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Building Envelope

Overview

Please refer to Chapter 3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

What's New for 2025

The 2025 Energy Code include several important changes to the building envelope component requirements as described below:

- Reduced the prescriptive U-factor requirement equivalent to an additional R-2 continuous insulation for:
    - All roof/ceiling assemblies in all climate zones.
    - Metal building walls in all climate zones.
    - Wood-framed and other walls in all climate zones.
- Mass light walls in all climate zones
- Mass heavy walls in Climate Zones 1 and 11–16. Added a mandatory vestibule requirement at public entrances for buildings of Occupancy Types A, B, E, I and M. Multiple exceptions are included.
- Added a mandatory area-weighted U-factor requirement for exterior vertical fenestration assemblies.
- Added a mandatory U-factor requirement for exterior vertical fenestration alterations.

Opaque Envelope Assembly

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

Opaque Envelope Definitions

Please refer to Chapter 3.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Thermal Properties of Opaque Envelope Components

Please refer to Chapter 3.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

General Envelope Requirements

Please refer to Chapter 3.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Requirements

Infiltration and Air Leakage

Reference: Section 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. This requirement applies to roof penetrations and penetrations for pipes and conduits, ducts, vents, and other openings in the building envelope. Particular attention should be paid to the junctures where assemblies meet and all gaps between wall panels, around doors, and other construction joints. Ceiling joints, lighting fixtures, and rough openings for doors and windows

should all be considered 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 Section 110.7.

Certification of Insulation Materials

Reference: Section 110.8(a)

Manufacturers must certify that insulating materials comply with the *California Quality Standards for Insulating Materials*, which became effective January 1, 1982. It ensures that insulation sold or installed in the state performs according to the stated R-value 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 Electronic and Appliance Repair, Home Furnishing and Thermal Insulation. Builders and enforcement agencies shall use the Department of Consumer Affairs *Directory of Certified Insulation Materials* to verify 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 Household Goods and Services, at (916) 999-2041 or by email: HomeProducts@dca.ca.gov.

Urea Formaldehyde Foam Insulation

Reference: Section 110.8(b)

The mandatory requirements 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.

Flame Spread Index and Smoke Development Index of Insulation

Reference: Section 110.8(c)

The *California Quality Standards for Insulating Materials* requires 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 index of 25 and a smoke development index 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 index and smoke density index are shown on the insulation or packaging material or may be obtained from the manufacturer.

Mandatory Requirements for Building Envelopes

Reference: Section 120.7

Nonresidential and hotels/motel buildings must meet mandatory U-factor requirements for opaque portions of the building and fenestration portions of the building that separate conditioned spaces from unconditioned spaces or ambient air.

See the sections in Section 120.7 on roof, walls, doors, floors, and windows.

An exception is specified that exempts buildings designed as data centers with high, constant server loads from the mandatory insulation requirements. To qualify for this exception, the building should have a design computer room process load of 750 kW or greater.

Vestibules

Reference: Section 120.7(e)

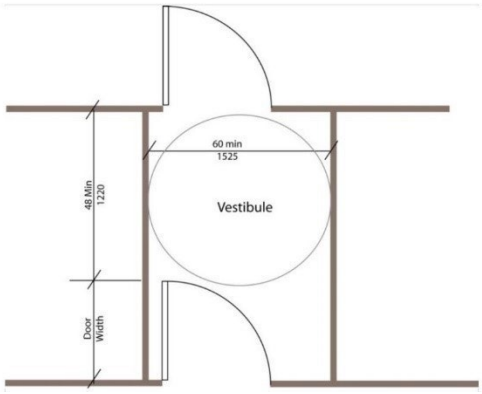
Public entrances in buildings of Occupancy Types A, B, E, I, and M must include an enclosed vestibule. A public entrance is defined in Title 24, Part 2, as an entrance that is not a service entrance or a restricted entrance. Vestibules are two doors or sets of doors between inside and outside that reduce air infiltration into the building as most times, when one door is open the other is still closed. See Figure 3- 1: Vestibule at Public Entrance. The use of vestibules leads to energy savings and improved indoor air quality in many climates.

- All doors opening into and out of the vestibule shall be equipped with self-closing devices.
- Vestibules shall be designed so that in passing through the vestibule, it is not necessary for the interior and exterior doors to open at the same time.
- Where a heating and cooling system is provided for the vestibule, it shall be thermostatically controlled to operate within a range of 60°F and 85°F and be automatically shut off when the outdoor air temperature is greater than 45°F.

Vestibules are not required for the following:

- Doors not intended to be used by the public, such as doors to mechanical or electrical equipment rooms, or intended solely for employee use
- Doors opening directly from a sleeping unit or dwelling unit
- Doors that open directly from a space less than 3,000 square feet in area
- Revolving doors installed where a public entrance to a newly constructed building is required
- Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors
- Doors that have an air curtain with a velocity of not less than 6.56 feet per second at the floor that have been tested in accordance with ANSI/AMCA 220 and installed in accordance with the manufacturer's instructions. Manual or automatic controls shall be provided that operate the air curtain with the opening and closing of the door
- Public entrances in buildings that are located in Climate Zones 2–13, where the building is less than four stories above grade and less than 10,000 square feet in of gross conditioned floor area
- Buildings with building plans that have been submitted to the local planning department before the effective date of the *2025 Building Energy Efficiency Standards,* where compliance with the vestibules requirements of Section 120.7(e) would require a resubmittal for approval

Figure 3-1: Vestibule at Public Entrance



Source: California Statewide CASE Team

Air Barrier

Prescriptive Requirements for Air Barriers

Reference: Section 140.3(a)9, Table 140.3-B

The 2025 Energy Code requires that the air barrier is clearly detailed on construction documents and that acceptable air barrier materials are used. Verification may be carried out by blower door testing. This measurement procedure is described in Nonresidential Appendix NA5.

Construction documents shall include details, notes, or specifications to clearly identify air barrier boundaries, interconnections, penetrations, and associated square foot calculations for all sides of the air barrier. See Figure 3-2: Sample Detail Indicating Strategy of Maintaining Air Barrier Continuity at Duct Penetration of a Concrete Wall, for example.

Table 140.3-B of the Energy Code specifies material requirements for air barriers in nonresidential buildings. Air barrier requirements apply to nonresidential buildings, but not relocatable public school buildings, and cannot be traded off in the performance approach. These requirements reduce the overall building air leakage rate. 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 one of the following:

- Materials having a maximum air permeance of 0.004 cfm/ft² (Table 3-1: Materials Deemed to Comply as Air Barrier).
- Assemblies of materials and components having an average air leakage not exceeding 0.04 cfm/ft².

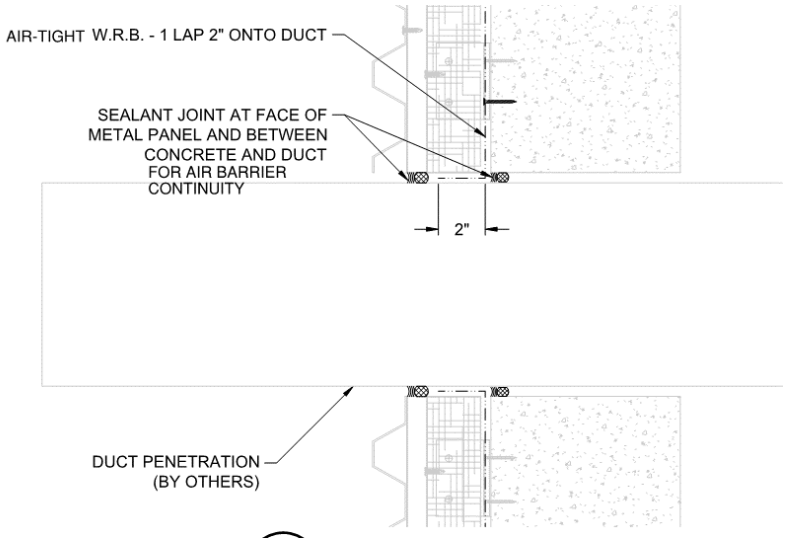
The air leakage requirements stipulated in Section 140.3 may be verified by demonstrating that the whole-building air leakage of 0.4 cfm/ft² is not exceeded.

Table 3-1: Materials Deemed to Comply as Air Barrier

MATERIALS AND THICKNESS
Plywood – min. 3/8 inches thickness
Oriented strand board – min. 3/8 inches thickness
Extruded polystyrene insulation board – min. ½ inches thickness
Foil-back polyisocyanurate insulation board – min. ½ inches thickness
Closed- cell spray foam with a minimum density of 2.0 pcf and a min. 1½2.0 inches thickness
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
Exterior or interior gypsum board min. ½ inches thickness
Cement board – min. ½ inches thickness
Built-up roofing membrane
Modified bituminous roof membrane
Fully adhered single-ply roof membrane
A Portland cement or Portland sand parge, or a gypsum plaster, each with min. 5/8 inches thickness
Cast-in-place concrete, or precast concrete
Fully grouted concrete block masonry
Sheet steel or sheet aluminum

Source: California Energy Commission

Figure 3-2: Sample Detail Indicating Strategy of Maintaining Air Barrier Continuity at Duct Penetration of a Concrete Wall



Source: California Statewide CASE Team

Roofing Products and Insulation

The U-factor criteria for roofs depend on the class of construction. U-factors used for compliance must be selected from Reference Appendices, Joint Appendix JA4. Alternatively, the assembly calculator that is incorporated into California Building Energy Code Compliance (CBECC) software can be used to determine U-factors for assemblies or components not listed in JA4 or both.

Mandatory Requirements for Roofing Products and Insulation

Roof/Ceiling Insulation

Reference: Section 120.7(a)

Metal building: Weighted average U-factor of U-0.098 (R-19 screw down roof, no thermal blocks. See JA4 Tables for additional configurations).

Wood-framed and others: Weighted average U-factor of U-0.075 (2x4 rafter, R-19 insulation. See JA4 Tables for additional configurations).

Insulation Placement on Roof/Ceilings

Reference Section 120.7(a)3

Insulation installed on top of suspended (T-bar) ceilings with removable ceiling panels may not be used to comply with the Energy Code unless the installation meets the criteria described in the *Exception* to Section 120.7(a)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 Energy Code.

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 Section 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 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 complying with California Building Code (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 Section 120.7(a)3: When there are conditioned spaces with a combined floor area no greater than 2,000 square feet in an otherwise unconditioned building, and when the average height of the space between the ceiling and the roof over these spaces is greater than 12 feet, insulation placed in direct contact with a suspended ceiling with removable ceiling panels shall be an acceptable method of reducing heat loss from a conditioned space and shall be accounted for in heat loss calculations.

Wet Insulation Systems

Reference Section 110.8(h)

Wet insulation systems are roofing systems where the insulation is installed above the waterproof membrane of the roof. Water can penetrate this insulation material and affect 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 waterproof membrane of the roof must be multiplied by 0.8 before choosing the table column in Reference Joint Appendix JA4 for determining assembly U-factor. See the footnotes in JA4 for Tables 4.2.1 through 4.2.7.

Roofing Products: Aged Solar Reflectance (SR) and Thermal Emittance (TE)

Reference: Section 10-113, Section 110.8(i)

In general, 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 heated. The Energy Code prescribes cool-roof radiative properties for low-sloped and steep-sloped roofs. Low-sloped roofs receive more solar radiation than steep-sloped roofs in the summer when the sun is higher in the sky.

Roofing products must be tested and labeled by the Cool Roof Rating Council (CRRC), and liquid-applied products must meet minimum standards for performance and durability per Section 110.8(i)4. When installing cool roofs, the aged solar reflectance and thermal emittance of the roofing product must be tested and certified according to CRRC procedures. The aged solar reflectance and thermal emittance properties are rated and listed by the Cool Roof Rating Council, https://www.coolroofs.org/. When a CRRC rating is not obtained for the roofing products, the Energy Code default values for solar reflectance and thermal emittance must be used.

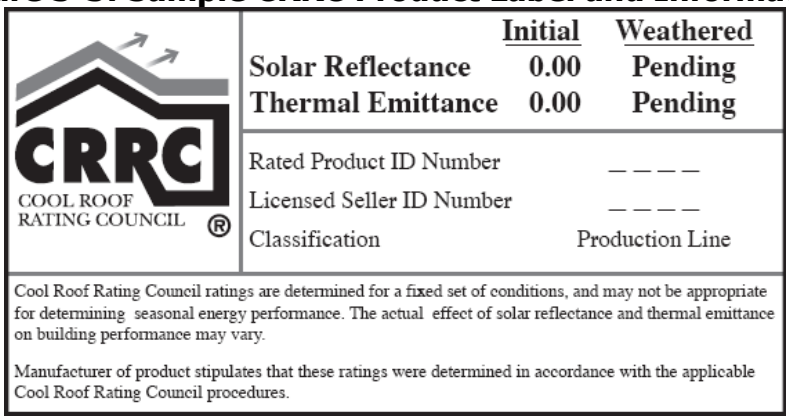
Rating and Labeling

Reference: Section 10-113

When a cool roof is installed to meet the prescriptive requirement or when it is used for compliance credit, the products must be tested and labeled by the CRRC as specified in Section 10-113. 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. See Figure 3-3: Sample CRRC Product Label and Information for an example of an approved CRRC product label.

Figure 3-3: Sample CRRC Product Label and Information



Source: Cool Roof Rating Council

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

Reference: Section 110.8(i)1-3

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 adequate cool roof properties. Excess heat can increase the air-conditioning load of a building, 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 roof surfaces with low-emitting properties.

Solar reflectance (SR): There are three measurements of solar reflectance:

- Initial solar reflectance
- Three-year aged solar reflectance
- Accelerated aged solar reflectance

All requirements of the Energy Code are based on the three-year aged solar reflectance. 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 or an accelerated testing process. Until the appropriate age-rated value for the reflectance is posted in the directory, or a new method of testing is used to find the accelerated solar reflectance, the equation below can be used to calculate the aged rated solar reflectance.

$$Aged\ Reflectance_{calculated} = [0.2 + \beta \times (r_{initial} - 0.2)]$$

Where,

- rinitial = 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

Thermal emittance: The Energy Code does not distinguish between initial and aged thermal emittance, meaning that either value can be used to demonstrate compliance with the Energy Code.

Default values: If a manufacturer fails to obtain CRRC certificate for its roofing products, the following default aged solar reflectance and thermal emittance values must be used for compliance:

- For asphalt shingles, 0.08/0.75
- For all other roofing products, 0.10/0.75

Solar reflectance index (SRI): The temperature of a surface depends on the solar radiation incidence, surface 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 that calculates the SRI by designating the solar reflectance and thermal emittance of the desired roofing material. The calculator can be found at Solar Reflective Index (SRI) Calculation Worksheet. The SRI worksheet can calculate the aged solar reflectance of the roofing product if it is not available. The thermal emittance value can be either the initial or the three-year aged value. By using the SRI calculator, a cool roof may comply with a lower emittance, as long as the aged solar reflectance is higher and vice versa. The CRRC aged SRI values can be used to show compliance. However, when the aged SRI value is not available from the CRRC, then use the CEC SRI calculation worksheet.

Field-Applied Liquid Coatings

Reference: Section 110.8(i)4, Table 110.8-C

There are several liquid products, including elastomeric coatings and white acrylic coatings that qualify for field-applied liquid coatings. The Energy Code specifies minimum performance and durability requirements for field-applied liquid coatings in Table 110.8-C depending on the type of coating. 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.

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 surface of the coating and provides a shiny 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 performance 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. Also, the aluminum-

pigmented asphalt roof coatings shall be manufactured in accordance with ASTM D2824.[1] Standard specification is also required for aluminum-pigmented asphalt roof coatings, nonfibered, asbestos-fibered, and fibered without asbestos that are suitable for applying to roofing or masonry surfaces by brush or spray.

Cement-based roof coatings: This class of coatings consists of a layer of cement and has been used for several years in California's Central Valley and 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 percent Portland cement and meet the requirements of ASTM D822,[2] ASTM C1583, and ASTM D5870.

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 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 performance and durability requirements as specified in Table 110.8-C of the Energy Code or the minimum performance requirements of ASTM C836, D3468, D6083, or D6694, whichever are appropriate to the coating material.

Prescriptive Requirements for Roofing Products and Insulation

Thermal Emittance and Aged Solar Reflectance

Reference: Section 140.3(a)1A, Table 140.3-B, Table 140.3-C, Table 140.3-D

The prescriptive requirements call for roofing products to meet the aged solar reflectance and thermal emittance in 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 the values indicated in Tables 140.3-B of the Energy Code.

Note: The Energy Code does not distinguish between initial and aged thermal emittance, meaning that either value can be used to demonstrate compliance with the Energy Code.

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1 A. This specification covers asphalt-based, aluminum roof coatings suitable for application to roofing or masonry surfaces by brush or spray.

B. The values stated in SI units are to be regarded as the standard. The values in parentheses are for information only.

C. 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.

2 A. This guide is intended for the evaluation of clear and pigmented coatings designed for use on rigid or semi rigid plastic substrates. Coated film and sheeting are not covered by this guide.

B. 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.

Exceptions to the minimum prescriptive requirements for aged solar reflectance and thermal emittance include the following:

- Roof area covered by building-integrated photovoltaic panels and building-integrated solar thermal panels is not required to meet the cool roof requirements. Building-integrated photovoltaics are photovoltaic materials that are used to replace conventional building materials in parts of the building envelope such as the roof, skylights, or façades.
- 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.
- Wood-framed roofs in Climate Zones 3 and 5 with a U-factor of 0.034 are exempt from the low-sloped cool roof requirement.

Where the aged reflectance of a low-sloped nonresidential roof is less than the prescribed requirement, insulation tradeoffs are available. By increasing the insulation level of a roof, 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 3-2: Roof/Ceiling Insulation Tradeoff for Aged Solar Reflectance for nonresidential buildings based on roof type, climate zone and aged reflectance of at least 0.25.

Table 3-2: Roof/Ceiling Insulation Tradeoff for Aged Solar Reflectance

Aged Solar Reflectance	Metal Building Climate Zone 1-16 U-factor	Wood-Framed and Other Climate Zone 6, 7, and 8 U-factor	Wood Framed and Other All Other Climate Zones U-factor
0.62-0.56	0.038	0.039	0.029
0.55-0.46	0.035	0.036	0.028
0.45-0.36	0.033	0.033	0.027
0.35-0.25	0.031	0.032	0.026

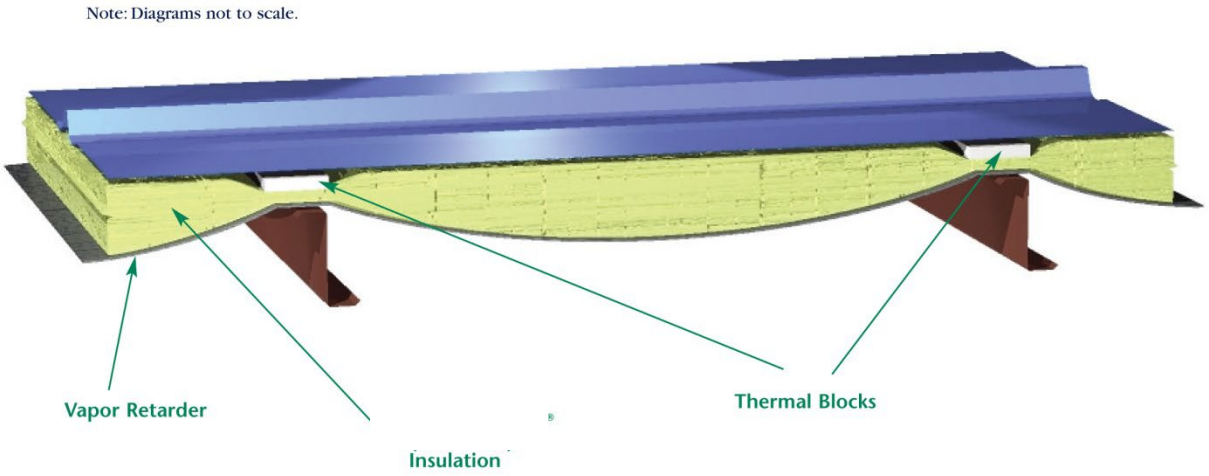
Source: Energy Code, Table 140.3

Reference: Section 140.3(a)1B, Table 140.3-B, Table 140.3-C, Table 140.3-D

Under the prescriptive requirements, roofs or ceilings must have an assembly U-factor equal to or lower than the U-factor criterion for nonresidential buildings. The U-factor values for exterior roofs and ceilings from Reference Appendices, Joint Appendix JA4 must be used to determine compliance with the maximum assembly U-factor requirements. Alternatively, the assembly calculator that is incorporated into the approved energy modeling software can be used to determine U-factors for assemblies or components not listed in JA4 tables or both.

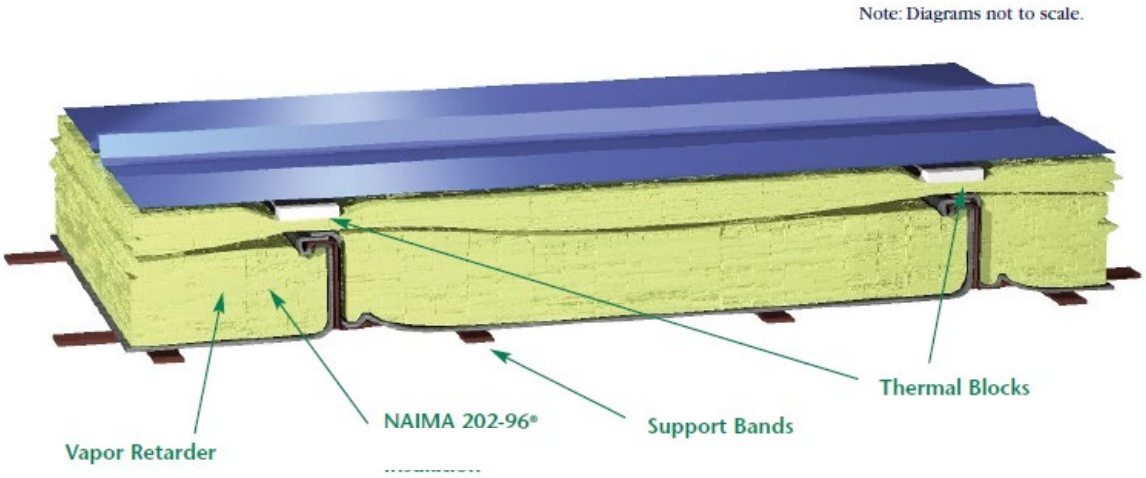
The prescriptive requirement for metal building roofs requires the entire cavity be filled with insulation. A common technique for standing seam metal roofs is to drape a layer of insulation over the purlins, using thermal blocks where the insulation is compressed at the supports (See Figure 3-4: Standing Seam Metal Building Roof with Single Insulation Layer). Either approach on insulation may be used in the performance approach. However, there are significant benefits to using the "filled cavity" approach, as shown in Figure 3-5: Filled Cavity Insulation for Metal Building Roofs.

Figure 3-4: Standing Seam Metal Building Roof with Single Insulation Layer



Source: North American Insulation Manufacturers Association (NAIMA)

Figure 3-5: Filled Cavity Insulation for Metal Building Roofs



Source: North American Insulation Manufacturers Association (NAIMA)

A rigid polyisocyanurate ("polyiso") thermal block with a minimum R-value of R-3.5 should be installed at the supports (a 1-inch-thick thermal block is recommended). The first rated R-value of the insulation is for faced insulation installed between the purlins. The second rated R-value of insulation represents unfaced insulation installed above the first layer, perpendicular to the purlins and compressed when the metal roof panels are attached. A supporting structure retains the bottom of the first layer at the prescribed depth required for the full thickness of insulation.

The bottom layer of insulation should completely fill the space between the purlins, and the support bands should be installed tightly to prevent the insulation from sagging.

The configuration in Figure 3-5: Filled Cavity Insulation for Metal Building Roofs shown with two layers, one of R-19 and one of R-10 insulation, corresponds to the prescriptive

requirement of U-0.038. Other insulation combinations exceeding the minimum requirement are readily achievable. See the JA4 Tables for additional configurations.

Performance Approach

Reference: Section 10-113, Section 140.1, Table 140.3

Compliance options for roofing products and insulation. See Performance Approach and Chapter 12 for more on the performance approach.

Example 3-1

Question:

According to the provisions of the Energy Code, are cool roofs mandatory for nonresidential buildings?

Answer:

No. Cool roofs are not mandatory. The prescriptive compliance requirements depend on the climate zone, building type, and roof slope. Compliance with aged solar reflectance and thermal emittance, or SRI, is required per the Energy Code, 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. Some local jurisdictions may have additional cool-roof requirements.

Example 3-2

Question:

Must all roofing materials used in California, whether cool roof or not, be certified by the Cool Roof Rating Council (CRRC) and labeled accordingly?

Answer:

Yes, when altering your roof, such as a new reroof or replacement of 50 percent or 2,000ft², whichever is less, either the prescriptive envelope component approach or the performance approach can be used for compliance. In these cases, the roof must be certified and labeled by the CRRC for nonresidential roofs. 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. 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. The default solar reflectance for asphalt shingles is 0.08.

However, in the case of a roof repair, such as for a leak, the roofing product does not need to be a cool roof nor certified by the CRRC.

Example 3-3

Question:

Can I use aged 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:

No. 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 3-4

Question:

Can the reflectance and emittance requirements of ENERGY STAR® cool roofs be substituted for standards requirements?

Answer

No. Only roofing products that are listed by the CRRC in its Rated Product Directory can be used to comply with the standards. The CRRC is the only organization that has met the criteria set in Section 10-113.

Example 3-5

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 Energy Code?

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 Energy Code for field-applied coatings.

Example 3-6

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 United States or (510) 482-4420, ext. 215, or email info@coolroofs.org. In addition, the CRRC publishes the procedures in the *CRRC-1 Program Manual*, available for free on http://www.coolroofs.org or by calling the CRRC. Working with CRRC staff is strongly recommended.

Example 3-7

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 newly constructed and altered unconditioned buildings; these requirements include Section 140.3(c), the skylight requirements. Building envelope (other than skylight requirements) and space-conditioning requirements do not apply to unconditioned buildings.

Example 3-8

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 Section 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 areas.

Example 3-9

Question:

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

Answer:

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

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

Example 3-10

Question:

When installing a new roof with building-integrated photovoltaic panels, is the entire roofing exempt from the Energy Code requirements in Section 140.3(a)1A?

Answer:

No. Only the active photovoltaic area of the roof is exempt from these requirements. The nonactive sections of the roofing product must comply with the Energy Code and be rated by the CRRC.

Exterior Walls

The U-factor criteria for walls depend on the class of construction. U-factors used for compliance must be selected from Reference Appendices, Joint Appendix JA4. Alternatively, the assembly calculator that is incorporated into California Building Energy Code Compliance (CBECC) software can be used to determine U-factors for assemblies or components not listed in JA4 or both.

There are five common classes of wall constructions: wood-framed, metal-framed, metal building walls, light mass, and heavy mass (Figure 3-7). The following provides information about these wall systems, as well as furred walls, spandrel panels, and opaque curtain walls:

- Wood-framed walls: As defined by the 2025 California Building Code, Type IV buildings typically have wood-framed walls. Framing members typically consist of 2x4 or 2x6 framing members spaced at 24-inch or 16-inch OC. Composite framing members and engineered wood products also qualify as wood-framed walls if the framing members are nonmetallic. Reference Joint Appendix JA4, Table 4.3.1, has data for conventional wood-framed walls.
- Metal-framed walls: Many nonresidential buildings require noncombustible construction, and this is often 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. Reference Appendices, Joint Appendix JA4, Table 4.3.3, has data for metal-framed walls.
- 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 feet. A typical method of insulating metal building walls is to drape the insulation over the horizontal framing members and compress the insulation when the metal exterior panel is installed.
- Light-mass walls: Light-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. Reference Appendices, 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.
- Heavy-mass walls: These walls have a HC equal to or greater than 15.0 Btu/°F-ft². See Reference Joint Appendix JA4 for HC data on mass walls.

Note**:** For light- and heavy-mass walls, heat capacity (HC) is the amount of heat required to raise the temperature of the material by 1 degree F. In the Energy Code, it is defined as the product of the density (lb/ft^3), specific heat (Btu/lb-F), and wall thickness (ft). For instance, a 6” medium weight concrete hollow unit masonry wall has a heat capacity of 8.4 and is considered a light-mass wall. The same masonry wall with solid grout that is 10 inches thick has a heat capacity of 19.7 and is considered a heavy-mass wall.

- Furred walls: These walls are a specialty wall component, commonly applied to a mass wall type. See Figure 3-6: Brick Wall With Furring Details. The Reference Appendices, Joint Appendix JA4, Table 4.3.5, 4.3.6, or other masonry tables list alternative walls. Additional continuous insulation layers are selected from JA4 Table 4.3.13 and calculated using either Equation 4-1 or 4-4 from JA4. The effective R-value of the furred component depends upon the framing thickness, type, and insulation level.

Figure 3-6: Brick Wall With Furring Details

Source: California Energy Commission

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

For some climate zones, mass walls and metal-framed walls require continuous insulation to meet the prescriptive U-factor requirements. When this is the case, the effect of the continuous insulation is estimated by Equation 4-1 in Reference Appendices, Joint Appendix JA4.

$$U_{prop} = \frac{1}{U_{col,A}} + R_{cont,insul}$$

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 Appendix JA4.

Example 3-11

Question:

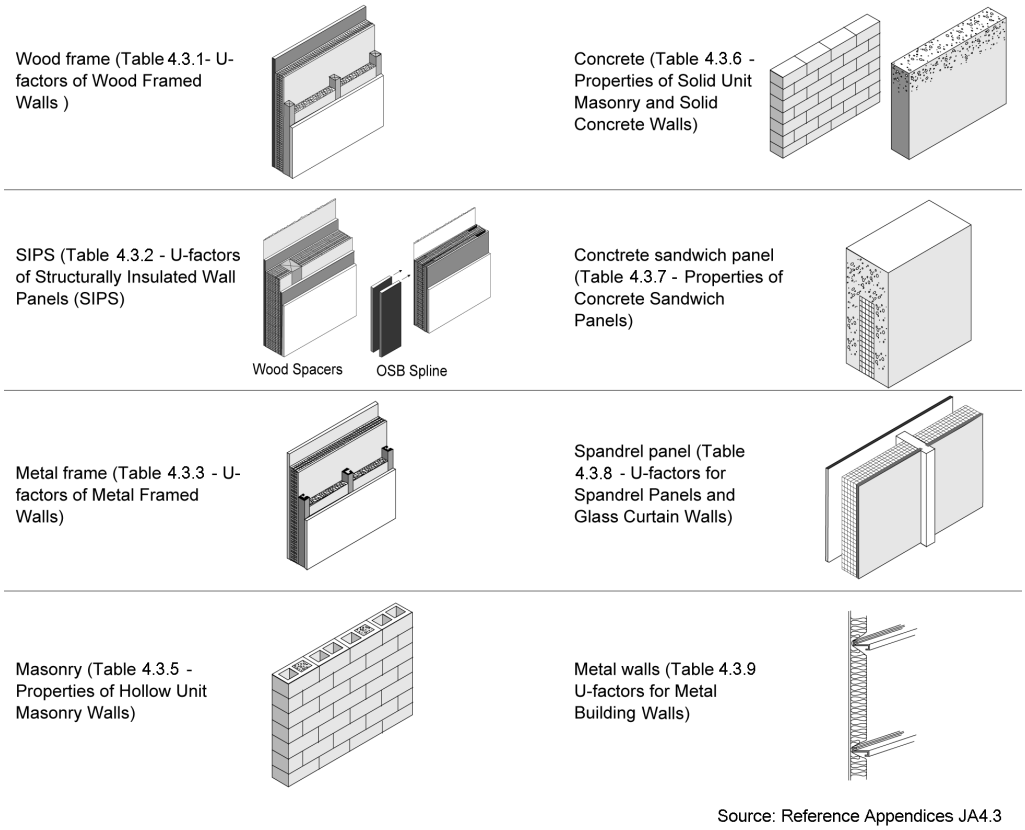
An 8-inch (20 cm) medium-weight concrete block wall with uninsulated cores has a layer of 1-inch- (25 mm) thick exterior polystyrene continuous insulation with an R-value of R-5. What is the U-factor for this assembly?

Answer:

From Reference Appendices, Joint Appendix JA4, 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 3-7: Classes of Wall Construction



Source: Reference Appendix JA4.3

Mandatory Requirements for Wall Insulation

Reference: Section 110.8, Section 120.7(b)

In addition to the mandatory requirements in Section 110.8 for all buildings, nonresidential hotels and motels must also meet the requirements in Section 120.7.

The opaque portions of walls that separate conditioned spaces from unconditioned spaces or ambient air shall meet these applicable requirements.

- Metal building: Weighted average U-factor of U-0.113 (single layer of R-13 batt insulation. See JA4 Tables for additional configurations).
- Metal-framed: Weighted average U-factor of U-0.151 (R-8 continuous insulation, or R-13 batt insulation between studs and 1/2" of continuous rigid insulation of R-2. See JA4 Tables for additional configurations). It may be possible to meet the area-weighted average U-factor without continuous insulation if the appropriate siding materials are used.
- Light-mass walls: 6 inches or greater hollow core concrete masonry unit having a U-factor not exceeding 0.440 (partially grouted with insulated cells).
- Heavy-mass walls: 8 inches or greater hollow core concrete masonry unit having a U-factor not exceeding 0.690 (solid grout concrete, normal weight, 125 lb/ft^3).

- Wood-framed and others: Weighted average U-factor of U-0.110 (R-11 batt insulation. See JA4 Tables for additional configurations).
- Spandrel panels and curtain wall: Weighted average U-factor of U-0.280.

Exception to Section 120.7: Buildings designed as data centers with high, constant server loads are exempt from the mandatory minimum requirements. To qualify for this exception, it should have a design computer room process load of 750 kW or greater.

Prescriptive Requirements for Wall Insulation

Reference: Section 140.3(a)2, Table 140.3-B, Table 140.3-C, Table 140.3-D

Under the prescriptive requirements, exterior walls must have an assembly U-factor equal to or lower than the U-factor criterion for nonresidential buildings in Tables 140.3-B, C, or D.

The U-factor for exterior walls from Reference Appendices, Joint Appendix JA4, must be used to determine compliance with the assembly U-factor requirements. The Energy Code does not allow using the R-value of the cavity or continuous insulation alone to demonstrate compliance with the insulation values of Reference Appendices, Joint Appendix JA4; only U-factors may be used to demonstrate compliance.

For metal-framed walls with insulation between the framing sections, continuous insulation may need to be added to meet the U-factor requirements of the Energy Code. For light mass walls, insulation is required in all climate zones. For heavy mass walls, insulation is not required for buildings in Climate Zones 2–10 but is required for other climate zones.

Demising Walls

Mandatory Insulation for Demising Walls

Please refer to Chapter 3.2.10.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Exterior Doors

Exterior doors are operable openings in the building envelope, including swinging and roll-up doors, fire doors, pet doors, and access hatches with less than 25 percent glazed area. When an exterior door has 25 percent or more glazed area, it is considered fenestration.

Mandatory Requirements for Exterior Doors

Please refer to Chapter 3.2.11.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Requirements for Exterior Doors

Reference: Section 140.3(a)7, Table 140.3-B, Table 140.3-C, Table 140.3-D

The Energy Code defines prescriptive requirements for exterior doors in Tables 140.3-B and 140.3-C. For swinging doors, the maximum U-factor is 0.70, and for nonswinging doors, the maximum allowed U-factor is 1.45 in Climate Zones 2 through 15 and 0.50 in Climate Zones 1 and 16. Refer to the Energy Code, Tables 140.3-B, 140.3-C, and 140.3-D, for exterior door U-factor requirements. The U-factor must be rated in accordance with NFRC 100 or the

applicable default U-factor defined in Reference Appendices, Joint Appendix JA4, Table 4.5.1, must be used.

The swinging door requirement corresponds to uninsulated double-layer metal swinging doors. The 1.45 swinging door U-factor requirement corresponds to insulated single-layer metal doors or uninsulated single-layer metal roll-up doors and fire-rated doors. The 0.50 U-factor requirement for Climate Zones 1 and 16 corresponds to wood doors with a minimum nominal thickness of 1¾ inches. For more information, consult Reference Appendices, Joint Appendix JA4, Table 4.5.1.

When glazing area is 25 percent or more of the entire door area, it is then defined as a fenestration product in the Energy Code, and the entire door area is modeled as a fenestration unit. If the glazing area is less than 25 percent of the door area, the glazing must be modeled as the glass area plus two inches in each direction of the opaque door surface (to account for a frame). However, exterior doors are part of the gross exterior wall area and must be considered when calculating the window-to-wall ratio.

Floors

Please refer to Chapter 3.2.12 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Requirements for Floors

Please refer to Chapter 3.2.12.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Requirements for Floors

Please refer to Chapter 3.2.12.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Fenestration (Window/Skylight/Glazed Door)

Please refer to Chapter 3.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Fenestration Definitions

Please refer to Chapter 3.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Fenestration Categories

Please refer to Chapter 3.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additional Fenestration Definitions

Please refer to Chapter 3.3.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Requirements for Fenestration Certification and Labeling

Please refer to Chapter 3.3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Certification and Labeling

Reference: Section 10-111, Section 10-112, Section 110.6. Reference Nonresidential Appendices NA6

The Administrative Regulations Section 10-111 and Section 110.6 require that fenestration products have labels that list the U-factor, solar heat gain coefficient (SHGC), visible

transmittance (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 Section 110.6(a)1.

Manufactured (Factory-Assembled) Fenestration Label Certificates

Each manufactured (factory-assembled) fenestration product must have a clearly visible temporary label attached to it (Figure 3-8: NFRC Manufactured Label), which is not to be removed before inspection by the enforcement agency. The manufacturer rates and labels its fenestrations products for U-factor, SHGC, and VT.

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

Figure 3-8: NFRC Manufactured Label

Source: NFRC

Default Temporary Label

Fenestration product manufacturers can choose to use default performance values for U-factors in Table 110.6-A and SHGC in Table 110.6-B. For fenestration products requiring a VT value, assume a value of 1.0 as specified in the Reference Appendices, Nonresidential Appendix NA6. The manufacturer must attach a temporary label to each window (Figure 3-9: Sample Default Temporary Label), and manufacturer specification sheets or cut sheets must be included with compliance documentation. An NRCC-ENV-E will be required to document the thermal performance if no default temporary labels are attached to the window units.

There is no exact format for the default temporary label. It must be clearly visible and large enough to be clearly visible from 4 feet for the enforcement agency field inspector to read easily. It must include all information required by the regulations. The minimum suggested

label size is 4 inches x 4 inches, and the label must have the following words at the bottom of the label:

"Product meets the air infiltration requirements of Section 110.6(a)1, U-factor criteria of Section 110.6(a)2, SHGC criteria of Section 110.6(a)3, and VT criteria of Section 110.6(a)4 of the 2025 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 upon which the default value is based are met by placing a check in the check box:

- Air space 7/16 inch or greater
- For skylights, the label must indicate the product was rated with a built-in curb
- Meets thermal-break default criteria

Figure 3-9: Sample Default Temporary Label
2025 California Energy Commission Default Label

XYZ Manufacturing Co.

Key Features:	o Doors	o Double-Pane
	o Skylight	o Glass Block
Frame Type	**Product Type:**	**Product Glazing Type:**
o Metal	o Operable	o Clear
o Non-Metal	o Fixed	o Tinted
o Metal, Thermal Break	o Greenhouse/Garden Window	o Single-Pane
o Air space 7/16 in. or greater o With built-in curb o 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 =

Source: California Energy Commission

For the visible transmittance (VT) of diffusing skylights that is not covered by NFRC 200 or NFRC 203, a test report should be included using the ASTM E972 method.

Component Modeling Approach (CMA)

The NFRC has developed a performance base calculation, the *component modeling approach* (CMA), to make the rating process quick and simple. This approach serves as an energy ratings certification program for fenestration products used in nonresidential projects. The CMA allows users to assemble fenestration products in a virtual environment. The CMA draws data for NFRC-approved components from online libraries choosing from preapproved glazing, frame, and spacer components. CMA users are able to obtain preliminary ratings for various configurations of their designs. The CMA is a fair, accurate, and credible method based on NFRC 100 and 200 program documents, which are verified by third-party rating procedures. This tool helps users to:

- Design energy-efficient windows, curtain wall systems, and skylights for high-performance building projects.
- Determine whether a product meets the specifications for a project and local/state building energy codes.
- Model different fenestration designs to compare energy performance.

Once the user is satisfied with the product, they create a bid report containing the data for all fenestration products to be reviewed. The 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), and a license agreement is signed with the NFRC. Then the NFRC issues a CMA label certificate for the project. This label certificate is a 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 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

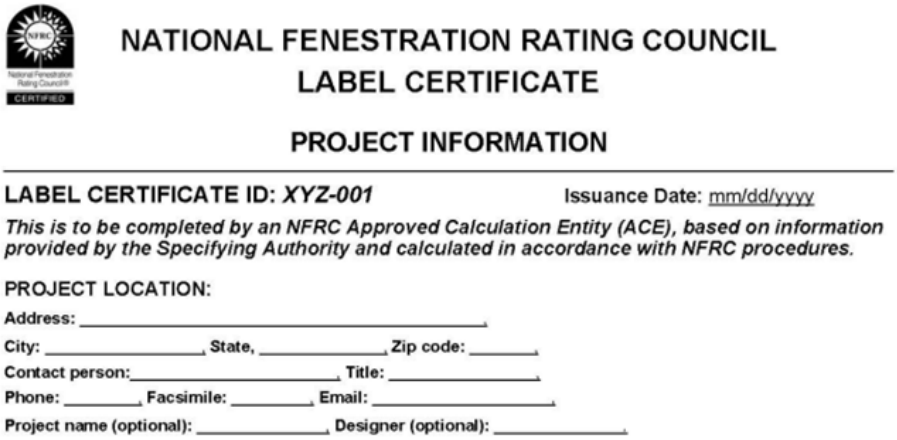
The CMA provides facility managers, specifiers, building owners, and design teams with a simple method for designing and certifying the energy performance of fenestration systems for their buildings without having to test every possible variation of glazing and framing. This is significantly less expensive than building sample wall sections and testing them in a large test enclosure. There are several additional advantages gained by using the CMA:

- The CMA's online tool has the ability to output a file with values for use in building energy analysis software programs.
- The program can export detailed information for angular-dependent SHGC and VT values, seamlessly transferring the data to the analytical software.

- A 2010 study[3] 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 default calculation methods of the Energy Codes.
- The CMA can help demonstrate above-code performance, which is useful for environmental rating programs such as Leadership in Energy and Environmental Design (LEED™) or local green building programs.

Use of the CMA can lead to a more efficient building and enable cost savings because of more accurate fenestration performances and potential energy benefits from above-code utility incentives. Details are available at www.NFRC.org.

Figure 3-10: NFRC - CMA Label Certificate, Page 1



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): _____,

Source: NFRC

3 Study conducted by the Heschong Mahone Group for NFRC, "Compared to alternative fenestration rating values detailed in California's Title 24, using CMA provides a maximum increase of 11.7 percent in energy compliance margins. This means that compared to other available options, CMA provides the most accurate values on window energy and visible performance."

Figure 3-11: NFRC-CMA Label Certificate, Page 2

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	Name	Framing Ref	Glazing Ref	Spacer Ref	U**	SHGC**	VT**
	ft^2					Btu/ hr·ft²·°F	-	-
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

Source: NFRC

Fenestration Certificate NRCC-ENV-E

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

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

The NRCC-ENV-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 that list the center-of-glass values must also be attached to the NRCC-ENV-E and located at the job site for verification.

Site-Built Label Certificates

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.

- For site-built skylight fenestration totaling 200 ft^2 or greater, or for site-built vertical fenestration being used in newly constructed buildings, the glazing contractor or specifier must generate a NFRC label certificate from either approach listed below:
    - A NFRC label certificate generated by the CMA computer program
    - Default to the U-factor values from Table 110.6-A, the SHGC values from 110.6-B, and for VT values, use the method specified in NA6
- For new, altered and replacement site-built skylight fenestration totaling less than 200 ft^2 the glazing contractor or specifier must comply with one of the following:
    - A NFRC label certificate generated by the CMA computer program

- The center-of-glass values from the manufacturer's product literature to determine the total U-factor, SHGC, and VT. (See Reference Nonresidential Appendix NA6 — the *Alternative Default Fenestration Procedure*).
- 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

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 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.

Site-built certificates should be filed at the contractor's project office during construction or in the building manager's office. Site-built fenestration has multiple responsible parties. The steps of producing site-built fenestration are as follows:

- Architects or engineers or both design the basic glazing system by specifying the components, the geometry of the components, and, sometimes, the assembly method.
- 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 the contractor's 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 Section 10-111.
- 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.

It is typical for the glazing contractor to assume responsibility and coordinate the certification and labeling process. The design team may 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 the NFRC.

It is not necessary to complete the NFRC testing and labeling before completing the building permit application. Designers should specify the type of glass and whether the frame has a

thermal break or is thermally improved. Plans examiners should verify that the fenestration performance shown in the plans and used in the compliance calculations is reasonable and achievable by consulting the default values for U-factor and SHGC in Reference Nonresidential Appendix NA6.

Field-Fabricated Fenestration and Field-Fabricated 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.

No attached labeling is required for field-fabricated fenestration products; only the NRCC-ENV-E with the default values is required. Field-fabricated fenestration and field-fabricated exterior doors may be installed only if the documentation has demonstrated compliance with the Energy Code.

For field-fabricated fenestration, the U-factor and SHGC default values can be found in Table 110.6-A and Table 110.6-B, respectively, below. Values are determined by frame type, fenestration type, and glazing composition.

Exterior doors with glazing for 25 percent or more 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 25 percent the door area, the portion of the door with fenestration must be treated as part of the envelope and the fenestration independent of the remainder of the door area.

The field inspector is responsible for ensuring field-fabricated fenestration meets the specific U-factor, SHGC, and VT, as listed on the NRCC-ENV-E. Thermal break values do not apply to field-fabricated fenestration products.

Vertical Fenestration (Windows and Doors)

Mandatory Requirements for Vertical Fenestration

Reference: Section 120.7(d)

Exterior vertical fenestration assemblies in new construction are required to have a maximum area-weighted average U-factor no greater than 0.47. This requirement must be met even when complying using the performance approach. The U-factors essentially require thermally broken metal frames or better (wood, metal clad wood, or plastic frames) and double glazing with either low-emissivity coating or a low-conductivity gas fill (argon or krypton). Since the requirement is an area-weighted U-factor, one can offset higher U-factor windows with more efficient lower U-factor windows.

Prescriptive Requirements for Vertical Fenestration

Reference: Section 140.3(a)5

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

- Maximum total area plus west-facing
- Maximum U-factor
- Maximum relative solar heat gain coefficient (RSHGC)

- Minimum visible transmittance (VT)

Conditioned greenhouses are excepted from the requirements of Section 140.3(a)5 and must meet the requirements of Section 120.6(h)3B.

Window Area

Reference: Section 140.3(a)5.A.

In the prescriptive approach, the total window area may not exceed 40 percent of the gross wall area (encompassing total conditioned space) for the building. Likewise, the west-facing window area may not exceed 40 percent of the west gross wall area (encompassing total conditioned space for the building). This maximum area requirement will affect those buildings with very large glass areas, such as high-rise offices, automobile showrooms, or airport terminals.

The maximum area may be determined by multiplying the length of the display perimeter by 6 feet in height and use the larger of the product of that multiplication or 40 percent of gross exterior wall area.

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 (no obstructions, limits to access, or intervening nonpublic spaces). Demising walls are not counted as part of the display perimeter.

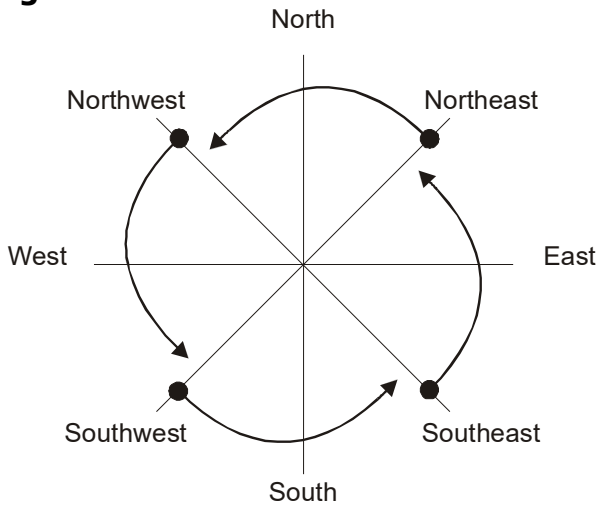
Glazing in a demising wall does not count toward the total building allowance. There is no limit to the amount of glazing allowed in demising walls, but it must meet the prescriptive U-factor requirements for the climate zone.

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.

Glazed doors use the rough opening area, except where the door glass area is less than 25 percent of the door, in which case the glazing area may be either the entire door area or the glass area plus 2 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.

The orientation can be determined from an accurate site plan. Any orientation within 45 degrees of true north, east, south, or west will be assigned to that orientation. Figure 3-12: Four Surface Orientations demonstrates how surface orientations are determined and what to do if the surface is oriented exactly at 45 degrees 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 3-12: Four Surface Orientations



Source: California Energy Commission

Window U-Factor

Reference: Section 140.3(a)5B, Table 140.3-B, Table 140.3-C

Fenestration products must meet the prescriptively required maximum U-factor criteria in Tables 140.3-B and 140.3-C of the Energy Code for each climate zone. Most NFRC-rated multiglazed windows with a low-e coating and a thermally broken frame will comply with the U-factor criterion. See NFRC's Certified Product Directory database at https://nfrc.org/ or use Equation NA6-1 found in Reference Appendices Nonresidential Appendix NA6. Note that NA6 calculations are applicable for skylights.

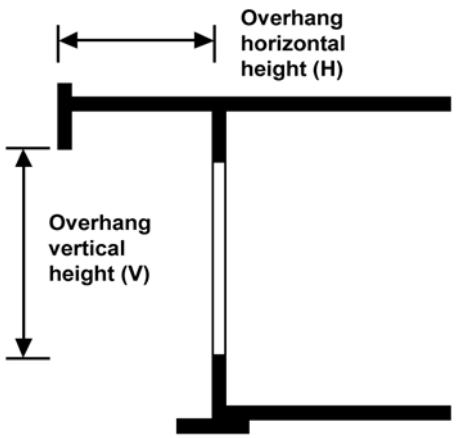
SHGC and Shading Factor

Reference: Section 140.3(a)5C

Relative solar heat gain (RSHGC) allows for an external shading correction. It is calculated by multiplying the SHGC of the fenestration product by a shading factor (SHF). If shading does not exist, then the shading factor is 1.0. Relative solar heat gain is applicable only when using the prescriptive compliance approach. Tables 140.3-B and 140.3-C specify the maximum area-weighted average RSHGC, excluding the effects of interior shading.

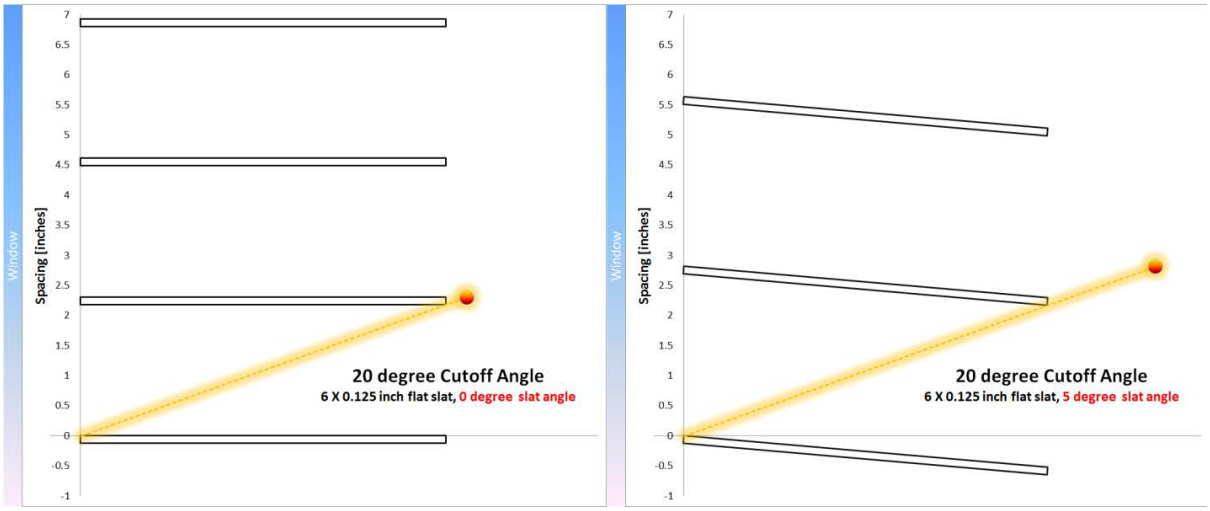
Shading factors depend upon the projection factor (PF) from Equation 140.3-C, which is the ratio of the projection (P) and the spacing (s). These dimensions are measured from the vertical and horizontal planes passing through the bottom edge of the window glazing for overhangs or the slat below for horizontal slats, as shown in Figure 3-13: Overhang Dimensions and Figure 3-14: Exterior Horizontal Slat — Cutoff Angle, Tilt Angle, and Projection Factor. A shading factor may be used if the shading extends beyond both sides of the window jamb a distance equal to the overhang projection (Section 140.3(a)5Cii), or if the entire horizontal slat assembly is completely contained within a window setback. If the shading is continuous along the side of a building, this restriction will usually be met. If there are shades for individual windows, each must be shown to comply.

Figure 3-13: Overhang Dimensions



Source: California Energy Commission

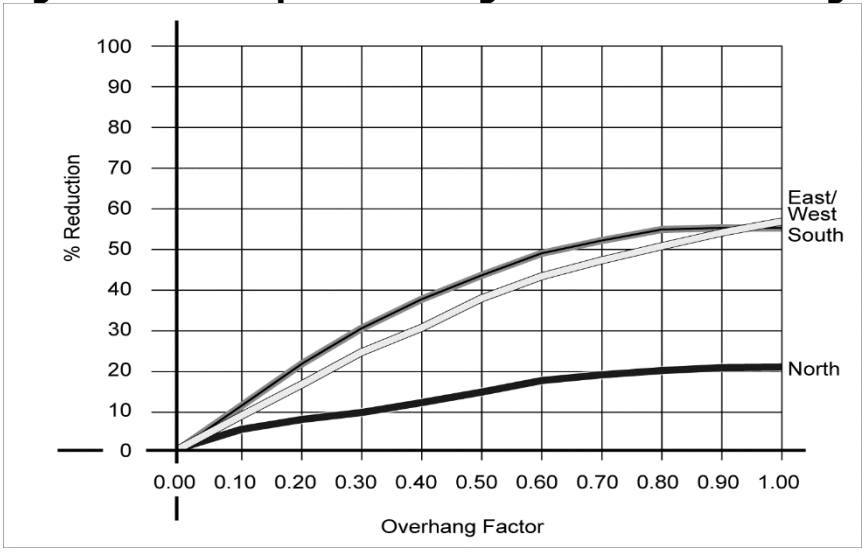
Figure 3-14: Exterior Horizontal Slat – Cutoff Angle, Tilt Angle, and Projection Factor



Source: California Energy Commission

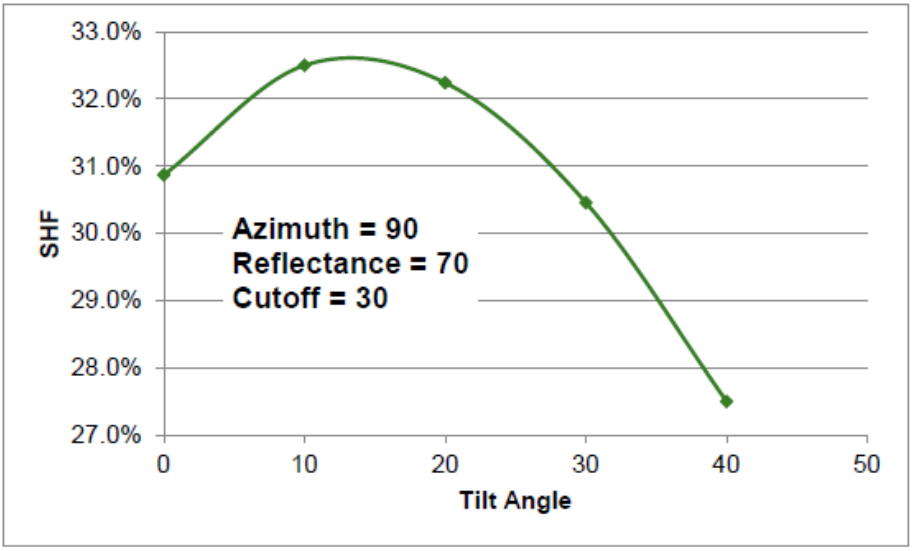
Figure 3-15: Graph of Shading Factors for Overhangs and Figure 3-16: Graph of Shading Factors for Horizontal Slats illustrate the benefits of shading factors of the various projection factors as a function of azimuth (orientation) for overhangs and as a function of tilt angle for horizontal slats. The chosen projection factors correspond to cutoff angles every 15 degrees. The graph shows that savings can be significant and that benefits increase as windows face more toward a southerly direction and also increase as overhangs or slats project more (i.e., have a higher projection factor).

Figure 3- 15: Graph of Shading Factors for Overhangs



Source: California Energy Commission

Figure 3-16: Graph of Shading Factors for Horizontal Slats



Source: California Energy Commission

Example 3--12

Question:
A window facing due east has glass with a solar heat gain coefficient of 0.71. It has a fixed overhanging eave that extends 3 feet out from the plane of the glass (P = 3) and is 6 feet above the bottom of the glass (s = 6). The overhang extends more than 3 feet beyond each side of the glass, and the top of the window is less than 2 feet vertically below the overhang. What is the RSHGC for this window?

Answer:
First, calculate the projection factor as P/s. This value is 3 / 6 = 0.50. Next, calculate the shading factor using the 90 degrees azimuth of the window. This value is 0.60. Finally, multiply it by the solar heat gain coefficient to obtain the RSHGC: 0.62 x 0.71 = 0.44.

Visible Light Transmittance (VT)

Reference: Section 140.3(a)5D

The prescriptive requirements of Tables 140.3-B and 140.3-C of the Energy Code 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. The performance method is discussed in more detail in Chapter 5.

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.

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. The strategy of using high VT glazing in the upper part of a window allows daylight to enter the space through the high VT glazing, making a better daylighting design.

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

$VT \geq 0.11 / WWR VT \geq \frac{0.11}{WWR}$

Where,

- VT = the visible transmittance of the framed window
- WWR = the gross window-to-wall ratio

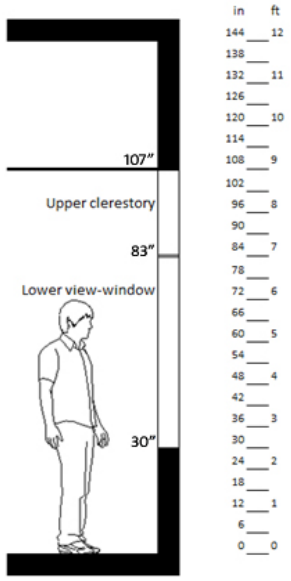
The average VT requirements apply separately to chromatic (dynamic or color-changing) glazing and nonchromatic glazing. For chromatic glazing, higher ranges of VT can be used to meet the prescriptive requirements. All glazing that is not chromatic must separately meet the area-weighted VT prescriptive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

Example 3-13

Question:

A space has a gross window-to-wall ratio of 30 percent 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?

Figure 3-17: Example Window/Wall



Source: California Energy Commission

Answer:

Use the formula VT ≥ 0.11 / WWR, to determines the minimum area weighted average VT for this space,

VT ≥ 0.11 / 0.3 = 0.367. The area weighted minimum VT we need for this window is 0.367.

(View window Area x View window VT) + (Clerestory Area x Clerestory VT) / Total Window Area = 0.367

In this case:

Clerestory area = 24" height x 120" width = 2,880 sq.in

View window area = (83" - 30") height x 120" width = 6,360 sq.in.

Using a 0.30 VT glazing in the view window then View window VT = 0.30

Total window area = (107" - 30") height x 120" width = 9,240 sq.in.

Solve the equation for Clerestory VT: Clerestory VT = 0.515

(6360 x 0.367) + (2880 x VT_{CL})/9240

To use a 0.3 VT glazing in the view window, the designer must use a 0.515 VT window in the clerestory.

Example 3-14

Question:

A designer is using a U-factor of 0.57 for compliance with a curtain wall system. The glazing system uses two lites of 1/4-in (6mm) glass with a low-e = 0.1 coating on the second surface. The air gap is 1/2 inch (12 mm). A standard metal frame is proposed for the curtain wall system. Is 0.57 a reasonable U-factor for compliance, and can it reasonably be achieved by the glazing contractor through the NFRC process for site-built fenestration?

Answer:

No. If this is a newly constructed building and there is no NFRC rating, then the default U-factor must be used for this glazing combination from Table 110.6-A of the Energy Code. In this example, the U-factor would be 0.71.

However, if this is part of an alteration, then the design U-factor may be calculated using the default U-factor equation (Equation NA6-1) in the Reference Appendices, Nonresidential Appendix, NA6. Assuming a center of glass U-factor of 0.32, then the calculated U-factor would be 0.59.

Compliance Options

Please refer to Chapter 3.3.9 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Skylights

Please refer to Chapter 3.3.10 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Requirements for Skylights

Please refer to Chapter 3.3.10.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Requirements for Skylights

Please refer to Chapter 3.3.10.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Ignoring Partitions and Shelves

Please refer to Chapter 3.3.10.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Glazing Material and Diffusers

Please refer to Chapter 3.3.10.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Daylighting Design Power Adjustment Factors (PAFs)

Please refer to Chapter 3.3.11 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Clerestory Fenestration

Please refer to Chapter 3.3.11.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Interior and Exterior Horizontal Slats

Please refer to Chapter 3.3.11.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Interior and Exterior Light Shelves

Please refer to Chapter 3.3.11.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Relocatable Public School Buildings

Please refer to Chapter 3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Performance Approach

Reference: Section 140.1

Under the performance approach, energy use of the building is modeled by compliance software approved by the Energy Commission. The compliance software simulates the long-term system cost (LSC) of the proposed building, including a detailed accounting of envelope heat transfers using the assemblies and fenestration input, and the precise geometry of any exterior overhangs or side fins. The most accurate tradeoffs between different envelope components — and among the envelope, the space-conditioning system, and the installed lighting design — are accounted for and compared with the standard design version of the building. The proposed design must have LSC energy less than or equal to the standard design.

This section presents some basic details on the modeling of building envelope components. 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. More information may be found in the *ACM Reference Manual* and the CBECC User Guide.

Compliance Modeling

Mass Characteristics

Please refer to Chapter 3.5.1.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Opaque Surfaces

Please refer to Chapter 3.5.1.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Fenestration

Please refer to Chapter 3.5.1.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Overhangs and Vertical Shading Fins

Please refer to Chapter 3.5.1.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Slab-on-Grade Floors and Basement Floors

Please refer to Chapter 3.5.1.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Please refer to Chapter 3.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Requirements

Additions

All additions must meet the applicable mandatory requirements from the following Energy Code sections:

- Section 110.6 — Mandatory Requirements for Fenestration Products and Exterior Doors
- Section 110.7 — Mandatory Requirements to Limit Air Leakage

- Section 110.8 — Mandatory Requirements for Insulation, Roofing Products and Radiant Barriers
- Section 120.7 — Mandatory Requirements for Building Envelopes

Alterations

Please refer to Chapter 3.6.1.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Requirements

Please refer to Chapter 3.6.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions

Please refer to Chapter 3.6.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Alterations

Reference: Section 141.0(b)2

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

The altered components of the envelope shall meet the applicable mandatory requirements of Section 110.6, Section 110.7, and Section 110.8.

Fenestration

When fenestration is altered that does not increase the fenestration area, it shall meet the requirements of Table 141.0-A of the Energy Code based on climate zone.

When more than 50 square feet of new vertical fenestration area is added to an alteration, it shall meet the requirements of Section 120.7(d), Section 140.3(a), and Tables 140.3-B, C, or D of the Energy Code. Compliance with Section 140.3(a) is not required when the fenestration is temporarily removed and then reinstalled.

In cases where fenestration is replaced or added, the following mandatory requirements apply:

- If more than 150 ft^2 of fenestration area is replaced throughout the entire building, the Energy Code requires that the maximum U-factor of the replaced units shall not exceed U-0.58. The SHGC, RSHGC, or VT requirements need not be met.
- If more than 50 ft^2 of fenestration is added through, the Energy Code requires that the added fenestration meet Section 120.7(d).

The following prescriptive requirements are also applicable:

- If less than 150 ft^2 of fenestration area is replaced throughout the entire building, then the Energy Code requires that only the U-factor requirements in Tables 140.3-B, C, or D are met. The SHGC, RSHGC, or VT requirements need not be met.
- The same requirements and exceptions apply if 50 ft^2 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.

Example 3-15

Question:

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

- Existing glazing remains in place during the alteration.
- Existing glazing is removed, stored during the alteration period, and then reinstalled (glazing is not altered in any way).
- Existing glazing is removed and replaced with new site-built glazing with the same dimensions and performance specifications.

Answer:

NFRC label certificate requirements do not apply to Scenarios 1 and 2 but do apply to Scenario 3.

- Requirement does not apply because the glazing remains unchanged and in place.
- Exception to Section 110.6(a) applies to fenestration products removed and reinstalled as part of a building alteration or addition.
- NFRC label certificate applies in this case as 24,000 ft² of new fenestration is being installed.

Walls and Floors

All nonresidential building alterations involving exterior walls, demising walls, external floors, or soffits must either comply as a component with the requirements in Tables 140.3-B, C, or D in the Energy Code, or by approved compliance software following the rules of the *ACM Reference Manual* that demonstrates that the overall LSC use of the altered building complies with the Energy Code.

Air Barrier

If 25 percent or more of the building envelope wall area is altered, it needs to meet the air barrier design and material requirements for newly constructed buildings. See Air Barrier for detailed guidance on the air barrier requirements for newly constructed buildings and how to perform the blower door testing.

If a blower door test is performed and the air leakage rate exceeds 0.4 cfm/ft2, a visual inspection and diagnostic evaluation must be completed in accordance with Nonresidential Appendix, NA5.7 to find the sources of excessive leakage. The leaks shall then be sealed. An additional report identifying the corrective actions taken to seal air leaks should be submitted to the building owner and code official. Retesting is not needed.

Additions that do not have a completely separate air barrier from the existing building — there is not wall separating the two — shall be temporarily partitioned to conduct the air leakage test if the pressurization test is chosen to comply with the requirements of 140.3(a)9C.

Roofs

Existing roofs being replaced, recovered, or recoated for nonresidential and hotels/motels buildings shall meet the requirements of Section 110.8(i). When the alteration is being made to 50 percent or more of the existing roof area or when more than 2,000 ft^2 of the roof is being altered (whichever is less), the requirements apply. When a small repair is made, these requirements do not apply. For example, the requirements for roof insulation would not be triggered if the existing roof surface were overlaid instead of replaced.

These requirements apply to roofs over conditioned, nonprocess 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, nonprocess areas.

The California Building Code (CBC) 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 insulation recover boards.

Roof Insulation

When a roof is replaced or recovered, and the alteration complies with the prescriptive requirements for roofing products, the altered roof area shall be insulated to the levels specified in Table 141.0-C of the Energy Code.

Roof replacement and roof recover are defined in Title 24, Part 2, Chapter 2 — Definitions. A roof replacement is the process of removing the existing roof covering, repairing any damaged substrate, and installing a new roof covering. A roof recover is the process of installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering. Roof recovers are typically a less expensive option but can only be performed if the existing roof is in good condition. Usually, one roof recover is allowed before the roof needs to be replaced.

Title 24, Part 2, Chapter 15, does not permit roof recovers where the existing roof or roof covering is water soaked or has deteriorated to the point where it is not an adequate base for additional roofing; where the existing roof covering is slate, clay, cement, or asbestos-cement title; or where the existing roof has two or more applications of any type of roof covering.

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 Appendices, Joint Appendix JA4. The U-factor method provides more 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.

For roof alterations, when roofs are replaced or recovered and meet the roofing products requirements in Section 141.0(b)2Bi or ii, the altered area must be insulated to levels specified in the Energy Code, Table 141.0-C. For nonresidential buildings, this level is:

- R-17 or R-23 (depending on climate zone) with the use of continuous insulation; or
- U-0.047 or U-0.037 (depending on climate zone) if the insulation is a combination of above deck continuous insulation and cavity insulation. Under the U-factor option, at least R-10 of continuous insulation must be installed above the roof deck.

Exceptions to Section 141.0(b)2Bii:

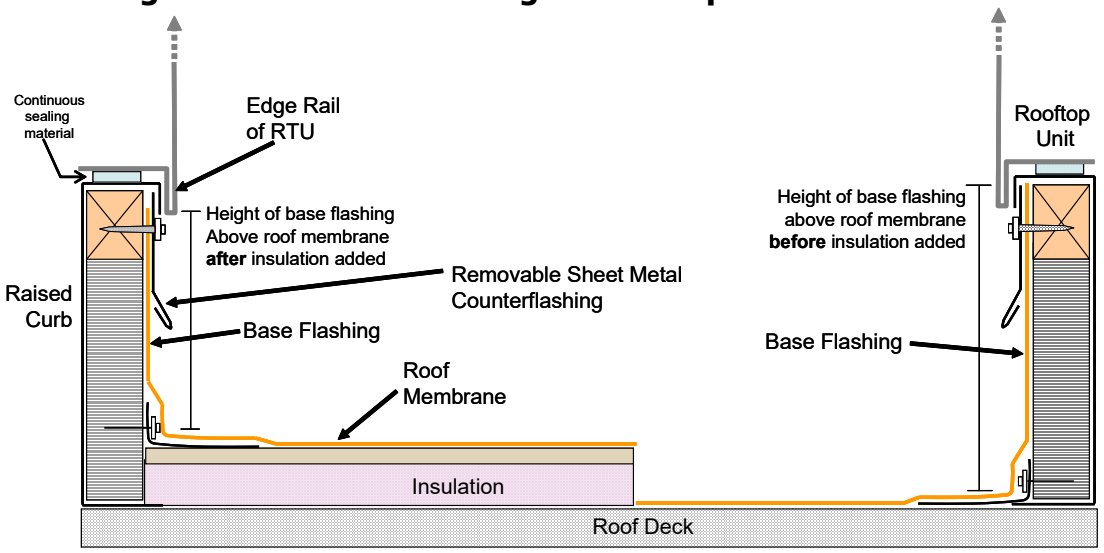
- Roof recovers with new R-10 insulation added above deck do not need to be insulated to the level specified in Table 141.0-C.
- When mechanical equipment located on the roof will not be disconnected and lifted as part of the roof replacement, insulation added may be the greater of R-10 or the maximum installed thickness that will allow the distance between the height of the roof membrane surface to the top of the base flashing to remain in accordance with the manufacturer's instructions.

Increasing the elevation of the roof membrane by adding insulation may also affect roof drainage. The Energy Code allows tapered insulation to be used that 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.

When insulation is added on top of a roof, the elevation of the roof membrane is increased. When insulation is added to a roof and the curb height (counterflashing for walls) is unchanged (Figure 3-18: Base Flashing on Rooftop Unit Curb Detail), 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 orientation 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.

When adding insulation on top of a formerly uninsulated or underinsulated roof, consider the effects 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, 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 3-18: Base Flashing on Rooftop Unit Curb Detail



Source: California Energy Commission

Roof Products

Reference: Section 141.0(b)2B

Thermal Emittance and Aged Solar Reflectance Prescriptive Requirements are described here.

For nonresidential buildings, the prescriptive requirements for roofing products are:

- Low-sloped roofs in Climate Zones 1 through 16 have a required minimum aged solar reflectance of 0.63 and a minimum thermal emittance of 0.75, or a minimum SRI of 75.
- Steep-sloped roofs in Climate Zones 1 and 3 have a minimum aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum SRI of 16. Climate Zones 2 and 4 through 16 have a minimum aged solar reflectance of 0.25 and a minimum emittance of 0.80, or a minimum SRI of 23.

Exception for nonresidential buildings: an aged solar reflectance less than 0.63 is allowed, provided that additional insulation is installed.

For hotel and motel buildings, the prescriptive requirements for roofing products are the following:

- Low-sloped roofs in Climate Zones 9, 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.

Exceptions for hotel and motel buildings:

- For roof areas 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.

- For low-sloped 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.

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. Table 141.0-B shows the overall roof U-factors trade-off requirements by climate zones.

Table 141.0-B of the Energy Code not only takes into account of the amount of insulation necessary to compensate for using a noncompliant roofing product, but it also accounts for the minimum insulation requirements that apply to roof alterations generally.

Example 3-16

Question:

What are the Energy Code requirements for cool roofs when reroofing a low-sloped roof on an unconditioned warehouse containing conditioned office space?

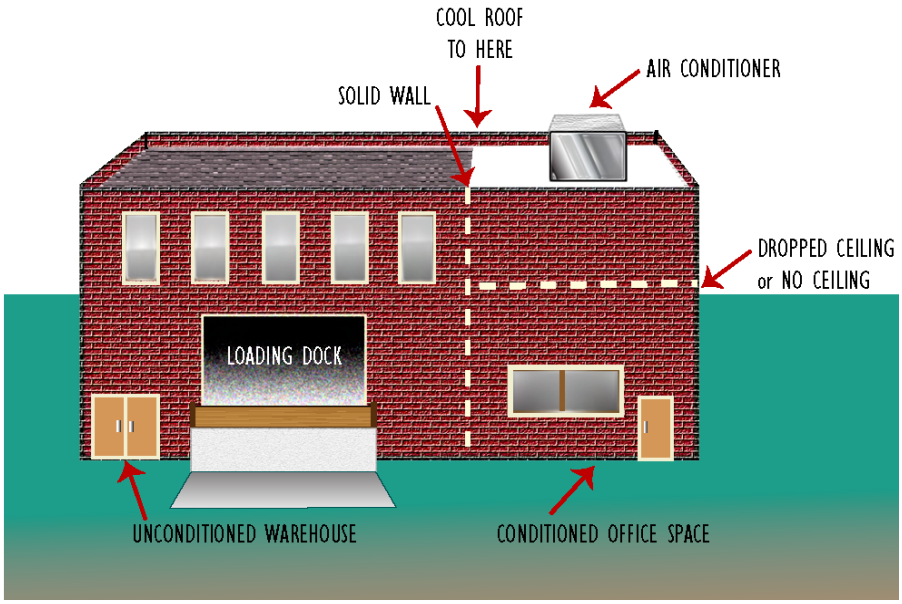
Answer:

Scenario 1.

There is 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.

Figure 3-19: Example Warehouse Scenario 1

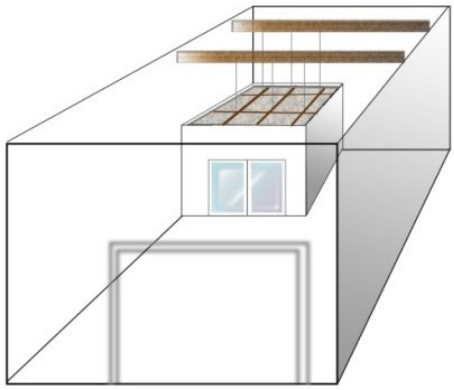


Source: California Statewide CASE Team

Scenario 2.

The walls of the conditioned space do not reach all the way to the warehouse roof. 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.

Figure 3-20: Example Warehouse Scenario 2



Source: California Statewide CASE Team

Example 3--17

Question:

I have a barrel roof on nonresidential conditioned building that needs to be reroofed. Must I follow the Energy Code roofing product requirement?

Answer:

Yes, the roof would need to meet the aged solar reflectance and thermal emittance for a steep-sloped roof. Although a barrel roof has both low-sloped and steep-sloped roofing areas, the continuous gradual slope change allows the steep-sloped section of the roof to be seen from ground level. Barrel roofs only need to meet the steep-sloped requirement for the entire roof area.

Figure 3-21: Example Barrel Roof Building

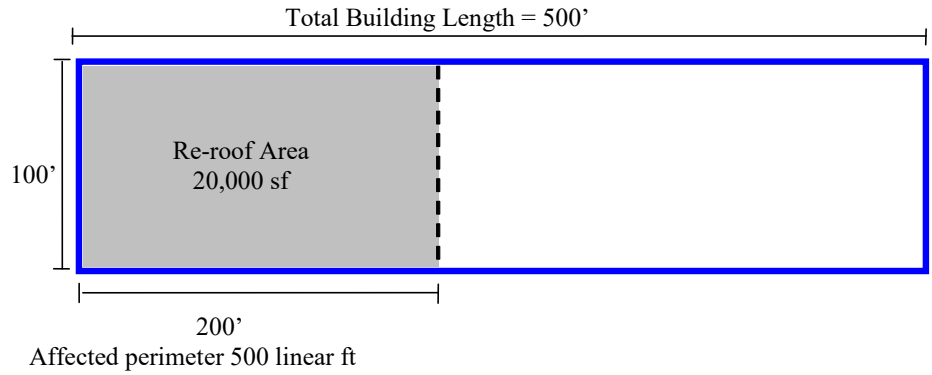
Source: California Statewide CASE Team

Example 3--18

Question 1:

Forty percent of the low-sloped roof on a 500 ft by 100 ft retail building in Concord, California (CZ12), is being reroofed. The roofing is removed down to the roof deck, and there is no insulation. Must insulation be added before reroofing?

Figure 3-22: Example Building With Partial Low-Slope Roof



Source: California Statewide CASE Team

Answer 1:

Yes, Section 141.0(b)2B requires when either 50 percent (or more) of the roof area or 2,000 ft² (whichever is less) is reroofed down to the roof deck or recover boards, that insulation be installed if the roof has less than the insulation in Energy Code, Table 141.0-C. Though the reroofing 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. The roof does not have any insulation and, therefore, is required to add insulation. As per Energy Code, Table 141.0-C Insulation Requirements for Roof Alterations, for nonresidential buildings in

Climate Zone 12, the requirement for insulation is either R-23 continuous insulation (e.g., 4-inches of polyisocyanurate (polyiso) rated at R-5.7/inch) or an effective roof U-factor of 0.037 Btu/h•ft²•°F with at least R-10 continuous insulation installed above deck.

Question 2:

If the building is in San Francisco, would the insulation requirements be different on the building?

Answer 2:

No. San Francisco (as shown in Reference Appendices, Joint Appendix JA2) is in Climate Zone 3. Per Table 141.0-C from Section 141.0(b)2B, the insulation requirement for roof alterations for nonresidential buildings in Climate Zone 3 is R-23 or a U-factor of 0.037 with at least R-10 continuous insulation installed above deck.

Example 3--19

Question 1:

A nonresidential building is having 5,000 ft² of roofing replaced in Richmond (Climate Zone 3). During roofing replacement, the roof deck will be exposed. This building has a rooftop air conditioner that is sitting on an 8-inch-high curb above the roof membrane level. The roof is uninsulated. If the rooftop air-conditioner unit is not disconnected and not lifted off the curb during reroofing, is adding insulation required? If so, how much?

Answer 1:

Yes, the only time insulation is not required to be added is if the roof already meets the insulation requirements in Energy Code, Table 141.0-C. However, the exception to Section 141.0(b)2Bii allows for less insulation to be installed if the space-conditioning equipment is not disconnected and lifted during reroofing. In this case, the requirements for adding insulation are limited to the greater of R-10 (for example, 1.75 inches of polyisocyanurate insulation rated at R-5.7/inch) or the maximum installed thickness that will allow the distance between the height of the roof membrane surface to the top of the base flashing to remain in accordance with the manufacturer's instructions. Ask the roofing manufacturer what the lowest curb height is that they will provide a warranty for. If it is 6.25 inches or lower (8-inch curb height – 1.75 inches of polyiso), install the maximum amount of insulation to remain in accordance with the manufacturer's instructions. If it is higher than 6.25 inches and therefore it is not possible to install R-10 or greater, the space conditioning must be disconnected and lifted, the curb must be replaced or a curb extension added, and the full insulation required by Energy Code, Table 141.0-C must be added, in this case R-23 or U-0.037 with at least R-10 above deck.

Question 2:

What if the rooftop air conditioner is lifted temporarily during reroofing to remove and replace the roofing membrane? How much is added insulation is required?

Answer 2:

The insulation required by Energy Code, Table 141.0-C must be added — in this case R-23 or U-0.037 with at least R-10 above deck.

When the rooftop unit is lifted as part of the reroofing project, the incremental cost of replacing the curb or adding a curb extension is reduced; therefore, the exception does not apply.

Thus, to maintain the 8-inch base flashing height, one can replace the curb or add a curb extension before reinstalling the rooftop unit. Alternatively, one can ask for a roofing manufacturer's variance to the warranty 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 Section 141.0(b)2B.

Example 3-20

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–inch-high (20 cm) curb above the roof membrane level. The roof is uninsulated. Is added insulation required?

Answer:

Yes, insulation is required. There are no exceptions for skylights. Removing a unit skylight and increasing the associated curb height is substantially less effort than that for space-conditioning equipment.

Example 3-21

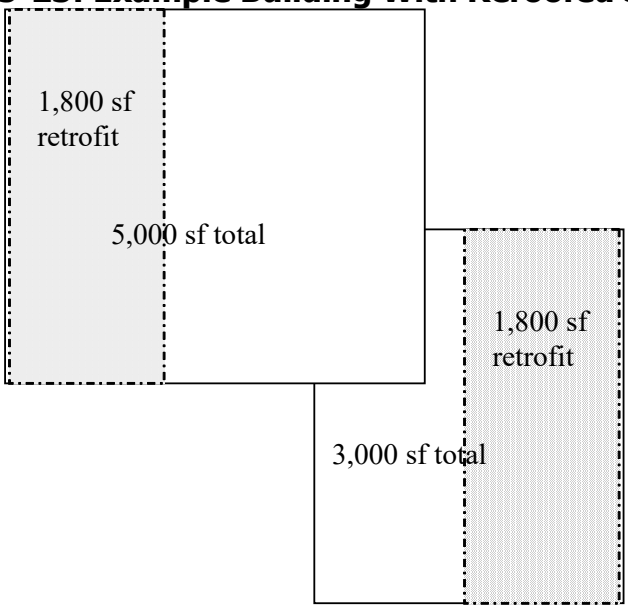
Question 1:

A building has low-sloped roofs at two elevations. 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 reroofed 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 1:

Yes, the reroofed section of the roof must be insulated and have a cool roof. Section 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.

Figure 3-23: Example Building With Reroofed Section



Source: California Statewide CASE Team

Question 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 be a cool roof and have insulation installed?

Answer 2:

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 is less than 2,000 ft²; thus, it is not required to comply with the insulation and cool roof requirements in Section 141.0(b)2B.

Example 3-22

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 rooftop units on this section of the roof that is being altered. One rooftop unit has a curb with a 9-inch base flashing, and the other has a modern curb with a 14-inch base flashing. Consider the following three scenarios:

Question 1: The rooftop unit with the 9-inch base flashing is disconnected and lifted during reroofing. However, the rooftop unit on the curb with the 14-inch (36 cm) base flashing is not lifted. In this situation, is the insulation added limited to the greater of R-10 or the maximum installed thickness that will allow the distance between the height of the roof membrane surface to the top of the base flashing on the unit with the lower curb to remain in accordance with the manufacturer's instructions?

Answer 1:

No. The unit with the 9-inch base flashing was disconnected and lifted and thus does not qualify for the exception to Section 141.0(b)2Bii. There is plenty of room to meet the insulation requirements in Energy Code Table 141.0-C in any climate zone without impacting the unlifted rooftop unit with a 14-inch curb.

Question 2:

The rooftop unit with the 9-inch base flashing is not disconnected and lifted during reroofing. In this situation, does an exception apply for the amount of insulation that must be added?

Answer 2:

Yes. The unit with the 9-inch (23 cm) base flashing was not disconnected and lifted and thus qualifies for the Exception 2 to Section 141.0(b)2Bii. This should be handled in the same way as Example 3-22, Question 1, above.

Question 3:

In Question 2, does this reduced amount of required insulation apply only to the area immediately surrounding the unlifted unit or to the entire roof?

Answer 3:

The reduced amount of insulation applies to the entire roof. However, if a building has multiple roofs, the limitation would apply only to any roof with a rooftop unit that was not disconnected and lifted and that has a low curb.

Example 3-23

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 exceptions in 140.3(a)Ai?

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. Therefore, the gravel roof over existing cap sheet may not qualify for the exception.

Example 3-24

Question:

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

Answer:

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

Example 3-25

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 sets of rules in Section 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. These requirements are climate zone-based.

Example 3-26

Question:

A low-sloped nonresidential building in Santa Rosa needs to be reroofed. It has a wood-framed rafter roof. The rafters are 2x4'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.

To make an insulation/reflectance trade-off under the prescriptive approach, use Table 141.0-B. 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 in Climate Zone 2, so the appropriate U-factor is found in row 1, column 2 of the table. It is 0.052. Consult Section 4.2 (Roofs and Ceilings) of Reference Appendices, Joint Appendix JA4 to find the U-factor table for the type of roof in question. Reference Appendices, Joint Appendix JA4 can be accessed on the Energy Commission's website at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency.

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 2x4 rafters spaced 16 inches on center. There are several 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 3-27

Question:

Is a full roof recoat exempt from the Energy Code insulation requirements in Section 141.0(b)2Bii?

Answer:

Yes. If a roof has an existing coating, the application of a top coating for renewal or maintenance (roof recoat) is exempt from the low-sloped roof insulation requirements of Section 141.0(b)2Bii. However, when a roof recoat layer is part of a roof recover as defined in Section 100.1, it is required to meet the insulation requirements of Section 141.0(b)2Bii.

Example 3-28

Question:

There are several exceptions to the minimum insulation requirements for roof alterations. Can these be used to limit the insulation required to make a trade-off under Table 141.0-B?

Answer:

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

Performance Requirements

Additions

Please refer to Chapter 3.6.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Alterations

Please refer to Chapter 3.6.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.