Fenestration areas. The glazing width and height dimensions are those of the rough-out opening for the window or fenestration product. Window area of the standard design is limited to the prescriptive limit of 40 percent of the gross wall area or 6 times the display perimeter, whichever is greater. If the proposed design window area exceeds this limit, a trade-off may be made with measures such as increased envelope insulation or increased equipment efficiency to offset the energy penalty from fenestration.

B. Fenestration orientation and slope. Vertical windows installed in a building located in any of the four cardinal orientation; North, South West, and East. Skylights are considered less than 60o from the horizontal and all windows and skylights provide solar gain that can have an effect on the overall energy of the building unless they are insulated glass.

C. Fenestration thermal conductance. The overall U-factor shall be taken from NFRC rating information, default values in Table 110.6-A of the Standards or from the Alternative Default Fenestration, Reference Nonresidential Appendix NA6, if less than 1,000 ft².

D. Fenestration solar heat gain coefficient. The SHGC shall be taken from NFRC rating information default values in Table 110.6-B of the Standards or from the Alternative Default Fenestration, Reference Nonresidential Appendix NA6 if less than 1,000 ft². The baseline building uses a solar heat gain coefficient equal to the relative solar heat gain value from Table 140.3-B, 140.3-C or 140.3-D. The baseline building has no overhangs, but overhangs can be modeled in the baseline building, as described below.

If the compliance software requires input of the shading coefficient (SC) instead of the SHGC, the shading coefficient shall be calculated by the following formula:
SC = SHGC / 0.87

3.4.5 Overhangs and Vertical Shading Fins

Approved compliance software programs are able to model overhangs and vertical fins. Typical inputs are overhang projection, height above window, window height and the overhang horizontal extension past the edge of the window. If the overhang horizontal extension (past the window jambs) is not an input, then the program must assume that the extension is zero (i.e., overhang width is equal to window width) which results in less benefits from the overhang.

Vertical fins are modeled with inputs of horizontal and vertical position relative to the window, the vertical height of the fin and the fin depth (projection outward perpendicular to the wall).

3.4.6 Interzone Surfaces

Heat transfer modeled through all surfaces separating different space conditioning zones may be modeled with inputs such as surface area, surface tilt and thermal conductance. Thermal mass characteristics may be modeled using the thickness, specific heat, density and types of layers that comprise the construction assembly. Demising partitions separating a conditioned space from an unconditioned space that are insulated with R-13 cavity insulation or with a U-factor less than 0.218 are modeled as adiabatic partitions (no heat transfer). Walls that separate directly conditioned zones from other conditioned zones are modeled as “air walls” with no heat capacity and an overall U-factor of 1.0 Btu/h-ft²-˚F.

3.4.7 Slab-on-Grade Floors and Basement Floors

Heat transfer through slab-on-grade floors and basement floors is modeled by calculating perimeter heat losses and interior slab heat losses. The heat lossees from the presimeter and the interior are modeled by the use of an F-factor that accounts for the rate of heat transfer from the slab to the soil. Reference Appendix JA4 contains F-factors for common insulation conditions (vertical insulation outside or a combination of the two. The user must select from the list of insulation conditions in Reference Appendix JA4. The insulation depth and insulation R-value affect heat loss through basement floors.

3.4.8 Historic Buildings

§100.0(a), Exception 1, states that qualified historic buildings, as defined in the California Historical Building Code (Title 24, Part 8 or California Building Code, Title 24, Part 2, Volume I, Chapter 34, Division II) are not covered by the Standards. However, non-historical components of the buildings, such as new or replaced space-conditioning, plumbing, and electrical (including lighting) equipment, additions and alterations to historic buildings, and new appliances in historic buildings must comply with Building Energy Efficiency Standards and Appliance Efficiency Regulations, as well as other codes. Additions and alterations to historic buildings must also meet applicable requirements of the Standards. For more information about energy compliance requirements for Historic Buildings, see Section 1.7.1, Building Types Covered, in Chapter 1, the Overview of this manual.

3.5 Simplified Performance Tradeoff Approach

The Simplified Performance Tradeoff Approach has been modified for the 2013 Standards. A simplified tradeoff in the performance approach replaces the prescriptive, spreadsheet-based tradeoff in the 2008 Standards. With the new approach called, “Simplified Performance Tradeoff Approach,” the user can tradeoff the energy efficiency benefits between roof reflectance and roof insulation through a simplified approach that only requires a limited set of inputs. This compliance approach allows the user to enter inputs such as building type, building vintage, roof insulation and roof reflectance details and compliance software analyzes the energy effects of design choices without the need for elaborate lookup tables and other detailed information. The procedure can be accessed on the Energy Commission’s web site at http://www.energy.ca.gov/title24/2013standards.

The previously used Overall Envelope TDV approach is no longer available for compliance use with new construction. In its place, simplified tradeoffs have been incorporated into the prescriptive standards for new construction (§140.3) and alterations (§141.0) in tabulated form.

3.6 Additions and Alterations

The Standards offer prescriptive approaches and a performance approach to additions and alterations (but they do not apply to repairs). Relevant definitions from §100.1(b) are provided below:

A. **Addition** is a change to an existing building that increases conditioned floor area and volume. See §141.0(a) and §100.1(b) for detailed definition.

When an unconditioned building or unconditioned part of a building adds heating or cooling so that it becomes conditioned, this area is treated as an addition.

B. **Alteration** is a change to an existing building that is not an addition. An alteration could include a new HVAC system, lighting system, or change to the building envelope, such as a new window. See §141.0(b) and §100.1(b). Roof replacements (reroofing) and reconstructions and renewal of the roof are considered alterations and are subject to all applicable Standards requirements. For alterations, the compliance procedure includes:

1. The prescriptive envelope component approach
2. The addition alone approach
3. The existing-plus-alteration performance approach
4. The existing-plus-addition-plus alteration performance approach

C. **Repair** is the reconstruction or renewal of any part of an existing building for the purpose of its maintenance. For example, a repair could include the replacement of a pane of glass in an existing multi-lite window without replacing the entire window. Repairs must not increase the preexisting energy consumption of the repaired component, system, or equipment; otherwise, it is considered to be an alteration. See §141.0(b) and §100.1(b).

For more information on the performance approach with additions and alterations, refer to Section 9.3 of this Manual.

3.6.1 Mandatory Requirements

A. Additions

All additions must meet the applicable mandatory measures from the following Standards sections:

- §110.6 - Mandatory Requirements for Fenestration Products and Exterior Doors;
- §110.7 - Mandatory Requirements for Joints and Other Openings;
- §110.8 - Mandatory Requirements for Insulation and Roofing Products (Cool Roofs);
- §120.7- Mandatory Requirements for Insulation.

B. Alterations

All alterations must meet the above mandatory requirements stated for additions, with the exception of the insulation requirement of §120.7 for opaque envelope components (roofs, ceilings, walls and floors). Alterations for nonresidential, high-rise residential and hotel/motel buildings must meet the following:

1. Insulation levels for roofs and ceilings shall follow the prescriptive requirements of Section 141.0(b)2Biii of the Standards. These requirements are explained in more detail in Section 3.3.2 of this document.
2. Light mass and heavy mass walls do not have mandatory requirements for minimum R-value and maximum U-factor.
3. Insulation for walls that separate conditioned space from either unconditioned space or the exterior shall comply with the mandatory requirements of §141.0(b)1B of the Standards. This section provides two options for wall insulation compliance; either a minimum insulation R-value or a maximum assembly U-factor. The mandatory requirements are determined by the wall type:

A. **Metal buildings:** a minimum of R-13 insulation between framing members, or a weighted average U-factor no greater than 0.113 is required
B. **Metal framed walls:** a minimum of R-13 insulation between framing members, or a weighted average U-factor no greater than 0.217 is required.
C. **Wood framed walls and other wall types:** a minimum of R-11 insulation between framing members, or a weighted average U-factor no greater than 0.110 is required.
D. **Spandrel panels and glass curtain walls:** a minimum of R-4 insulation, or a weighted average U-factor no greater than 0.280 is required.

Insulation for floors that separate conditioned space from either unconditioned space or the exterior shall comply with the mandatory requirements of §141.0(b)1C of the Standards. This section provides two options for compliance with the mandatory requirements; either a minimum insulation R-value or a maximum assembly U-factor. For floors, the mandatory requirements are determined by both building type and floor type:

A. **Raised framed floors:** a minimum of R-11 insulation between framing members, or the weighted average U-factor no greater than 0.071 is required.

B. **Raised mass floors in high-rise residential and hotel/motel guest rooms:** a minimum of R-6 insulation, or the weighted average U-factor no greater than 0.111 is required.

C. **Raised mass floors in all other occupancies:** no minimum U-factor is required.

3.6.2 Prescriptive Requirements

Additions

Prescriptive compliance for the building envelope of additions is addressed in §141.0(a)1 and §140.3 of the Standards. §140.3(a) provides prescriptive compliance alternatives for the building envelope including tradeoffs between roofing insulation and the solar reflectance of roofing products (cool roofs) in Table 140.3-A. Tradeoffs between other envelope components are no longer allowed in the prescriptive method. The Simplified Performance Tradeoff Approach described in section 3.6 may also be used. The performance method may be used for tradeoff for both new construction and alterations.

All additions must also comply with §140.3(c), Minimum Skylight Area for large enclosed spaces in buildings with three or fewer stories.

For more details on the prescriptive requirements for additions, see Sections; Overview (Building Envelope); 3.2.4, Window Prescriptive Requirements; 3.2.5, Skylight Prescriptive Requirements; 3.3.2, Prescriptive Requirements (Opaque Envelope Insulation);

Alternatively, the addition may meet compliance by using the performance compliance approach of §140.1, which compares the TDV energy (space conditioning, lighting and water heating) of the proposed building addition to a TDV energy budget that complies with prescriptive requirements.

Alterations

In general, any alteration to an existing building that involves changes to a portion of the building envelope triggers the Standards. The prescriptive requirements for alterations to building envelopes are in §141.0(b)2A and B of the Standards.

The altered components of the envelope shall meet the applicable mandatory requirements of §110.6 and §110.8 of the Standards.

Fenestration

§140.3(a)5, §141.0(b)2A

For all nonresidential, high-rise residential, and hotel/motel occupancies, when fenestration is altered or where there are alterations that do not increase the fenestration area, all altered fenestration shall meet the requirements of Table 141.0-A of the Standards (table duplicated below) based on climate zone.

When new fenestration area is added to an alterations it shall meet the requirements of; §140.3(a) and Tables 140.3-B, C, or D of the Standards. In cases where the fenestration is temporarily removed and then reinstalled compliance with §140.3(a) is not required.

In cases where small amounts of fenestration area are changed, a number of options exist. If less than 150 ft² of fenestration area is replaced throughout the entire building, then the Standards require that only the U-factor requirements in Tables 140.3-B, C, or D are met. The SHGC, Relative Solar Heat Gain Coefficients or Visible Transmittance requirements need not be met. The same requirements and exceptions apply if 50 ft² or less of fenestration (or skylight) area is added. A typical example of this may be changing a door from a solid door to a glass door.

Table-3-19 (Standards Table 141.0-A) Altered Window Maximum U-Factor and Minimum RSHGC and VT

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
U-factor	0.47	0.47	0.58	0.47	0.58	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
RSHGC	0.41	0.31	0.41	0.31	0.41	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31

		Fixed Window	Operable Window	Curtainwall/ Storefront	Glazed Doors
VT	Vertical	0.42	0.32	0.46	0.17
		Glass, Curb Mounted	Glass, Deck Mounted	Plastic, Curb Mounted	
	Skylights	0.49	0.49	0.64	

3.7 Roofing Products (Cool Roofs)

§141.0(b)2B

When more than 2,000 ft² or more than 50 percent of a roof (whichever is less) is being replaced on a conditioned building, energy code requirements for roof surface radiative (cool roofs) properties and roof insulation levels are triggered. Thus when a small repair is made, these requirements don't apply. The requirements of the Standards regarding roof insulation would not be "triggered" if the existing roof surface were overlaid instead of replaced.

These envelope requirements only apply to conditioned spaces and do not apply to unconditioned and process spaces. However, these requirements do apply to roofs over conditioned non-process spaces even if the building has a portion that is a process space. These roof areas can be delineated by the fire separation walls between process areas and conditioned, non-process areas.

For nonresidential buildings, the prescriptive requirements for roofing products are based on roof slope, and climate zone. Low-sloped roofs in climate zones 1 through16 have a required minimum aged solar reflectance of 0.63 and a minimum thermal emittance of 0.75, or a minimum SRI of 75.

For high-rise residential buildings and hotels and motels, the prescriptive requirements for roofing products are based on roof slope and climate zone. Low-sloped roofs in climate zones 10, 11, 13, 14, and 15 have a required minimum aged solar reflectance of 0.55 and a minimum thermal emittance of 0.75, or a minimum SRI of 64. Steep-sloped roofs in climate zones 2 through 15 have a required minimum aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum SRI of 16.

There are two exceptions to the prescriptive requirements for all nonresidential, high-rise residential, and hotel/motel buildings:

1. For roof area covered by building integrated photovoltaic panels and building integrated solar thermal panels, roofing products are not required to meet the minimum requirements for solar reflectance, thermal emittance, or SRI.
2. For roof constructions that have thermal mass over the roof membrane with a weight of at least 25 lb/ft² roofing products are not required to meet the minimum requirements for solar reflectance, thermal emittance, or SRI.

A new Exception has been added to the 2013 Standards. It applies only to low-sloped nonresidential buildings. An aged solar reflectance less than 0.63 is allowed, provided that additional insulation is installed. Table 141.0-B (Table 3-20 below) has been added to the Standards to simplify the process of making insulation/aged solar reflectance trade-off. The table expresses the trade-off requirements in terms of overall roof U-factors, rather than in terms of continuous insulation R-value.

Table 3-20 (Standards Table 141.0-B) Roof/Ceiling Insulation Tradeoff for Aged Solar Reflectance

Aged Solar Reflectance	**Climate Zone 1, 3-9 U-factor**	**Climate Zone 2, 10-16 U-factor**
0.62 - 0.60	0.075	0.052
0.59 - 0.55	0.066	0.048
0.54 - 0.50	0.060	0.044
0.49 - 0.45	0.055	0.041
0.44 - 0.40	0.051	0.039
0.39 - 0.35	0.047	0.037
0.34 - 0.30	0.044	0.035
0.29 - 0.25	0.042	0.034

U-factors measure the thermal performance of the entire roof assembly, both above and below the roof deck. Utilizing U-factors provides flexibility. Trade-offs can be made by installing additional insulation continuously above the roof deck, between the joists below the roof deck or a combination of both approaches.

The new, simplified trade-off process begins by locating in Table 141.0-B of the Standards the maximum roof/ceiling U-factor that applies to the aged reflectance of the roofing products to be installed and the climate zone of the building. By consulting the U-factor tables in reference Joint Appendix JA4, one can then determine what configurations of above and/or below-deck insulation satisfy the trade-off. Reference Joint Appendix JA4 contains U-factor tables for many common roof constructions (wood framed, metal framed, span deck and concrete roofs, etc). See the examples at the end of this section for illustrations of insulation/reflectance trade-offs.

To make the new trade-off process as simple as possible, Table 141.0-B of the Standards not only takes account of the amount of insulation necessary to compensate for using a noncompliant roofing product, it also accounts for the minimum insulation requirements that apply to roof alterations generally.

3.7.1 Opaque Envelope

§141.0, §141.0(b)2Biii

All nonresidential building alterations involving exterior walls, demising walls, external floors, or soffits must either comply as a component with the requirements in Tables 143-B, C, or D in the Standards, or calculations must be provided which demonstrate that the overall TDV energy use of the overall building or component is equal to or less than the unaltered configuration.

In general, additions and alterations to the building envelope must meet the prescriptive insulation requirements in §141.0 of the Standards or comply with the performance compliance approach. Note that §141.0(b)2 of the Standards lists prescriptive requirements for alterations; this means that the altered component must have a U-factor within limits defined in Table 140.3-B, C or D of the Standards. Additions to an existing building must comply with insulation requirements of §141.0(a) of the Standards. Additional insulation modifications and tradeoffs based on roof finish properties can be found in Sections 3.3.2 Roofing Products (Cool Roofs).

Existing roofs being replaced, recovered or recoated, for nonresidential, high-rise residential and hotels/motels buildings shall meet the requirements of §110.8(i). When the alteration is being made to either 50 percent of the existing roof area or when more than 2,000 ft^2 of the roof is being altered, the requirements of this section apply.

The California Building Code and local amendments place limitations on the number of new roof covering layers that are allowed to overlay an existing roof covering in accordance with CBC 1510. When this limit is reached, the existing roof covering must be removed down to the roof deck or to the insulation recover boards.

When a roof is exposed to the roof deck, or to the roof recover boards and alteration complies with the prescriptive requirements for roofing products, the exposed roof area shall be insulated to the levels specified in Table 141.0-C of the Standards (duplicated below).

The amount of insulation required varies by climate zone and building type. The requirements are given in terms of a continuous layer of insulation (usually installed on top of the roof deck) or an overall roof U-factor based on the default tables and calculation method in Reference Joint Appendix JA4. The U-factor method provides the most flexibility, as insulation can be added continuously on top of the roof deck, below the roof deck between roof joists, or a combination of insulation above and below the roof deck.

Table 3-21 (Standards Table 141.0-C) Insulation Requirements for Roof Alterations

	Nonresidential		High-Rise Residential and Guest Rooms of Hotel/Motel Buildings	
Climate Zone	Continuous Insulation R-value	U-factor	Continuous Insulation R-value	U-factor
1	R-8	0.082	R-14	0.055
2	R-14	0.055	R-14	0.055
3-9	R-8	0.082	R-14	0.055
10-16	R-14	0.055	R-14	0.055

For reroofing, when roofs are exposed to the roof deck and also meet the roofing products requirements in §141.0(b)2Bi or ii, the exposed area must be insulated to levels specified in Standards Table 141.0-C. For nonresidential buildings, this level is R-8 continuous insulation in climate zones 1 and 3 through 9; and R-14 continuous insulation in climate zones 2 and 10 through 16. Several exceptions are provided:

1. No additional insulation is required if the roof is already insulated to a minimum level of R-7.
2. When insulation is added on top of a roof, the elevation of the roof membrane is increased. As shown in figure 3-26, when insulation is added to a roof and the curb height (or reglet or counterflashing for walls) is unchanged, the height of the base flashing above the roof membrane will be reduced. In some cases when the overhanging edge of the space-conditioning equipment is very close to the side of the curb, this may also limit how far up the curb the base flashing may be inserted. Many manufacturers and the National Roofing Contractors Association (NRCA) recommend maintaining a minimum base flashing height of 8 inches above the roofing membrane.

Thus, when adding insulation on top of a formerly uninsulated or under insulated roof, one must consider the impacts on base flashing height. It may be desirable to increase curb heights or counterflashing heights to maintain the same or higher base flashing heights above the roof membrane. In other cases, where leak risk is low, one can ask the roofing manufacturer for a variance on installation requirements for a roofing warranty; this may require additional waterproofing measures to obtain the manufacturer’s warranty. Installing insulation under the roof deck when access is feasible doesn’t change the base flashing height and in some cases may be the least expensive way to insulate the roof.

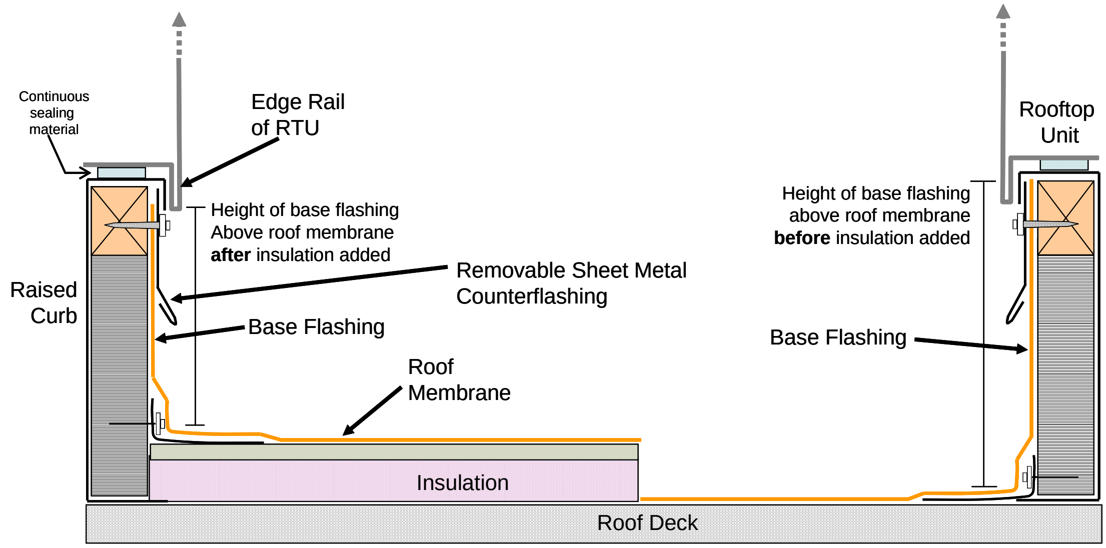


Figure 3-26 - Base flashing on roof top unit curb detail

In some circumstances it is costly or difficult to increase the curb or counterflashing height for the purpose of maintaining the base flashing at a suitable height above the roof membrane. In the following situations, added insulation is limited to the thickness that will still maintain a base flashing height of 8 inches (20 cm) above the surface of the roof membrane:

If there is any space-conditioning equipment on the roof that is not disconnected and lifted during reroofing the condition of this “undisturbed” equipment will determine how much, if any, insulation must be added to the entire roof. That is, if the equipment that is not disconnected and lifted is situated on a curb that is 9 inches above the roof membrane, only 1 inch of insulation must be added to the roof. If the undisturbed equipment is situated on a curb that is 8 inches (20 cm) or less above the roof membrane, no additional insulation is required.

If adding the required insulation will reduce the base flashing height to less than 8 inches at penthouse or parapet walls, the insulation added may be limited to the maximum insulation thickness that will allow a height of 8 inches from the roof membrane surface to the top of the base flashing. For the above exemption to apply the following conditions must be met:

1. The penthouse or parapet walls are finished with an exterior cladding material other than the roofing covering membrane material; and
2. The penthouse or parapet walls have exterior cladding material that must be removed to install the new roof covering membrane to maintain a base flashing height of 8 inches; and
3. For nonresidential buildings, the ratio of the replaced roof area to the linear dimension of affected penthouse or parapet walls shall be less than 25 square feet per linear foot for climate zones 2, and 10 through 16, and less than 100 square feet per linear foot for climate zones 1, and 3 through 9; and
4. For high-rise residential buildings, hotels or motels, the ratio of the replaced roof area to the linear dimension of affected penthouse or parapet walls shall be less than 25 square feet per linear foot for all climate zones.

5. It is important to note that increasing the elevation of the roof membrane by adding insulation may also affect roof drainage. The Standards allow tapered insulation to be used which has a thermal resistance less than that prescribed in Table 141.0-C at the drains and other low points, provided that the thickness of insulation is increased at the high points of the roof so that the average thermal resistance equals or exceeds the value that is specified in Table 141.0-C.

For more details on the prescriptive requirements for alterations, see Sections 3.1, Overview (Building Envelope); 3.1.1, Prescriptive Requirements (Building Envelope); 3.2.4, Window Prescriptive Requirements; 3.2.5 Skylight Prescriptive Requirements; 3.3.2, Prescriptive Requirements (Opaque Envelope Insulation).

Example 3-14

Question

A building is being re-roofed and the roofing is torn off down to the roof deck. The roof has no insulation but it does have a single layer radiant barrier that is stapled to the underside of the roof joists. This forms an air cavity between the underside of the roof deck and the radiant barrier. The radiant barrier has a low emissivity (around 5 percent). Does this create enough of an insulating value that the roof does not need to be insulated?

Answer

Added insulation is not required when the existing roof insulation exceeds R-7 or the roof has an overall U-factor less than 0.089 Btu/h•ft²•°F.

[*Exception* to §149(b)2B(iii)] However the effective R-value of a sealed air cavity formed by a single layer radiant barrier on the bottom, roof joists on the side and the roof deck on top is around R-2, much less than the needed R-7 insulation. Thus, upon re-roofing where the roof deck is exposed, added insulation would be required.

In Section 4.1.2.3 of the Reference Joint Appendix JA4, “Accounting for Unusual Construction Layers,” the calculation of the effective thermal resistance of an air cavity is described as follows:

“The thermal resistance of air layers shall be taken from the 2009 ASHRAE Handbook of Fundamentals, for a mean temperature of 50°F, a temperature difference of 20 °F and an effective emittance of 0.82. R-values for air layers for roof and ceiling assemblies shall be based on heat flow up.” Applying these conditions but using an effective emittance of 0.05 the thermal resistance values for a cavity depth of 3.5 inches in the appropriate table in the ASHRAE Handbook of Fundamentals[5] yields an effective R-value of 2.18 ft²•°F•h/Btu. If one assumes surface degradation (or slight condensation) of the radiant barrier to an emittance of 0.2, the effective R-value is 1.79 ft²•°F•h/Btu.

Example 3-15

Question

What are the Standards requirements for cool roofs when reroofing an unconditioned warehouse containing conditioned office space? The warehouse has a low-sloped roof.

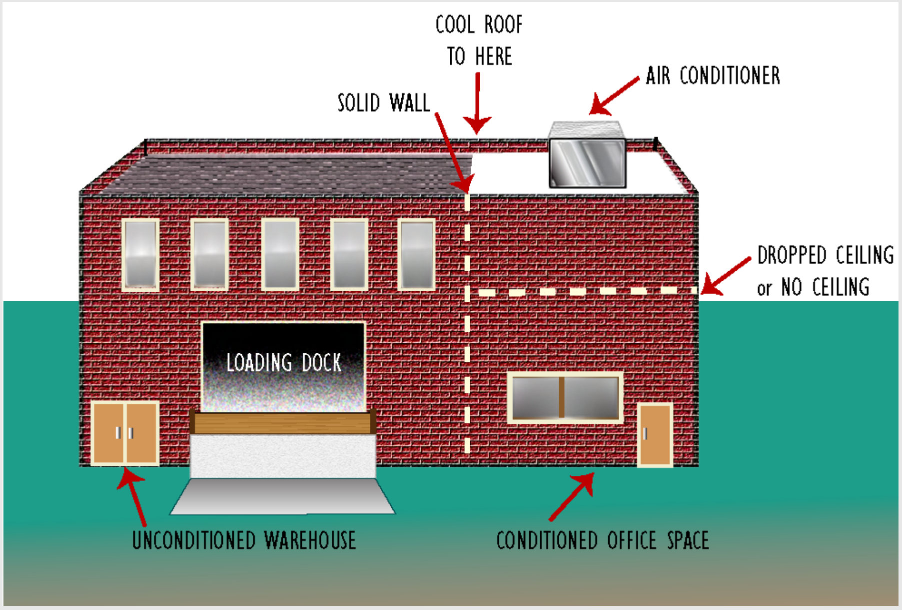
Answer

Scenario 1.

In this situation (see picture below), we now have either directly or indirectly conditioned space under the roof. The cool roof requirements apply to just the portion(s) of the warehouse roof over the conditioned space(s). The rest of the roof (over unconditioned warehouse space) is not required to be a cool roof.

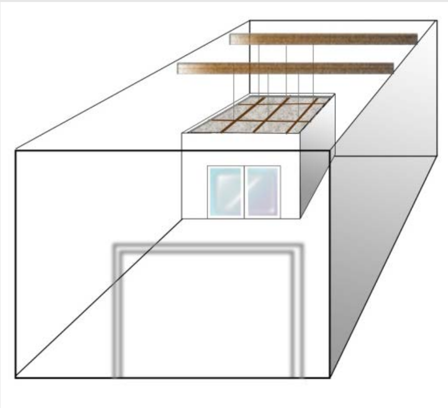
The walls of the conditioned space go all the way up to the underside of the warehouse.

[5] 2005 ASHRAE Fundamentals Handbook Table 3 (p. 25.4): The Thermal Resistances of Plane Air Spaces, ft²•°F•h/Btu



Scenario 2.

The walls of the conditioned space do not reach all the way to the warehouse roof (see picture below). In this case, the roof requirements do not apply, because the space directly below the roof is unconditioned and communicates with the rest of the unconditioned portion of the warehouse.



Example 3-16

Question

I have a barrel roof on nonresidential conditioned building that needs to be re-roofed. Must I follow the Standards roofing product requirement?

Answer

Yes, the roof would need to meet the aged solar reflectance and thermal emittance for a steep-sloped roof. The reason being is that a barrel roof, although it has both low-sloped and steep-sloped roofing areas, has a continuous gradual slope change which would allow the steep-sloped section of the roof to be seen from ground level. This was the reason to allow barrel roofs to only meet the steep-sloped requirement for the entire roof area.

Example 3-17

Question

As shown in Figure 3-27, 40 percent of the low-sloped roof on a 500 ft by 100 ft retail building in Concord, California (CZ12) is being re-roofed. The roofing is removed down to the roof deck and there is no insulation. The building has a stucco-clad parapet roof and the current base flashing is 9 inches above the level of the roof. Must insulation be added before re-roofing?

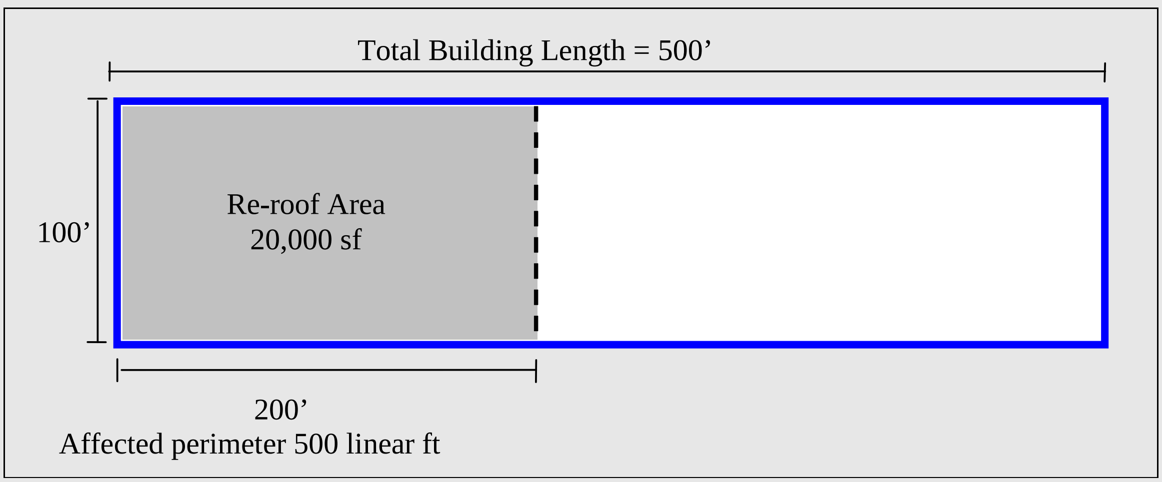


Figure 3-27 - Plan View of Partial Building Re-roofing Project

Answer

Yes, §141.0(b)2B requires when either 50 percent (or more) of the roof area or 2,000 ft² (whichever is less) is re-roofed down to the roof deck or recover boards, that insulation be installed if the roof has less than R-7 insulation. Though the re-roofing covers only 40 percent of the roof area, the requirements still apply because the 20,000 ft² of replacement roof area is greater than the threshold area of 2,000 ft². As stated in the question, the roof does not have any insulation and therefore it is required to add insulation.

Concord, California is in climate zone 12.[6] As per Standards Table 141.0-C "Insulation Requirements for Roof Alterations," for nonresidential buildings in climate zone 12, the requirement for insulation is either R-14 continuous insulation or an effective roof U-factor of 0.055 Btu/h•ft²•°F. If the ratio of replaced roof area to affected clad wall length is less than 25 ft² of roof per linear foot of wall, then the insulation thickness is allowed to be limited to the maximum thickness that will maintain a base flashing height of no less than 8 inches above the roof membrane.

The ratio of the replaced roof to the affected wall area is 20,000 ft² / 500 linear ft = 40:1. Since this ratio is greater than 25:1, the full required insulation must be installed regardless of the existing base flashing height. This may require changing the height of the base flashing, removing some of the parapet wall cladding and moving the counterflashing (or reglet) higher up on the wall. Alternatively, the installer may ask for the roofing manufacturer to provide a variance in the warrantee to accept a slightly lower base flashing height above the roof surface. The specific risk of roof leakage at a given site has to be considered carefully before reducing the base flashing height. When access to the underside of the roof deck is available, an alternative method of compliance that does not affect base flashing heights is to add insulation below the roof deck to the overall U-factor levels given in Standards Table 141.0-C.

Example 3-18

Question

If the building in the question above was located in San Francisco, would the insulation requirements be different on the building?

Answer

Yes. San Francisco (as shown in Reference Joint Appendix JA2) is in Climate Zone 3. In Standards Table 141.0-C from §141.0(b)2B "Insulation Requirements for Roof Alterations," for nonresidential buildings in climate zone 3 is R-8 or a U-factor of 0.081.

The criteria for limiting the insulation thickness based on the existing base flashing height are different for climate zone 3 than for climate zone 12. For nonresidential buildings in climate zone 3, if the ratio of replaced roof area to affected clad wall length is less than 100 ft² of roof per linear ft of wall, then the insulation thickness is limited to the thickness that will maintain a base flashing height of no less than 8 inches above the roof membrane. The ratio of the replaced roof to the affected wall area is 20,000 ft² / 500 linear ft = 40:1. Since this ratio is less than 100:1, only the amount of insulation (and recover board) that will still maintain a base flashing height of 8 inches above the roofing membrane is required. Thus one could still add one inch of insulation board.

Example 3-19

Question

A nonresidential building is having 5,000 ft² of roofing replaced. During roofing replacement the roof deck will be exposed. This building has a rooftop air conditioner that is sitting on an 8 inches high curb above the roof membrane level. The roof is currently uninsulated. If the rooftop air conditioner unit is not disconnected and not lifted off of the curb during re-roofing, is adding insulation required?

Answer

No, the *Exception* to §141.0(b)2Biii of the Standards, specifically exempts re-roofing projects when space-conditioning equipment is not disconnected and lifted. In this case the requirements for adding insulation are limited to the thicknesses that result in the base flashing height to be no less than 8 inches above the roofing membrane surface, Adding insulation increases the height of the membrane surface and thus for a given curb would reduce the base flashing height above the roof membrane. Since the base flashing height is already 8 inches above the roof membrane, no added insulation is required.

[6] A listing of climate zones by city is found in Reference Joint Appendix JA2.

Example 3-20

Question

What if the rooftop air conditioner from Example 3-25 is lifted temporarily during re-roofing to remove and replace the roofing membrane? Is added insulation required?

Answer

Yes, insulation is required.

The *Exception* to §141.0(b)2Biii specifically applies when the space-conditioning equipment

is not disconnected and lifted. Since the roof membrane level will be higher after the addition of insulation, the base flashing height will no longer be 8 inches above the roof membrane. When the rooftop unit is lifted as part of the re-roofing project, the incremental cost of replacing the curb or adding a curb extension is reduced.

Thus to maintain the 8 inch base flashing height, one can replace the curb or add a curb extension before re-installing the roof top unit. Alternatively one can ask for a roofing manufacture's variance to their warrantee from the typical minimum required 8 Inches base flashing height above the roof membrane to the reduced amount after the roof insulation is installed. The specific risk of roof leakage at a given site has to be considered carefully before reducing the base flashing height. An alternative method of compliance that does not affect base flashing heights is to add insulation below the roof deck to the overall U-factor levels given in Table 141.0-C of §141.0(b)2B.

Example 3-21

Question

A nonresidential building is having 5,000 ft² of roofing replaced. During roofing replacement the roof deck will be exposed. This building has several unit skylights that are sitting on an 8 inches (20 cm) high curb above the roof membrane level. The roof is currently uninsulated. Is added insulation required?

Answer

Yes, insulation is required. The *Exception* to §141.0(b)2Biii specifically applies when space-conditioning equipment is not lifted. Unit skylights are not space-conditioning equipment and thus the exception does not apply. Removing a unit skylight and increasing its curb height is substantially less effort than that for space-conditioning equipment.

Example 3-22

The roof top unit with the 9 inches base flashing is disconnected and lifted during re-roofing. However, the rooftop unit on the curb with the 14 inches (36 cm) base flashing is not lifted. In this situation, is the insulation added limited to the amount of insulation that will result in an 8 inches base flashing on the unit with the lower curb?

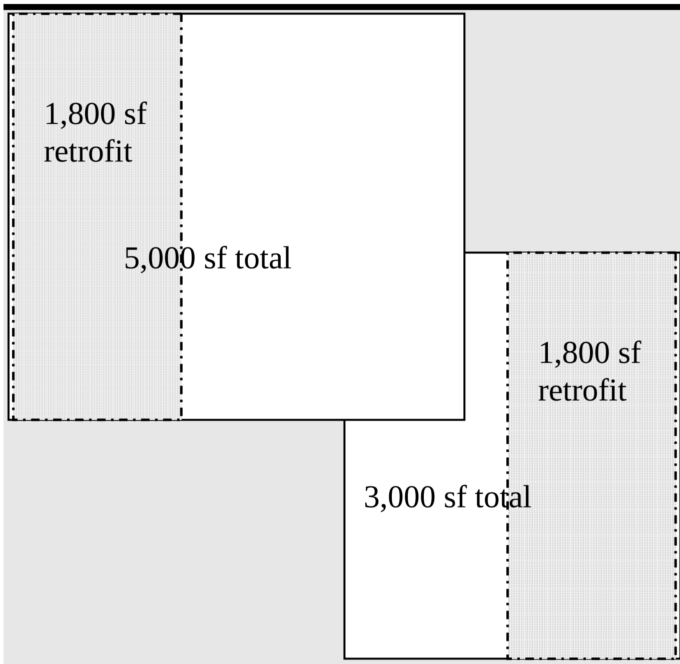


Figure 3-1 – Building with two roofs configurations.

Scenario 1

A building has low-sloped roofs at two different elevations.(Figure 3-28) One roof is 18 feet above grade and has a total area of 5,000 ft², the other roof is 15 feet above grade and has a total area of 3,000 ft². Both roofs are uninsulated and are above conditioned space. If 1,800 ft² of the 3,000 ft² roof is being re-roofed and the roof deck is exposed, is that portion of the roof required to be insulated and be a "cool roof" (high reflectance and emittance)?

Answer

Yes, the re-roofed section of the roof is required to be insulated and have a "cool roof". §141.0(b)2B requires insulation and cool roofs for low-sloped roof alterations if the alteration is greater than 2,000 ft² or greater than 50 percent of the roof area. Since 1,800 ft² is 60 percent of 3,000 ft², the cool roof and insulation requirements apply.

Scenario 2

If the 1,800 ft² of roofing being replaced was on the 5,000 ft² uninsulated roof, would the portion of the roof replaced be required to have "cool roof" radiative properties and have insulation installed?

Answer

No. The 1,800 ft² retrofit is 36 percent of the 5,000 ft² roof. Thus the 1,800 ft² retrofit is less than 50 percent of the roof area and it is also less than 2,000 ft², thus it is not required to comply with the insulation and cool roof requirements in §141.0(b)2B.

Example 3-23

A 10,000 ft² building in climate zone 10, with an uninsulated roof above conditioned space is having roofing removed so that the roof deck is exposed. There are two roof top units on this section of the roof that is being altered. One roof top unit has a curb with a 9 inches base flashing and the other has a modern curb with a 14 inches base flashing. Consider the following three scenarios:

Scenario 1

Answer

No. The unit with the 9 inches base flashing was disconnected and lifted and thus it does not qualify for the *Exception* to §141.0(b)2Biii:

"not be disconnected and lifted as part of the roof replacement." One could add as much as 6 inches or more of insulation before the base flashing height would be reduced below 8 inches on the un-lifted rooftop unit with a 14 inches curb. The climate zone 10 roof insulation requirement is R-14. The thickness of rigid insulation that provides this amount of R-value is substantially thinner than 6 inches. Thus the full R-14 insulation would be required.

Scenario 2

The roof top unit with the 9 inches base flashing is **not** disconnected and lifted during re-roofing. In this situation, is the insulation that must be added limited to the amount of insulation that will result **in an 8 inches base flashing on the unit with the lower curb?**

Answer

Yes. The unit with the 9 inches (23 cm) base flashing was not disconnected and lifted and thus it qualifies for the *Exception* to §141.0(b)2Biiia. One could add only 1 inch (2.5 cm) of insulation efore the base flashing height would be reduced below 8 inches (20 cm) on the un-lifted rooftop unit with a 9 inch (23 cm) base flashing. The insulation requirement is R-14, but the thickness of rigid insulation that provides this amount of R-value is greater than 1 inch (2.5 cm). Therefore, only 1 inch (2.5cm) of additional insulation is required because adding any more insulation would reduce the base flashing height below 8 inches (20 cm) on the unlifted rooftop unit with a 9 inches (23 cm) base flashing.

Scenario 3

In scenario 2 above, does this reduced amount of required insulation apply only to the area immediately surrounding the un-lifted unit or to the entire roof?

Answer

The added insulation for the entire roof would be limited to 1 inch (2.5 cm) so that the base flashing of the un-lifted unit is not reduced to less than 8 inches (20 cm). However, if a building has multiple roofs, the limitation would only apply to any roof with a rooftop unit that was not disconnected and lifted and that has a low curb.

Example 3-24

Question

In reroofing, is existing roofing that is a rock or gravel surface equivalent to a gravel roof over an existing cap sheet, and therefore qualify for the exception discussed in the previous question?

Answer

No, the two roofs are not equivalent (rock or gravel roofs do not perform the same as gravel roofs over an existing cap sheet) and therefore the gravel roof over existing cap sheet may not qualify for the exception.

Example 3-25

Question

If I am doing a reroof, would Exceptions 1 through 4 to §140.3(a)1Ai apply to reroofing and roof alterations?

Answer

Yes, these Exceptions do apply to reroofing and alterations and the roofs that meet one or more of these exceptions are exempt from the cool roof requirements.

Example 3-26

Question

What happens if I have a low-sloped roof on most of the building but steep-sloped on another portion of the roof - do I have to meet two different sets of rules in §141.0(b)2Bi and ii?

Answer

Yes, the low-sloped portion of the roof must comply with the requirements for low-sloped roofs while the steep-sloped portion of the roof must comply with the requirements for steep-sloped roofs. Note that these requirements are climate zone-based and vary based on the density of the outer roofing layer.

Example 3-33

Question

A low-sloped nonresidential building located in Santa Rosa needs to be reroofed. It has a wood-framed rafter roof. The rafters are 2 x 4's spaced 16 inches on center. The owner wants to install a roofing product with an aged reflectance of 0.60, which is less than the prescriptive standard of 0.63. Can I install additional insulation to make up for the shortfall in reflectance?

Answer

Yes. There are two ways to make an insulation/reflectance trade-off when re-roofing a low-sloped nonresidential building.

Scenario1

The Simplified Performance Tradeoff Approach has been modified for the 2013 Standards. It is a software tool that allows users to make roof insulation/reflectance trade-offs through a simplified process. The user enters a limited number of inputs, such as building type, building vintage, roof insulation and reflectance details. The software analyzes the inputs and generates for the user a range of compliant design options. The software does all the work. There is no need for the user to consult reference appendices or make manual calculations. The software tool can be accessed on the Energy Commission's website at *http://www.energy.ca.gov/title24/2013standards*.

Scenario 2

Another way to make an insulation/reflectance trade-off is to utilize Table 141.0-B. First, look up in the table the maximum roof/ceiling insulation U-factor for the aged solar reflectance of the roofing product and the climate zone in which the building is located. In this case, the roofing product has an aged reflectance of 0.60 and Santa Rosa is located in climate zone 2, so the appropriate U-factor is found in row 1, column 2 of the table. It is 0.052.

Next, consult Section 4.2 (Roofs and Ceilings) of Reference Joint Appendix JA4 to find the U-factor table for the type of roof in question. Reference Joint Appendix JA4 can be accessed on the Commission's website at: http://www.energy.ca.gov/title24/2013standards/approved_alternatives/Appendix_JA4_U_C_factor_and_thermal_mass_data.pdf.

The appropriate table in this case is Table 4.2.2, U-factors of Wood Framed Rafter Roofs. Locate the section of the table that pertains to 2 x 4 rafters spaced 16 inches on center. There are a number of U-factors in this area of the table that are equal to or less than 0.052. A combination of R-11 cavity insulation and R-8 continuous insulation, for example, has a U-factor of 0.050. Similarly, a combination of R-13 cavity insulation and R-6 continuous insulation has a U-factor of 0.052. Any U-factor that is equal to or less than 0.052 represents a combination of above-and below-deck insulation that complies with the requirements for the proposed trade-off.

Example 3-34

Question

There are a number of Exceptions to the minimum insulation requirements for roof alterations. Can these be used to limit the insulation required to make a trade-off pursuant to Table 141.0-B?

Answer

No. The Exceptions to Section 141.0(b)2Biii of the Standards do not apply to trade-off situations. They only apply when a compliant roofing product is being installed and no trade-off is involved.

3.7.2 Performance Requirements

Additions

The envelope and indoor lighting in the conditioned space of the addition, and any newly installed space conditioning system or water-heating system serving the addition, shall meet the applicable requirements of § 110.0 through 130.5; and either 1 or 2 below:

1. The addition alone shall comply with §141.0(a); or
2. Existing plus addition plus alteration. The standard design building is the reference building against which the altered building is compared. The standard design building uses equivalent building envelope, lighting and HVAC components when those components are not altered. For components that are altered or added, the standard design uses either the prescriptive requirements for new construction, or envelope baseline specified in §141.0 of the Standards. The proposed design energy use is the combination of the existing building's unaltered components to remain and the altered component's energy features, plus the proposed energy features of the addition.

EXCEPTION to Additions - Performance Approach: Additions that increase the area of the roof by 2,000 square feet or less are exempt from the requirements of §110.10.

Alterations

The envelope and indoor lighting in the conditioned space of the alteration, shall meet the applicable requirements of §110.0 through 130.5; and either A or B below:

1. The altered envelope, space–conditioning system, lighting and water heating components, and any newly installed equipment serving the alteration, shall meet the applicable requirements of §110.0 through 110.9, §120.0 through 120.6, and §120.8 through 130.5. EXCEPTION to §141.0(b)3A Window Films. Applied window films installed as part of an alteration complies with the U-factor, RSHG and VT requirements of Table 141.0-D.

2. The standard design for an altered component shall be the higher efficiency of existing conditions or the requirements stated in Table 141.0-D. For components not being altered, the standard design shall be based on the existing conditions. When the third party verification option is specified, all components proposed for alteration must be verified. The Executive Director shall determine the qualifications required by the third party inspector.

   The proposed design shall be based on the actual values of the altered components.

Notes to Alterations – Performance Approach:

1. If an existing component must be replaced with a new component, that component is considered an altered component for the purpose of determining the energy budget and must meet the requirements of §141.0(b)3.
2. The standard design shall assume the same geometry and orientation as the proposed design.
3. The "existing efficiency level' modeling rules, including situations where nameplate data is not available, are described in the Nonresidential ACM Reference Manual.

Table 3-22 (Standards Table 141.0-D) – The Standard Design for an Altered Component

Altered Component	Standard Design Without Third Party Verification of Existing Conditions Shall be Based On	Standard Design With Third Party Verification of Existing Conditions Shall be Based On
Roof/Ceiling Insulation, Wall Insulation, and Floor/Soffit Insulation	The requirements of §141.0(b)2.	
Fenestration The allowed glass area shall be the smaller of the a. or b. below: a. The proposed glass area: or b. The larger of: 1.The existing glass area that remains; or 2.The area allowed in §140.3(a)5A.	The U-factor and RSHGC requirements of TABLE 141.0-A.	The existing U-factor and RSHGC levels.
Window Film	The U-factor, RSHGC and VT shall be based on TABLE 140.1-A. The existing fenestration in the alteration shall be based on TABLE 110.6-A and Table 110.6-B. Third Party verification not required.	
Roofing Products	The requirements of §141.0(b)2B.	
All Other Measures	The proposed efficiency levels.	