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INTRODUCTION

Chapter 3 Introduction

This chapter covers envelope requirements for all dwelling units and common use areas in multifamily buildings for newly constructed buildings and additions or alterations to existing buildings.

Guidance on general requirements is included in the Multifamily Compliance Manual Chapter 1: General Requirements. Guidance on administrative requirements is included in the Multifamily Compliance Manual Chapter 2: Compliance and Enforcement. This chapter includes guidance on covered process system requirements.

Table 3-2: Excerpt from Table 100.0-A Application of Standards provides an overview of the location of the envelope requirements that apply to multifamily occupancies in the Energy Code.

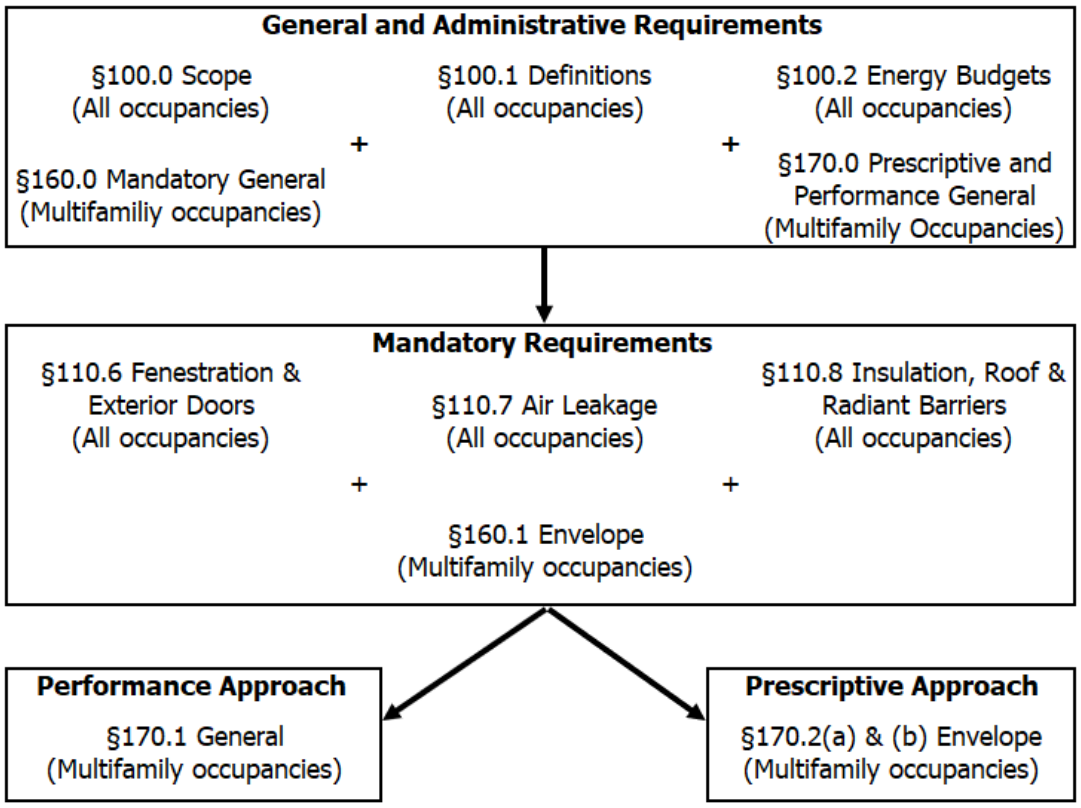
Table 3-2: Excerpt From Table 100.0-A Application of Standards

Application	Mandatory	Prescriptive	Performance	Additions/ Alterations
General[1]	160.0	170.0	170.0	180.0
Envelope (conditioned)	110.6, 110.7, 110.8, 160.1	170.2(a), 170.2(b)	170.1	180.1, 180.2

1. Guidance on General Requirements from Sections 160.0, 170.0 and 180.0 are included in the Multifamily Compliance Manual Chapter 1 General Requirements. Guidance specific to multifamily envelopes is included in this chapter.

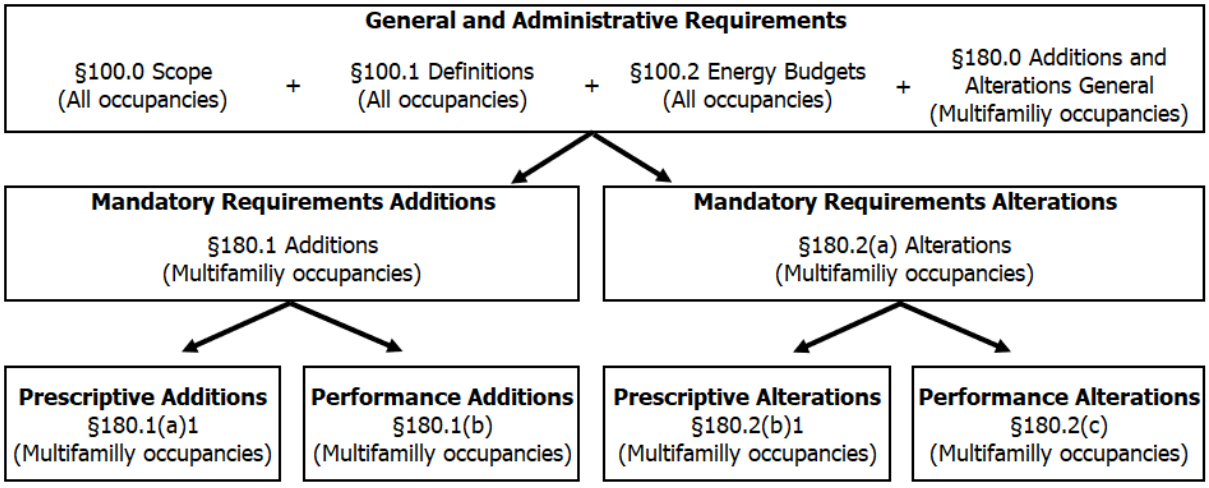
Figure 3-1: Flowchart Guidance for Application of New Construction Multifamily Envelope (Conditioned) Requirements and Figure 3-2: Flowchart Guidance for Application of Addition or Alteration Multifamily Envelope (Conditioned) Requirements below illustrate the applicable sections for newly constructed buildings and additions or alterations to existing buildings.

Figure 3-1: Flowchart Guidance for Application of New Construction Multifamily Envelope (Conditioned) Requirements



Newly Constructed Buildings Compliance Approaches

Figure 3-2: Flowchart Guidance for Application of Addition or Alteration Multifamily Envelope (Conditioned) Requirements



Addition, Alteration Compliance Approaches

Source: California Energy Commission

SECTION 110.6 – MANDATORY REQUIREMENTS FOR FENESTRATION PRODUCTS AND EXTERIOR DOORS

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

«» Commentary for Section 110.6(a):

Manufactured fenestration is a fenestration product constructed of materials that are factory-cut or otherwise factory-formed with the specific intention of being used to fabricate a fenestration product. Knocked down or partially assembled products may be sold as a fenestration product when provided with temporary and permanent labels, as described in Section 10-111, or as a site-built fenestration product when not provided with temporary and permanent labels, as described in Section 10-111.

Site-built fenestration is designed to be field-glazed or field-assembled units, using specific factory-cut or other factory-formed framing and glazing units that are manufactured with the intention of being assembled at the construction site. These include storefront systems, curtain walls or large-track sliding glass walls, and atrium roof systems.

Field-fabricated fenestration is when the windows are fabricated at the building site from elements that are not sold together as a fenestration product (that is, separate glazing, framing, and weather-stripping elements). Field-fabricated does not include site-assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked-down products, sunspace kits, and curtain walls). **«»**

1. **Air leakage.** Manufactured fenestration products and exterior doors shall have air infiltration rates not exceeding 0.3 cfm/ft^2 of window area, 0.3 cfm/ft^2 of door area for residential doors, 0.3 cfm/ft^2 of door area for nonresidential single doors (swinging and sliding), and 1.0 cfm/ft^2 for nonresidential double doors (swinging), when tested according to NFRC-400 or ASTM E283 at a pressure differential of 75 pascals (or 1.57 pounds/ft^2), incorporated herein by reference.

   NOTES TO SECTION 110.6(a)1: Pet doors must meet 0.3 cfm/ft^2 when tested according to ASTM E283 at 75 pascals (or 1.57 pounds per square foot). AAMA/WDMA/CSA 101/I.S.2/A440-2011 specification is equivalent to ASTM E283 at a pressure differential of 75 pascals (or 1.57 pounds per square foot) and satisfies the air leakage certification requirements of this section.

Exception to Section 110.6(a)1: Field-fabricated fenestration and field-fabricated exterior doors.

«» Commentary for Section 110.6(a)1:

Manufactured and site-built fenestration such as doors and windows must be tested and shown to have infiltration rates not exceeding the values shown in Table 3-2: Maximum Air Infiltration Rates. For field-fabricated products or exterior doors, the Energy Code requires that the unit be caulked, gasketed, weather stripped, or otherwise sealed. Unframed glass doors and fire doors are the two exceptions to these air leakage requirements.

Table 3-2: Maximum Air Infiltration Rates

Class	Type	Rate
Windows (cfm/ft^2) of window area	All	0.3
Residential Doors (cfm/ft^2) of door area	Swinging, Sliding	0.3
All Other Doors (cfm/ft^2) of door area	Sliding, Swinging (single door)	0.3
All Other Doors (cfm/ft^2) of door area	Swinging (double door)	1.0

Source: California Energy Commission, see Section 110.6(a)1

«»

2. **U-factor.** The fenestration product and exterior door's U-factor shall be rated in accordance with NFRC 100, or use the applicable default U-factor set forth in Table 110.6-A.

   Exception 1 to Section 110.6(a)2: If the fenestration product is a skylight in a building covered by the nonresidential standards with less than 200 square feet of skylight area, the default U-factor may be calculated as set forth in Reference Nonresidential Appendix NA6.

   Exception 2 to Section 110.6(a)2: If the fenestration product is an alteration consisting of any area replacement of glass in a skylight product in a building covered by the nonresidential standards, the default U-factor may be calculated as set forth in Reference Nonresidential Appendix NA6.

«» Commentary for Section 110.6(a)2:

U-Factor

A measure of how much heat can pass through a construction assembly or a fenestration product. The lower the U-factor, the more energy-efficient the product is. The units for U-factor are Btu of heat loss each hour per square foot (ft^2) of window area per degree Fahrenheit (°F) of temperature difference (Btu/hr-ft^2-°F). U-factor is the inverse of R-value. The U-factor considers the entire product, including losses through the center of glass, at the edge of glass where a metal spacer typically separates the double-glazing panes, losses through the frame, and through the mullions. For metal-framed fenestration products, the frame losses can be significant. **«»**

3. **Solar heat gain coefficient SHGC.** The fenestration product's SHGC shall be rated in accordance with NFRC 200, or use the applicable default SHGC set forth in TABLE 110.6-B.

   EXCEPTION 1 to Section 110.6(a)3: If the fenestration product is a skylight in a building covered by the nonresidential standards with less than 200 square feet of skylight area, the default SHGC may be calculated as set forth in Reference Nonresidential Appendix NA6.

   EXCEPTION 2 to Section 110.6(a)3: If the fenestration product is an alteration consisting of any area replacement of glass in a skylight product in a building covered by the nonresidential standards, the default SHGC may be calculated as set forth in Reference Nonresidential Appendix NA6.

«» Commentary for Section 110.6(a)3:

Solar Heat Gain Coefficient (SHGC)

The solar heat gain coefficient (SHGC) is a measure of the relative amount of heat gain from sunlight that passes through a fenestration product. The SHGC is a number between zero and one that represents the ratio of solar heat that passes through the fenestration product to the total solar heat that is incident on the outside of the window. A low SHGC number (closer to 0) means that the fenestration product keeps out most solar heat. A higher SHGC number (closer to 1) means that the fenestration product lets in most of the solar heat. The SHGC or $SHGC_t$ is the SHGC for the total fenestration product and is the value used for compliance with the standards. **«»**

4. **Visible transmittance (VT).** The fenestration product's VT shall be rated in accordance with NFRC 200 or ASTM E972, for tubular daylighting devices VT shall be rated using NFRC 203**.**

   Exception 1 to Section 110.6(a)4: If the fenestration product is a skylight in a building covered by the nonresidential standards with less than 200 square feet of skylight area, the default VT may be calculated as set forth in Reference Nonresidential Appendix NA6.

   Exception 2 to Section 110.6(a)4: If the fenestration product is an alteration consisting of any area; replacement of glass in a skylight product in a building

covered by the nonresidential standards, the default VT may be calculated as set forth in Reference Nonresidential Appendix NA6.

«» Commentary for Section 110.6(a)4:

Visible Transmittance (VT)

Visible transmittance is the ratio of visible light transmitted through the fenestration. The higher the VT rating, the more light is allowed through a window. **«»**

5. **Labeling.** Fenestration products and exterior doors shall:
   A. Have a temporary label for manufactured fenestration products and exterior doors or a label certificate when the Component Modeling Approach (CMA) is used and for site-built fenestration meeting the requirements of Section 10-111(a)1. The temporary label shall not be removed before inspection by the enforcement agency; and
   B. Have a permanent label or label certificate when the Component Modeling Approach (CMA) is used and for site-built fenestration meeting the requirements of Section 10-111(a)2 if the product is rated using NFRC procedures.

«» Commentary for Section 110.6(a)5:

Certification and Labeling

The Administrative Regulations Section 10-111 and Section 110.6 require that fenestration products have labels that list the U-factor, SHGC, VT, and the method used to determine those values. The label must also certify that the fenestration product meets the requirements for air leakage from 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 3-3: NFRC Manufactured Label), which is not to be removed before inspection by the enforcement agency. The manufacturer rates and labels its fenestration products for U-factor, SHGC and VT.

The manufacturer can choose to have the fenestration product rated and labeled in accordance with the 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 3-3: NFRC Manufactured Label

Source: California Energy Commission

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 and multifamily 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:

1. Design energy-efficient windows, curtain wall systems, and skylights for high-performance building projects.
2. Determine whether a product meets the specifications for a project and local/state building energy codes.
3. 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 (Figure 3-4: NFRC — CMA Label Certificate, Page

1) 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 (Figure 3-5: NFRC — CMA Label Certificate, Page 2) 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.

Figure 3-4: 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: California Energy Commission

Figure 3-5: 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**
	ft²					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: California Energy Commission

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:

1. CMA's online tool has the ability to output a file with values for use in building energy analysis software programs.
2. The program can export detailed information for angular-dependent SHGC and VT values, seamlessly transferring the data to the analytical software.
3. A 2010 study conducted in California demonstrated that fenestration modeled with the CMA program can provide an increase in compliance margins by as much as 11.7 percent over the Energy Code default calculation methods.
4. 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 due to more accurate fenestration performances and potential energy benefits from above-code utility incentives. Details are available at www.NFRC.org.

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.

1. For site-built skylight fenestration in low-rise multifamily buildings totaling 250 ft^2 or 5 percent of floor area or greater, or in high-rise multifamily buildings 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 an NFRC label certificate from either approach listed below:
2. 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.
3. For site-built skylight fenestration in low-rise multifamily buildings totaling less than 250 ft^2, or in high-rise multifamily buildings totaling less than 200 ft^2, or for site-built vertical fenestration being used in an alteration, the glazing contractor or specifier must comply with one of the following:
    - An 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:

1. Architects and/or engineers design the basic glazing system by specifying the components, the geometry of the components, and, sometimes, the assembly method.
2. An extrusion manufacturer provides the mullions and frames that support the glazing and is responsible for thermal breaks.
3. 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.
4. 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.
5. 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.
6. 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 prior to 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 the NA6. **«»**

6. **Fenestration acceptance requirements.** Before an occupancy permit is granted site-built fenestration products in other than single-family buildings shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified in the Reference Nonresidential Appendix NA7 to ensure that site-built fenestration meets Standards requirements, including a matching label certificate for product(s) installed and be readily accessible at the project location. A certificate of acceptance certifying that the fenestration product meets the acceptance requirements shall be completed, signed and submitted to the enforcement agency.

   Exception to Section 110.6(a): Fenestration products removed and reinstalled as part of a building alteration or addition.

«» Commentary for Section 110.6(a)6:

Acceptance tests are required for newly installed fenestration, window film, and dynamic glazing in new construction, additions, and alterations for all buildings except single-family residential per Section 110.6(a)6.

These fenestration products must be tested according to NA7.4 to verify that the NFRC label certificate or CEC fenestration certificate is provided for each fenestration product being installed. These certificates identify the thermal performance of the fenestration product (for example, U-factor, solar heat gain coefficient, and visible transmittance).

This test also verifies that the thermal performance of installed fenestration products match the label certificate, energy compliance documentation, and plan specifications. **«»**

(b) Installation of field-fabricated fenestration and exterior doors. Field-fabricated fenestration and field-fabricated exterior doors may be installed only if the compliance documentation has demonstrated compliance for the installation using U-factors from Table 110.6-A and SHGC values from Table 110.6-B. Field-fabricated fenestration and field-fabricated exterior doors shall be caulked between the fenestration products or exterior door and the building, and shall be weatherstripped.

Exception to Section 110.6(b): Unframed glass doors and fire doors need not be weatherstripped or caulked.

TABLE 110.6-A DEFAULT FENESTRATION PRODUCT U-FACTORS

Frame	Product Type	Single Pane [3, 4] U-Factor	Double Pane [1, 3, 4] U-Factor	Glass Block [2,3] U-Factor
Metal	Operable	1.28	0.79	0.87
Metal	Fixed	1.19	0.71	0.72
Metal	Greenhouse/Garden Window	2.26	1.40	N.A.
Metal	Glazed Doors	1.25	0.77	N.A.
Metal	Skylight	1.98	1.30	N.A.
Metal, Thermal Break	Operable	N.A.	0.66	N.A.
Metal, Thermal Break	Fixed	N.A.	0.55	N.A.
Metal, Thermal Break	Greenhouse/Garden Window	N.A.	1.12	N.A.
Metal, Thermal Break	Glazed Doors	N.A.	0.59	N.A.
Metal, Thermal Break	Skylight	N.A.	1.11	N.A.
Nonmetal	Operable	0.99	0.58	0.60
Nonmetal	Fixed	1.04	0.55	0.57
Nonmetal	Glazed Doors	0.99	0.53	N.A.
Nonmetal	Greenhouse/Garden Windows	1.94	1.06	N.A.
Nonmetal	Skylight	1.47	0.84	N.A.

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

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

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

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

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

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

TABLE 110.6-B DEFAULT SOLAR HEAT GAIN COEFFICIENT (SHGC)

FRAME TYPE	**PRODUCT**	**GLAZING**	**FENESTRATION PRODUCT SHGC Single Pane[2,3] SHGC**	**FENESTRATION PRODUCT SHGC** Double Pane[2,3] SHGC	**FENESTRATION PRODUCT SHGC** Glass Block[1,2] SHGC
Metal	Operable	Clear	0.80	0.70	0.70
Metal	Fixed	Clear	0.83	0.73	0.73
Metal	Operable	Tinted	0.67	0.59	N.A.
Metal	Fixed	Tinted	0.68	0.60	N.A.
Metal, Thermal Break	Operable	Clear	N.A.	0.63	N.A.
Metal, Thermal Break	Fixed	Clear	N.A.	0.69	N.A.
Metal, Thermal Break	Operable	Tinted	N.A.	0.53	N.A.
Metal, Thermal Break	Fixed	Tinted	N.A.	0.57	N.A.
Nonmetal	Operable	Clear	0.74	0.65	0.70
Nonmetal	Fixed	Clear	0.76	0.67	0.67
Nonmetal	Operable	Tinted	0.60	0.53	N.A.
Nonmetal	Fixed	Tinted	0.63	0.55	N.A.

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

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

3. Windows with window film applied that is not rated by NFRC 200 shall use the default values from this table.

«» Commentary for Section 110.6(b):

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 appropriate compliance documentation with the default values is required (i.e. Prescriptive LMCC-ENV-E or Performance LMCC-PRF-01-E for low-rise; Prescriptive NRCC-ENV-E or Performance NRCC-PRF-01-E for high-rise). Field-fabricated fenestration and field-fabricated exterior doors may be installed only if the documentation has demonstrated compliance with the Energy Code. **«»**

SECTION 110.7 – MANDATORY REQUIREMENTS TO LIMIT AIR LEAKAGE

All joints, penetrations and other openings in the building envelope that are potential sources of air leakage shall be caulked, gasketed, weather-stripped or otherwise sealed to limit infiltration and exfiltration.

Note**:** Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.8, and 25943, Public Resources Code*.*

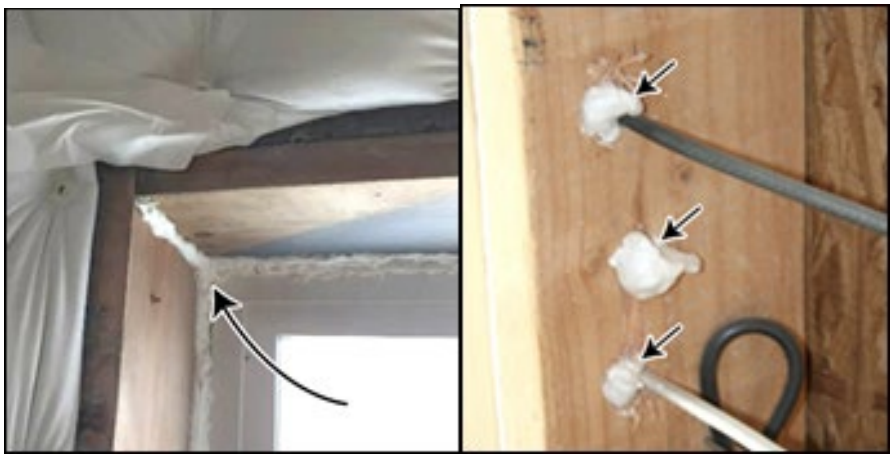
«» Commentary for Section 110.7:

All joints and other openings in the building envelope that are potential sources of air leakage must be caulked, gasketed, weatherstripped, 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.

Air leakage through joints, penetrations, cracks, holes, openings around windows, doors, walls, roofs, and floors can result in higher energy use. The following openings in the building envelope shall be caulked, gasketed, weatherstripped, or otherwise sealed:

1. Exterior joints around window and door frames, including doors between a dwelling unit and a garage, between interior HVAC closets and conditioned space, between attic access and conditioned space, between wall sill plates and the floor, exterior panels, and all siding materials.
2. Openings for plumbing, electricity, and gas lines in exterior and interior walls, ceilings, and floors.
3. Openings in the attic floor, such as where ceiling panels meet interior walls, exterior walls, and masonry fireplaces.
4. Openings around exhaust ducts, such as those for clothes dryers.
5. All other such openings in the building envelope.

Figure 3-6: Air Sealing



Source: Sierra Building Science

«»

SECTION 110.8 – MANDATORY REQUIREMENTS FOR INSULATION, ROOFING PRODUCTS AND RADIANT BARRIERS

(a) Insulation certification by manufacturers. All insulation shall be certified by Department of Consumer Affairs, Bureau of Household Goods and Services that the insulation conductive thermal performance is approved pursuant to the California Code of Regulations, Title 24, Part 12, Chapters 12-13, Article 3, "Standards for Insulating Material."

«» Commentary for Section 110.8:

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 Household Goods and Services. Builders and enforcement agencies shall use the Department of Consumer Affairs Directory of Certified Insulation Materials to verify certification of the insulating material (https://bhgs.dca.ca.gov/consumers/ti_directory.pdf). 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, using the contact information at https://www.bhgs.dca.ca.gov/about_us/contact_us.shtml. **«»**

(b) Installation of urea formaldehyde foam insulation. Urea formaldehyde foam insulation may be applied or installed only if:

1. It is installed in exterior side walls; and
2. A 4-mil-thick plastic polyethylene vapor retarder or equivalent plastic sheathing vapor retarder is installed between the urea formaldehyde foam insulation and the interior space in all applications.

«» Commentary for Section 110.8(b):

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

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

(c) Flame spread rating of insulation. All insulating material shall be installed in compliance with the flame spread rating and smoke density requirements of the CBC.

«» Commentary for 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. **«»**

(d) Installation of insulation in existing buildings. Insulation installed in an existing attic, or on an existing duct or water heater, shall comply with the applicable requirements of Subsections 1, 2 and 3 below. If a contractor installs the insulation, the contractor shall certify to the customer, in writing, that the insulation meets the applicable requirements of Subsections 1, 2 and 3 below.

1. **Attics.** If insulation is installed in the existing attic of a low-rise residential building, the R-value of the total amount of insulation (after addition of insulation to the amount, if any, already in the attic) shall meet the requirements of Section 150.0(a) for single-family buildings and Section 180.2(a)1 for multifamily buildings three habitable stories or less.

   Exception to Section 110.8(d)1: Where the accessible space in the attic is not large enough to accommodate the required R-value, the entire accessible space shall be filled with insulation, provided such installation does not violate Section 1202.2 of Title 24, Part 2 or Section 806 of Title 24, Part 2.5.

2. **Water heaters.** If external insulation is installed on an existing unfired water storage tank or on an existing back-up tank for a solar water-heating system, it shall have an R-value of at least R-3.5, or the heat loss of the tank surface based on an 80°F water-air temperature difference shall be less than 6.5 Btu per hour per square foot.

3. **Ducts.** If insulation is installed on an existing space-conditioning duct, it shall comply with Section 605.0 of the CMC.

(g) Insulation requirements for heated slab floors. Heated slab floors shall be insulated according to the requirements in Table 110.8-A.

1. Insulation materials in ground contact must:

   A. Comply with the certification requirements of Section 110.8(a); and

B. Have a water absorption rate for the insulation material alone without facings that is no greater than 0.3 percent when tested in accordance with Test Method A – 24 Hour-Immersion of ASTM C272.

C. Water vapor permeance no greater than 2.0 perm/ inch when tested in accordance with ASTM E96.

2. Insulation installation must:

A. Be covered with a solid guard that protects against damage from ultraviolet radiation, moisture, landscaping operation, equipment maintenance and wind; and

B. Include a rigid plate, which penetrates the slab and blocks the insulation from acting as a conduit for insects from the ground to the structure above the foundation.

TABLE 110.8-A SLAB INSULATION REQUIREMENTS FOR HEATED SLAB FLOOR

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

«» Commentary for Section 110.8(g)2:

Slab Insulation Products

The mandatory requirements state that the insulation material must be suitable for the application. Insulation material in direct contact with soil, such as perimeter insulation, must have a water absorption rate no greater than 0.3 percent when tested in

accordance with ASTM C272 Test Method A, 24-Hour Immersion, and a vapor permeance no greater than 2.0 perm/inch when tested in accordance with ASTM E96.

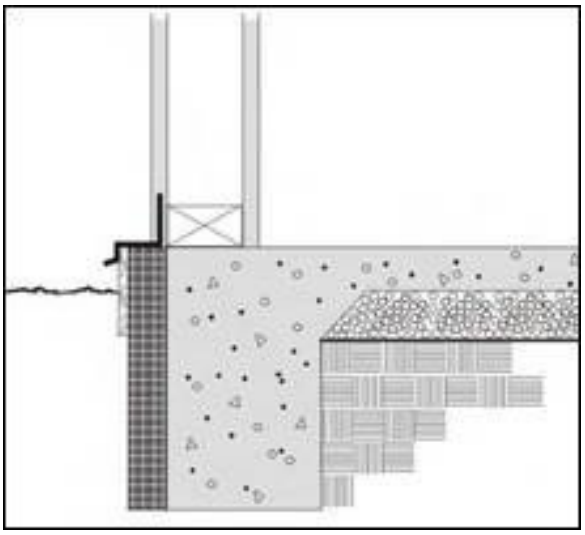
The insulation must be protected from physical and UV degradation by either installing a water-resistant protection board, extending sheet metal flashing below grade, choosing an insulation product that has a hard durable surface on one side, or using other suitable means.

The top of the insulation must be protected with a rigid material to prevent intrusion of insects into the building foundation.

A common location for the slab insulation is on the foundation perimeter (Figure 3-7: Perimeter Slab Insulation). Insulation that extends downward to the top of the footing is acceptable. Otherwise, the insulation must extend downward from the level of the top of the slab, down 16 inches (40 cm) or to the frost line, whichever is greater.

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

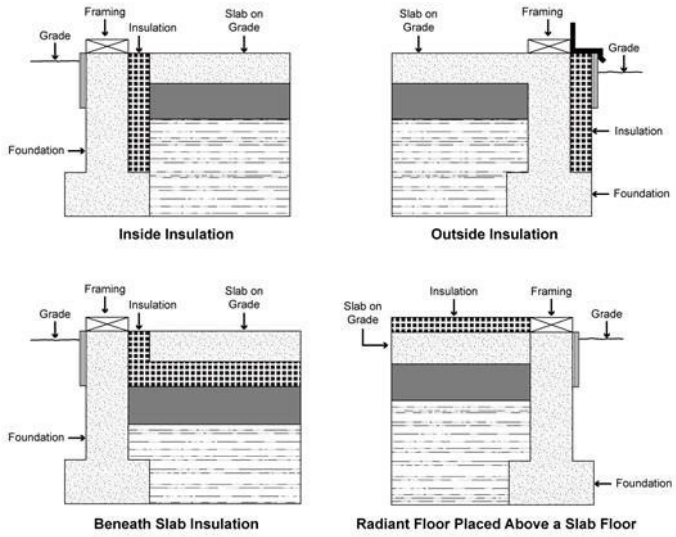
Figure 3-7: Perimeter Slab Insulation



Source: California Energy Commission

One option is to install the insulation between the heated slab and foundation wall. In this case, insulation must extend downward to the top of the footing and then extend horizontally inward 4 feet toward the center of the slab. R-5 vertical insulation is required in all climates except Climate Zone 16, which requires R-10 of vertical insulation and R-7 horizontal insulation.

Figure 3-8: Allowed Slab Edge Insulation Placement



Source: California Energy Commission

«»

(h) Wet insulation systems. When insulation is installed on roofs above the roofing membrane or layer used to seal the roof from water penetration, the effective R-value of the insulation shall be as specified in Reference Joint Appendix JA4.

«» Commentary for 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, and installers must use the resulting value in choosing the table column in Reference Appendices, Joint Appendix JA4 for determining assembly U-factor (when using the Joint Appendix JA4 table to comply). See the footnotes for Tables 4.2.1 through 4.2.7 in the Reference Appendices, Joint Appendix JA4. **«»**

(i) Roofing products solar reflectance and thermal emittance.

1. In order to meet the requirements of Sections 140.1, 140.2, 140.3(a)1, 141.0(b)2B, 150.1(c)11, 150.2(b)1I or 150.2(b)2, a roofing product's thermal emittance and an aged solar reflectance shall be certified and labeled according to the requirements of Section 10-113.

   Exception 1 to Section 110.8(i)1: Roofing products that are not certified according to Section 10-113 shall assume the following default aged solar reflectance/thermal emittance values:

   For asphalt shingles: 0.08/0.75

For all other roofing products: 0.10/0.75

2. If CRRC testing for an aged solar-reflectance is not available for a roofing product, the aged values shall be derived from the CRRC initial values using the equation $\rho_{aged}=[0.2+\beta[\rho_{initial}-0.2]$, where $\rho_{initial}$ = the initial solar reflectance and soiling resistance β is listed by product type in Table 110.8-B.

TABLE 110.8-B VALUES OF SOILING RESISTANCE β BY PRODUCT TYPE

Product Type	CRRC Product Category	β
Field-Applied Coating	Field-Applied Coating	0.65
Other	Not A Field-Applied Coating	0.70

3. Solar Reflectance Index (SRI), calculated as specified by ASTM E1980-11 (2019), may be used as an alternative to thermal emittance and an aged solar reflectance when complying with the requirements of Sections 140.2, 140.3(a)1, 141.0(b)2B, 150.1(c)11, 150.2(b)1I or 150.2(b)2. SRI calculations shall be based on approach I from Section 6.1.1 of ASTM E1980-11 (2019) using only equation 1 and 3 and a moderate wind velocity of 2–6 meters per second. The SRI shall be calculated based on the aged solar reflectance value of the roofing products.

«» Commentary for Section 110.8(i)3:

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

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.

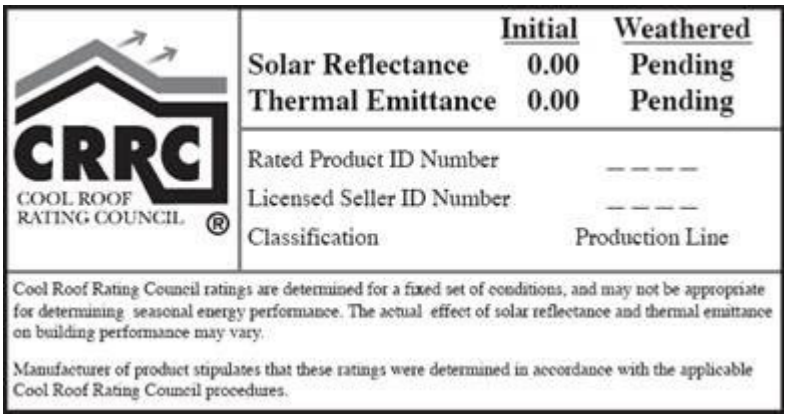
Roofing products must be tested and labeled by the Cool Roof Rating Council (CRRC), and liquid-applied products must meet minimum standards for performance and durability per Section 110.8(i)4. When installing cool roofs, the aged solar reflectance (SR) and thermal emittance (TE) of the roofing product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

Rating and Labeling

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 TE.

See Figure 3-9: Sample CRRC Product Label and Information for an example of an approved CRRC product label.

Figure 3-9: Sample CRRC Product Label and Information



Source: Cool Roof Rating Council

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

Both solar reflectance and TE 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 more quickly (upward and out of the building) than roof surfaces with low-emitting properties.

There are three measurements of solar reflectance:

1. Initial solar reflectance
2. Three-year SR
3. Accelerated SR

All requirements of the Energy Code are based on the three-year SR. 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.

$$Aged\ Reflectance_{calculated} = (0.2 + \beta[\rho_{inital} - 0.2])$$

Where,

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

β= 0.65 for field-applied coating, or 0.70 for not a field-applied coating

Thermal Emittance

The Energy Code does not distinguish between initial and aged TE, 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 SR and TE values must be used for compliance:

1. For asphalt shingles, 0.08/0.75.
2. 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 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 TE of the desired roofing material. The calculator can be found at https://www.energy.ca.gov/filebrowser/download/5237. The linked calculator does not work in a web browser and should be downloaded. To calculate the SRI, either the initial or the three-year SR value of the roofing product may be used. By using the SRI calculator, a cool roof may comply with a lower emittance, as long as the SR is higher and vice versa. **«»**

4. Liquid-applied roof coatings applied to low-sloped roofs in the field as the top surface of a roof covering shall:
   A. Be applied across the entire roof surface to meet the dry mil thickness or coverage recommended by the coating manufacturer, taking into consideration the substrate on which the coating is applied; and
   B. Meet the minimum performance requirements listed in Table 110.8-C or the minimum performance requirements of ASTM C836, D3468, D6083 or D6694, whichever are appropriate to the coating material.

      Exception 1 to Section 110.8(i)4B: Aluminum- pigmented asphalt roof coatings shall meet the requirements of ASTM D2824 and be installed as specified by ASTM D3805.

      Exception 2 to Section 110.8(i)4B: Cement- based roof coatings shall contain a minimum of 20 percent cement and shall meet the requirements of ASTM C1583, ASTM D822 and ASTM D5870.

TABLE 110.8-C MINIMUM PERFORMANCE REQUIREMENTS FOR LIQUID APPLIED ROOF COATINGS

Physical Property	ASTM Test Procedure	Requirement
Initial percent elongation (break)	D2370	Minimum 200% @ 73° F (23° C)
Initial percent elongation (break) OR Initial Flexibility	D2370 D522, Test B	Minimum 60% @ 0° F (-18° C) Minimum pass 1" mandrel @ 0° F (-18° C)
Initial tensile strength (maximum stress)	D2370	Minimum 100 psi (1.38 Mpa) @ 73° F (23° C)
Initial tensile strength (maximum stress) OR Initial Flexibility	D2370 D522, Test B	Minimum 200 psi (2.76 Mpa) @ 0° F (-18° C) Minimum pass 1" mandrel @ 0° F (-18° C)
Final percent elongation (break) after accelerated weathering 1000 h	D2370	Minimum 100% @ 73° F (23° C)
Final percent elongation (break) after accelerated weathering 1000 h OR Flexibility after accelerated weathering 1000 h	D2370 D522, Test B	Minimum 40% @ 0° F (-18° C) Minimum pass 1" mandrel @ 0° F (-18° C)
Permeance	D1653	Maximum 50 perms
Accelerated weathering 1000 h	D4798	No cracking or checking[1]

1. Any cracking or checking visible to the eye fails the test procedure.

«» Commentary for Section 110.8(i)4:

Field-Applied Liquid Coatings

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 TE 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. 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. Use ASTM D6848, Standard Specification for Aluminum Pigmented Emulsified Asphalt used as a Protective Coating for Roofing, installed in accordance with ASTM D3805, Standard Guide for Application of Aluminum-Pigmented Asphalt Roof Coatings.

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, 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. «»

(j) Radiant barrier. A radiant barrier shall have an emittance of 0.05 or less, tested in accordance with ASTM C1371 or ASTM E408, and shall be certified to the Department of Consumer Affairs as required by Title 24, Part 12, Chapter 12-13, Standards for Insulating Material.

«» Commentary for Section 110.8(j):

The radiant barrier is a reflective material that reduces radiant heat transfer into the attic from solar heat gain in the roof. Radiant barriers must have an air space next to the foil side to provide its energy benefit. When a radiant barrier is installed, the product must meet mandatory requirements in Section 110.8(j). The radiant barrier must have an emittance of 0.05 or less. The product must be tested according to ASTM C1371 or ASTM E408 and must be certified by the California Department of Consumer Affairs, Bureau of Household Goods and Services and listed in its Consumer Guide and Directory of Certified Insulation Material, at https://bhgs.dca.ca.gov/consumers/ti_directory.pdf. **«»**

Note**:** Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.8, and 25943, Public Resources Code

SECTION 160.1 – MANDATORY REQUIREMENTS FOR BUILDING ENVELOPES

(a) Ceiling and roof insulation. The opaque portions of ceilings and roofs separating conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of Item 1 or 2, and 3 below:

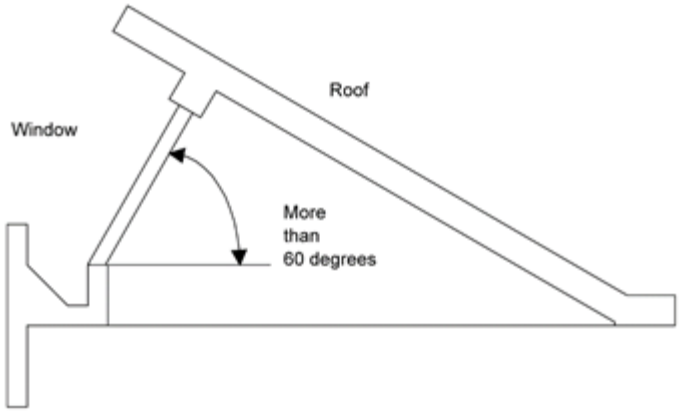
«» Commentary for Section 160.1(a):

Opaque Envelope Definitions

Opaque elements of the building envelope significantly contribute to the related energy efficiency. Components of the building envelope include walls, floors, soffits, roofs, and ceilings. Envelope and other building components definitions are listed in Section 100.1(b) of the Energy Code and the Reference Appendices, Joint Appendix JA1 and several relevant definitions are included here for ease of use.

1. The exterior partition is an opaque, translucent, or transparent solid barrier that separates conditioned space from ambient air or unconditioned space.
2. The demising partition is a wall, fenestration, floor, or ceiling that separates conditioned space from enclosed unconditioned space.
3. The conditioned space is an enclosed space within a building that is either directly conditioned or indirectly conditioned.
4. Unconditioned space is enclosed space within a building that is neither directly conditioned nor indirectly conditioned.
5. Plenum is an air compartment or chamber, including uninhabited crawl space, areas above a ceiling or below a floor, or attic spaces, to which one or more ducts are connected and that forms part of either the supply-air, return-air, or exhaust-air system, other than the occupied space being conditioned.
6. Attic is an enclosed space directly below the roof deck and above the ceiling.
7. Sloping surfaces are considered either a wall or a roof, depending on the slope. (See Figure 3-10: Slope of a Wall or Window [Roof or Skylight Slope Is Less Than 60°].) If the surface has a slope of less than 60° from horizontal, it is considered a roof; a slope of 60° or more is a wall. This definition extends to fenestration products, including windows in walls and any skylight types in roofs.

Figure 3-10: Slope of a Wall or Window (Roof or Skylight Slope Is Less Than 60°)



Source: California Energy Commission

8. The exterior roof is an exterior partition that has a slope less than 60 degrees from horizontal, that has conditioned space below, and that is not an exterior door or skylight.
9. The roof deck is the surface that supports the roofing material. Typically made of plywood or OSB, it is supported by the roof framing members such as rafters or trusses.
10. Exterior floor/soffit is a horizontal exterior partition, or a horizontal demising partition, under conditioned space.
11. Vapor retarder or vapor barrier is a material or assembly designed to limit the amount of vapor moisture that passes through that material or assembly.
12. Roofing products are the top layer of the roof that is exposed to the outside, which has properties including, but not limited to, solar reflectance, TE, and mass.
13. Cool roof is a roofing material with high TE and high solar reflectance, or low TE and exceptionally high solar reflectance, as specified in Part 6, that reduces heat gain through the roof.
14. Solar reflectance is the fraction of solar energy that is reflected by the roof surface.
15. TE is the fraction of thermal energy that is emitted from the roof surface.
16. A low-sloped roof is a surface with a pitch less than 2:12 (less than 9.5 degrees from the horizontal).
17. A steep-sloped roof is a surface with a pitch greater than or equal to 2:12 (9.5 degrees or greater from the horizontal).
18. Air leakage is a measurement of heat loss and gain by infiltration and exfiltration through gaps and cracks in the envelope.
19. Infiltration is the unintentional replacement of conditioned air with unconditioned air through leaks or cracks in the building envelope. It is a major component of heating and cooling loads. Infiltration can occur through holes and cracks in the building envelope and around doors and fenestration framing areas.
20. Reducing infiltration in the building envelope can result in significant energy savings, especially in climates with severe winter and summer conditions. It also can result in improved occupant comfort, reduced moisture intrusion, and fewer air pollutants.
21. Exfiltration is uncontrolled outward air leakage from inside a building, including leakage through cracks, joints, and intersections, around windows and doors, and through any other exterior partition or duct penetration.
22. Ventilation is the intentional replacement of conditioned air with unconditioned air through open windows and skylights or mechanical systems. **«»**

1. Attic roof. Roofs with an attic space shall meet the requirements of A through C below:

A. Shall be insulated to achieve an area-weighted average U-factor not exceeding U-0.043 or shall be insulated between wood-framing members with insulation resulting in an installed thermal resistance of R-22 or greater for the insulation alone. For vented attics, the mandatory insulation shall be installed at the ceiling level; for unvented attics, the mandatory insulation shall be placed at either ceiling or roof level;

B. Attic access doors shall have permanently attached insulation using adhesive or mechanical fasteners. The attic access shall be gasketed to prevent air leakage; and

C. When loose-fill insulation is installed, the minimum installed weight per square foot shall conform with the insulation manufacturer's installed design weight per square foot at the manufacturer's labeled R-value.

«» Commentary for Section 160.1(a)1C:

Attic Roof

Roof/ceiling construction assemblies with an attic space must have at least R-22 insulation between wood framing members or a maximum U-factor of 0.043. Some areas of the roof/ceiling can be greater than the maximum U-factor if other areas have lower U-factors such that the weighted average U-factor for the overall ceiling/roof is 0.043 or less. Metal framed assemblies must also have a weighted U-factor of 0.043 or less.

If insulation is not penetrated by framing, such as rigid insulation laid over a structural deck, then the rigid insulation can have a rated R-value of less than R-22 so long as the total roof/ceiling assembly U-factor is not greater than U-0.043.

Loose-fill insulation must be blown in evenly and insulation levels must be documented on the certificate of installation. The insulation level can be verified by checking that the depth of insulation conforms to the manufacturer’s coverage chart for achieving the required R-value. The insulation also must meet the manufacturer’s specified minimum weight per square foot for the corresponding R-value. **«»**

2. Non-attic roof. Roofs without attic spaces shall meet the applicable requirements of A through C below:

   A. Metal building — The area-weighted average U-factor of the roof assembly shall not exceed 0.098.

   B. Wood framed and others — The area-weighted average U-factor of the roof assembly shall not exceed 0.075.

   C. Insulation placement — When insulation is installed at the roof, fixed vents or openings to the outdoors or to unconditioned spaces shall not be installed. When the space between the ceiling and the roof is either directly or indirectly conditioned space, it shall not be considered an attic for the purposes of complying with CBC attic ventilation requirements.

      Exception to Section 160.1(a)2C: Vents that do not penetrate the roof deck and are instead designed for wind resistance for roof membranes are not within the scope of Section 160.1(a)2C.

«» Commentary for Section 160.1(a)2C:

Non-Attic Roof

For roof/ceiling construction assemblies without an attic space, the maximum weighted average U-factor is 0.098 for metal building and 0.075 for wood framing and others. If insulation is installed at the roof, vents or openings that penetrate the roof deck to the outdoor are prohibited. **«»**

3. Insulation shall be installed in direct contact with a 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.

«» Commentary for Section 160.1(a)3:

Regardless of whether or not there is an attic space, insulation must be installed in direct contact with the air barrier. **«»**

(b) Wall insulation. Opaque portions of above grade walls separating conditioned spaces from unconditioned spaces or ambient air shall meet the following applicable requirements:

1. Metal building—The area-weighted average U-factor of the wall assembly shall not exceed 0.113.
2. Metal framed—The area-weighted average U-factor of the wall assembly shall not exceed 0.151.
3. Wood framed and others—

   A. Nominal 2x4 inch framing shall have an area-weighted average U-factor of the wall assembly not exceeding 0.095.

   B. Nominal 2x6 inch framing shall have an area-weighted average U-factor of the wall assembly not exceeding 0.069.

C. Other wall assemblies shall have an area-weighted average U-factor of the wall assembly not exceeding 0.102.

4. **Light mass walls**—A 6 inch or greater hollow core concrete masonry unit shall have a U-factor not to exceed 0.440.
5. **Heavy mass walls**—An 8 inch or greater hollow core concrete masonry unit shall have a U-factor not to exceed 0.690.
6. **Spandrel panels and curtain wall**—The area-weighted average U-factor of the spandrel panels and curtain wall assembly shall not exceed 0.280.
7. **Demising walls**—The opaque portions of framed demising walls shall meet the requirements of Item A or B below:
   A. Wood framed walls shall be insulated to meet a U-factor not greater than 0.099.
   B. Metal framed walls shall be insulated to meet a U-factor not greater than 0.151.
8. Bay or bow window roofs and floors shall be insulated to meet the wall insulation requirements of Table 170.2-A.

«» Commentary for Section 160.1(a)3:

Wall Insulation Mandatory Requirements:

1. Above-grade walls separating conditioned spaces from other spaces must adhere to maximum area-weighted U-factor requirements based on the material, size, and location of the wall assemblies. The mandatory maximum U-factor requirements for wood-framed walls have been updated in 2025 code cycle to align with requirements for single family residential and reflect increased availability of cost-effective strategies to meet the insulation requirements. The wall insulation requirements listed below include cavity insulation suggestions for wood-framed wall applications. See Reference Joint Appendix JA 4.3 wall tables for more details.
2. The 2x4-inch wood-framed walls above grade must have a U-factor not exceeding 0.095. This requirement could be met with at least R-15 insulation installed in the cavities between framing members, such as a compressed fiber glass batt product that is manufactured to retain an R-15 value in a 3.5” cavity 16” on-center.
3. The 2x6-inch or greater wood-framed walls above grade must have a U-factor not exceeding 0.069. This requirement could be met with at least R-21 insulation installed in the cavities between framing members, such as a compressed fiber glass batt product that is manufactured to retain an R-21 value in a 5.5” cavity 16” on center.
4. Demising and knee walls must not exceed minimum U-factor requirements of 0.099 for wood framing and 0.151 for metal framing. This requirement could be met with at least R-15 compressed fiber glass batt in 3.5” cavity 16” on center.
5. Metal building, mass walls, and spandrel panels and curtain wall construction types must not exceed the U-factor requirement in Table 3-3: Wall Construction U-Factor Requirements.
6. All other wall types (not listed) above grade must meet a maximum U-factor of 0.102.
7. When determining envelope requirements for bay or bow window roofs and floors in Table 170.2-A, the requirements for walls of the same climate zone and material should be used.

Table 3-3: Wall Construction U-Factor Requirements

Wall Construction	Maximum U-Factor
2x4 inch wood-framed walls above grade	0.095
2x6 inch or greater wood-framed walls above grade	0.069
Demising partitions and knee walls – wood framing	0.099
Demising partitions and knee walls – metal framed	0.151
Metal Building	0.113
Metal Framed	0.151
Light Mass Wall	0.440
Heavy Mass Wall	0.690
Spandrel Panel and Curtain Wall	0.280

Source: California Energy Commission

«»

(c) Floor and soffit insulation. The opaque portions of floors and soffits that separate conditioned spaces from unconditioned spaces or ambient air shall meet the applicable requirements of Items 1 through 3 below:

1. Raised mass floors shall have a minimum of 3 inches of lightweight concrete over a metal deck or the area-weighted average U-factor of the floor assembly shall not exceed 0.269.
2. Raised wood floor shall have an overall assembly U-factor not exceeding 0.037. In a wood framed assembly, compliance with the U-factor may be demonstrated by installing insulation with an R-value of 19 or greater.
3. Other floors—The area-weighted average U-factor of the floor assembly shall not exceed 0.071.
4. Heated slab on grade floor—A heated slab on grade floor shall be insulated to meet the requirements of Section 110.8(g).

Exception to Section 160.1(c): A building with a controlled ventilation or unvented crawl space may omit raised floor insulation if all of the following are met:

A. The foundation walls are insulated to meet the wall insulation minimums as shown in Table 170.2-A; and

B. A Class I or Class II vapor retarder is placed over the entire floor of the crawl space; and

C. Vents between the crawl space and outside air are fitted with automatically operated louvers that are temperature actuated; and

D. The requirements in Reference Residential Appendix RA4.5.1.

(d) Vapor retarder.

1. In Climate Zones 1–16, the earth floor of unvented crawl space shall be covered with a Class I or Class II vapor retarder. This requirement shall also apply to controlled ventilation crawl space for buildings complying with the Exception to Section 160.1(c).
2. In Climate Zones 14 and 16, a Class I or Class II vapor retarder shall be installed on the conditioned space side of all insulation in all exterior walls, vented attics and unvented attics with air-permeable insulation.

«» Commentary for Section 160.1(d)2:

In Climate Zones 14 and 16, a continuous Class I or Class II vapor retarder, lapped or joint-sealed, must be installed on the conditioned-space side of all insulation in all exterior walls, on the roof decks of vented attics with above-deck or below-deck air-permeable insulation, and in unvented attics with air-permeable insulation.

Buildings with unvented or controlled-ventilation crawl spaces in all climate zones must have a Class I or Class II vapor retarder placed over the earth floor of the crawl space to reduce moisture entry and protect insulation from condensation in accordance with RA4.5.1.

Vapor retarder class is a measure of the ability of a material or assembly to limit the amount of moisture that passes through the material or assembly. Vapor retarder classes are defined in Section 202 of the California Building Code (CBC). Testing for vapor retarder class is defined using the desiccant method of ASTM E96.

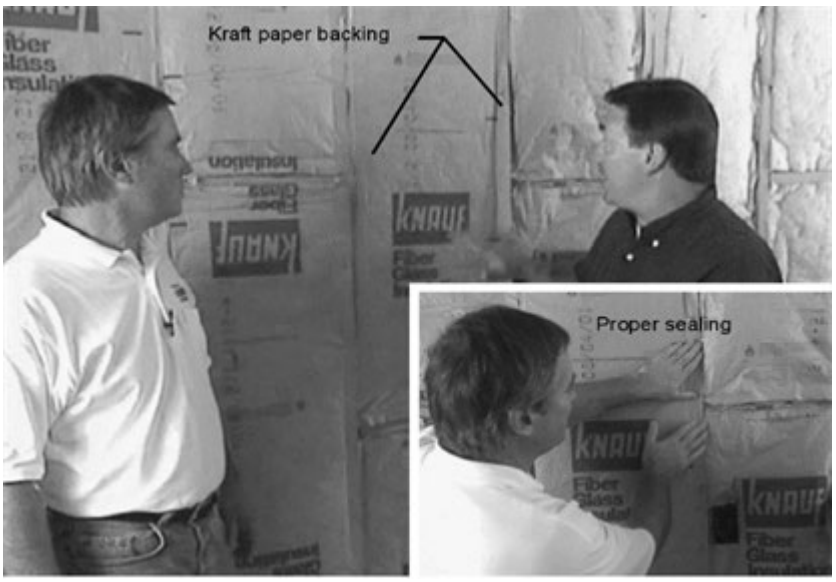
1. Class I: 0.1 perm or less
2. Class II: 0.1 < perm < 1.0 perm
3. Class III: 1.0 < perm < 10 perm

The following are common vapor retarder product types:

1. Foil and other facings on gypsum board can provide moisture resistance, and product literature shows conformance to ASTM E96.
2. Kraft paper facing on thermal batt insulation material is typically a Class II vapor retarder. Faced batts may have flanges for fastening to assembly framing. Fastening flanges may be face- or inset-stapled or not stapled at all, as the flanges provide no moisture control. Face stapling of flanged thermal batts helps ensure the insulation material is installed fully and properly within the framed cavity. Flangeless batts are also common and require no fastening as these materials maintain installation integrity through friction-fitting within the cavity of framed assemblies. In all cases, the insulation must be installed properly.
3. Interior painted surfaces may also serve as vapor retarders if the paint product has been tested and shown to comply with the vapor retarder requirements. The effectiveness of vapor retarder paint depends upon the installed thickness (in mils). These products often require more than one layer to achieve the tested perm rating. Installers of the paint, and building officials at inspection, must ensure proper application to comply with requirements.
4. Closed-cell spray polyurethane foam (ccSPF) products can provide Class I or Class II vapor retarder performance, depending on thickness.

For all types of vapor retarders, care should be taken to seal penetrations, such as electric outlets on exterior walls.

Figure 3-11: Typical Kraft-Faced Vapor Retarder Facing



Source: California Energy Commission

«»

(e) Fenestration products. Fenestration separating conditioned space from unconditioned space or outdoors shall meet the requirements of either Item 1 or 2 below:

1. Fenestration, including skylight products, must have a maximum U-factor of 0.58.

   Exception 1 to Section 160.1(e)1: Up to 0.5 percent of the conditioned floor area is not required to comply with the maximum U-factor requirement.

   Exception 2 to Section 160.1(e)1: For dual-glazed greenhouse or garden windows, up to 30 square feet of fenestration area per dwelling unit is not required to comply with the maximum U-factor requirement.

2. The area-weighted average U-factor of all fenestration, including skylight products, shall not exceed 0.58.

Exception to Section 160.1(e): Fenestration installed in buildings meeting Part 7 of the California Building Code, California Wildland-Urban Interface Code, where the building is located in Fire Hazard Severity Zones or Wildland-Urban Interface (WUI) Fire Areas as designated by the local enforcement agency.

«» Commentary for Section 160.1(e)2:

The preferred methods for determining fenestration U-factor are those in NFRC 100 for manufactured windows and for site-built fenestration. The default U-factors in Table 110.6-A must be used when a NFRC label for the U-factor is not available. The U-factors in Table 110.6-A represent the least efficient possible values, thereby encouraging designers to obtain ratings through NFRC test procedures, when they are available. **«»**

(f) Installation of fireplaces, decorative gas appliances and gas logs. If a masonry or factory-built fireplace is installed, it shall comply with Section 110.5, Section 4.503 of Part 11, and shall have the following:

1. Closable metal or glass doors covering the entire opening of the firebox; and
2. A combustion air intake to draw air from the outside of the building, which is at least 6 square inches in area and is equipped with a readily accessible, operable and tight-fitting damper or combustion-air control device; and

   Exception to Section 160.1(f)2: An outside combustion-air intake is not required if the fireplace will be installed over concrete slab flooring and the fireplace will not be located on an exterior wall.

3. A flue damper with a readily accessible control.

   Exception to Section 160.1(f)3: When a gas log, log lighter or decorative gas appliance is installed in a fireplace, the flue damper shall be blocked open if required by the CMC or the manufacturer's installation instructions.

«» Commentary for Section 160.1(f)3:

Closeable metal or glass doors must cover the entire firebox opening for fireplaces, decorative gas appliances, and gas logs in dwelling unit and common use areas. A combustion air intake no smaller than 6 square inches in area, with a tight-fitting damper or combustion-air control must also be installed. A flue damper with accessible control is also required. **«»**

(g) Slab edge Insulation. Slab edge insulation shall meet the following minimum specifications:

1. Insulation material alone without the facing shall have a water absorption rate no greater than 0.3 percent when tested in accordance with ASTM C272, Test Method A – 24-Hour-Immersion; and
2. Water vapor permeance no greater than 2.0 perm/inch when tested in accordance with ASTM C272; and
3. Concrete slab perimeter insulation shall be protected from physical damage and ultraviolet light deterioration; and
4. Insulation for a heated slab floor shall meet the requirements of Section 110.8(g).

«» Commentary for Section 160.1(g):

The Energy Code includes mandatory requirements for multifamily buildings to ensure that materials used for slab perimeter insulation are suitable for the application, including minimum specifications regarding water absorption rate, water vapor permeance, damage protection, and ultraviolet protection. Insulation material in direct contact with soil, such as perimeter insulation, must have a water absorption rate no greater than 0.3 percent when tested in accordance with ASTM C272 Test Method A, 24-Hour Immersion, and a vapor permeance no greater than 2.0 perm/inch when tested in accordance with ASTM E96. Several types of insulation are widely available in the market that are appropriate for ground contact and for slab edge insulation, such as extruded polystyrene (XPS), rigid fiberglass, and rock wool.

The insulation must be protected from physical and UV degradation by either installing a water-resistant protection board, extending sheet metal flashing below grade, choosing an insulation product that has a hard durable surface on one side, or using other suitable means. **«»**

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 170.1 – PERFORMANCE APPROACH

A building complies with the performance approach if the energy consumption calculated for the proposed design building is no greater than the energy budget calculated for the standard design building using Commission-certified compliance software as specified by Sections 10-109, 10-116 and the Alternative Calculation Method Reference Manual.

«» Commentary for Section 170.1

Performance approach information is included in Chapter 10. «»

(a) Energy budget. The Energy budget is expressed in terms of long-term system cost (LSC) and source energy:

1. **Long-term system cost (LSC).** The LSC energy budget is determined by applying the mandatory and prescriptive requirements of the standard design to the proposed design building and has two components, the Efficiency LSC and the Total LSC.
   A. The Efficiency LSC energy is the sum of the LSC energy for space-conditioning, water heating, mechanical ventilation, lighting and the self-utilization credit.
   B. The Total LSC energy is the sum of the Efficiency LSC energy and LSC energy from the photovoltaic system, battery energy storage systems (BESS), and demand flexibility.
2. **Source energy.** The source energy budget is determined by applying the mandatory and prescriptive requirements of the standard design, except with a consumer gas or propane water heater, to the proposed design building.

Exception to Section 170.1(a): A community shared solar electric generation system, or other renewable electric generation system, and/or community shared BESS, that provides dedicated power, utility energy reduction credits or payments for energy bill reductions to the permitted building and is approved by the Energy Commission as specified in Title 24, Part 1, Section 10-115, may offset part or all of the solar electric generation system or BESS LSC energy required to comply with the standards, as calculated according to methods established by the Commission in the Nonresidential ACM Reference Manual.

(b) Compliance demonstration requirements for performance standards.

1. Certificate of Compliance and Application for a Building Permit. The application for a building permit shall include documentation pursuant to Sections 10-103(a)1 and 10-103(a)2 that demonstrates, using an approved calculation method, that the building has been designed so that its source energy and LSC energy consumption do not exceed the standard design energy budgets for the applicable climate zone.
2. Field verification of individual dwelling unit systems. When performance of installed features, materials, components, manufactured devices or systems above the minimum specified in Section 170.2 is necessary for the building to comply with Section 170.1, or is necessary to achieve a more stringent local ordinance, field verification shall be

performed in accordance with the applicable requirements in the following subsections, and the results of the verification(s) shall be documented on applicable Certificates of Installation pursuant to Section 10-103(a)3 and applicable Certificates of Verification pursuant to Section 10-103(a)5.

F. Dwelling unit enclosure air leakage. When performance compliance requires a building enclosure leakage rate that is lower than the standard design, the building enclosure shall be field verified in accordance with the procedures specified in Reference Residential Appendix RA3.8.

G. Quality insulation installation (QII). When performance compliance requires field verification of QII, the building insulation system shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.5.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 170.2 – PRESCRIPTIVE APPROACH

Multifamily buildings, including both dwelling units and common use areas, that comply with the prescriptive standards shall be designed, constructed and equipped to meet all of the requirements for the appropriate climate zone shown in Table 170.2-A. In Table 170.2-A, NA (not allowed) means that feature is not permitted in a particular climate zone and NR (no requirement) means that there is no prescriptive requirement for that feature in a particular climate zone. Installed components shall meet the following requirements:

(a) **Envelope component requirements**.

1. **Exterior roofs and ceilings**. Exterior roofs and ceilings shall comply with each of the applicable requirements in this subsection:

   A. Roofing products. All roofing products shall meet the requirements of Section 110.8 and the applicable minimum aged solar reflectance and thermal emittance requirements of Table 170.2-A.

      Exception 1 to Section 170.2(a)1A: Roof area covered with building integrated photovoltaic panels and building integrated solar thermal panels are not required to comply with the minimum requirements for solar reflectance and thermal emittance or SRI.

      Exception 2 to Section 170.2(a)1A: Roof constructions with a weight of at least 25 lb/ft² are not required to comply with the minimum requirements for solar reflectance and thermal emittance or SRI.

«» Commentary for Section 170.2(a)1A:

Energy-efficient cool roofs are prescriptively required. The prescriptive requirements are defined based on three-year SR and TE, or SRI, as summarized in Table 3-4: Prescriptive Cool Roof Requirements. The requirements differ depending on roof slope, climate zone, and whether roof/ceiling Option B, C, or D (as defined below in Section 170.2(a)1B) is selected. These distinctions are used to maximize energy savings for specific roofing structures in climate zones with high solar heat gain. Climate Zones 10, 11, 13 and 15 have higher requirements for steep-slope Option B roof types, and the requirements for low-sloped roof Option D have been expanded to most climate zones. If a cool roof is being installed to comply with the Energy Code, it must meet the mandatory product and labeling requirements of Section 110.8(i) of the Energy Code. See Section 180.1 for additions and Section 180.2 for alterations.

Table 3-4: Prescriptive Cool Roof Requirements

Roof Type[1]	Climate Zone	Minimum Three-Year Solar Reflectance	Minimum Thermal Emittance	Minimum SRI
Steep-sloped, Option B	12, and 14	0.20	0.75	16
Steep-sloped, Option B	10-11, 13, and 15	0.25	0.75	23
Steep-sloped, Option C	10-15	0.20	0.75	16
Steep-sloped Option D	2-15	0.20	0.75	16
Low-sloped Option B and C	13, and 15	0.63	0.75	75
Low-sloped Option D	2, 4, and 6-15	0.63	0.75	75

[1] Low-sloped roof is defined as having a surface with a pitch less than 2:12 (less than 9.5 degrees from the horizon). A steep-sloped roof is a surface with a pitch greater than or equal to 2:12 (9.5 degrees or greater from the horizontal).

Source: California Energy Commission

There are two exceptions to meeting these prescriptive requirements:

1. Roof area covered with building-integrated photovoltaic panels or building-integrated solar thermal panels. 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 facades. These materials refer to roofing material that is a photovoltaic or solar thermal panel. Any roof area that is not building-integrated photovoltaic or solar thermal panel must still meet applicable roofing material requirements, including any roof area that has a photovoltaic or solar thermal system above it. **OR**
2. Roof constructions that have a weight of at least 25 pounds per square foot, including EPDM with stone ballast and slate roofing.**«»**

B. Roof insulation. Roofs shall have an overall assembly U-factor no greater than the applicable value in Table 170.2-A, meeting i, ii, iii or iv below. Where required by Sections 110.8 and 160.1(a), insulation shall be placed in direct contact with a continuous roof or drywall ceiling.

i. Option A: Reserved.

ii. Option B: A minimum R-value of insulation installed between the roof rafters in contact with the roof deck and an additional layer of ceiling insulation located between the attic and the conditioned space when meeting Section 170.2(c)3Biia; or

iii. Option C: A minimum R-value of ceiling insulation located between the attic and the conditioned space when meeting Section 170.2(c)3Biib.

iv. Option D: A minimum U-factor for roof assemblies above conditioned space without attic space.

«» Commentary for Section 170.2(a)1B:

The Energy Code is designed to offer flexibility to builders and designers of multifamily newly constructed buildings in terms of achieving the intended energy efficiency targets. Thus, the Energy Code offers several compliance options for roof insulation in multifamily buildings, as summarized in Table 3-5: Summary of Multifamily Roof Insulation Options.

Table 3-5: Summary of Multifamily Roof Insulation Options

Roof / Ceiling Insulation Option	Attic Space	Below Roof Deck Insulation	Ceiling Insulation	Radiant Barrier	Duct and Air Handler Location
B	Yes, ventilated	Required in climate zones 4 and 8-16	Yes	Required in climate zones 2-3, 5-7	Allowed in ventilated attic
C	Yes, ventilated	Not required	Yes	Required in climate zones 2-15	Within conditioned space
D	No	As needed to meet assembly U-factor requirements	As needed to meet assembly U-factor requirements	Not required	Within conditioned space

Source: California Energy Commission

Option B has a vented attic space and uses a combination of ceiling insulation and below-roof deck insulation.

Option C also has a vented attic space but uses ceiling insulation only.

Option D has no attic space and uses U-factor requirements instead of insulation levels.

The prescriptive requirements for Option B and Option C assume that the building is built with the following construction practices:

1. The attic is ventilated with an appropriate free vent area as described below.
2. The roof is constructed with standard wood rafters and trusses.
3. For Option B, the outermost layer of the roof construction is either tiles or a roofing product installed with an air gap between it and the roof deck.
4. The air handler and ducts are in the ventilated attic for Option B and are otherwise in conditioned space for Option C.
5. The air barrier is located at the ceiling (except cathedral and sealed attic roof/ceiling systems).

If a building design does not meet all of these specifications, for example, an unvented attic, it must comply through the performance approach.

Section 170.2 requires different values of roof and ceiling insulation, depending on whether Option B or Option C is chosen. Table 3-6: Prescriptive Insulation Options shows a prescriptive requirements checklist for each option based on Table 170.2-A.

Table 3-6: Prescriptive Insulation Options

Ventilated Attics	Ventilated Attics With Ducts in Conditioned Space	No Attic
Option B	**Option C**	**Option D**
¨ Vented attic ¨ R-19 (CZ 4, 8-9, 11-15) or R-13 (CZ 10, 16) **below roof deck** batt, spray in cellulose/fiberglass secured with netting, or spray foam ¨ R-38 (CZ 1, 2, 4, 8-16) ceiling insulation or R-30 (CZ 3 and 5-7) ¨ Radiant barrier (CZ 2, 3, 5-7) ¨ Air space between roofing and the roof deck	¨ Vented attic ¨ R-38 (CZ 1, 11-16) ceiling insulation or R-30 (CZ 2-10) ¨ R-6 or R-8 ducts (climate zone-specific) ¨ Radiant barrier (CZ 2-15)	¨ No attic space ¨ Maximum U-factor of 0.041 for metal buildings ¨ Maximum U-factor of 0.028 (CZ 1-2, 4, 8-16) or 0.034 (CZ 3, 5-6) or 0.039 (CZ7)

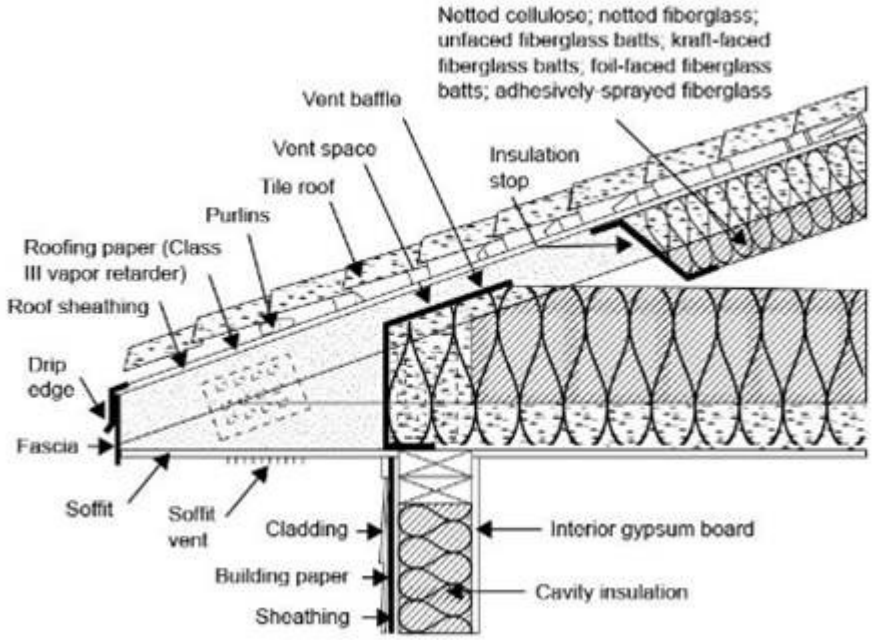
Source: California Energy Commission

Below Roof Deck Insulation (Option B)

In a vented attic, air-permeable or air-impermeable insulation (batt, spray foam, loose-fill cellulose, or fiberglass) should be placed directly below the roof deck between the truss members and secured in place to provide a thermal break. Figure 3-12: Details of Option B Assembly shows an example of insulation details in an Option B attic. Insulation must be in direct contact with the roof deck and secured by the insulation adhesion, facing, mechanical fasteners, wire systems, a membrane material, or netting. Batts supported with cabling or other mechanical methods from below must have supports that are less than or equal to 16" apart and no further than 8" from the end of the batt. Figure 3-13: Placement of Insulation Below the Roof Deck shows the placement and provides example attachment methods for below-deck insulation.

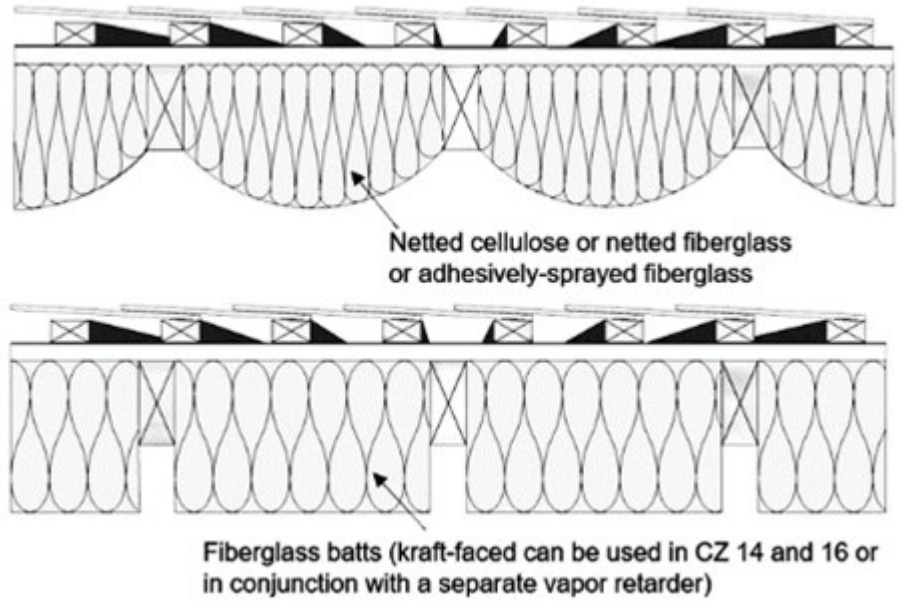
When batt thickness exceeds the depth of the roof framing members, full-width batts must be used to fit snugly and allow batts to expand beyond the framing members. Full coverage of the top chord framing members by insulation is recommended as best practice but is not required.

Figure 3-12: Details of Option B Assembly



Source: California Energy Commission

Figure 3-13: Placement of Insulation Below the Roof Deck



Source: California Energy Commission

When insulation is installed below the roof deck to meet the prescriptive requirements of Option B, a radiant barrier is not required.

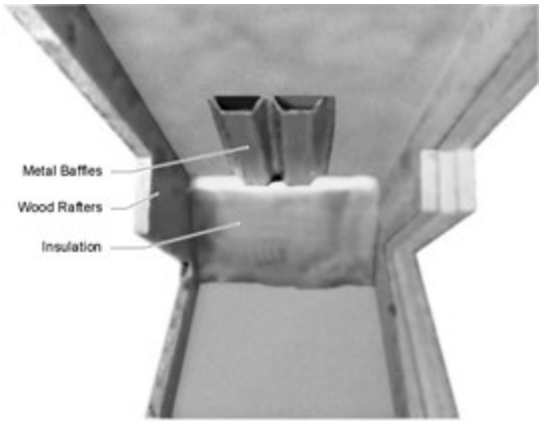
Attic Ventilation (Options B and C)

Proper attic ventilation occurs at two points at the roof: the soffit (or eave) vents and the ridge vents.

When installing insulation below the roof deck, vent baffles and insulation barriers should be used to maintain proper ventilation space. Proper airflow through the space helps remove moisture and prevents any associated issues.

Where ceiling insulation is installed next to eave or soffit vents, a rigid baffle should be installed at the top plate to direct ventilation air up and over the ceiling insulation. (See Figure 3-14: Baffles at the Eave in Attics.) The baffle should extend beyond the height of the ceiling insulation and should have sufficient clearance between the baffle and roof deck at the top. There are several acceptable methods for maintaining ventilation air, including preformed baffles made of cardboard or plastic. In some cases, plywood or rigid foam baffles are used.

Figure 3-14: Baffles at the Eave in Attics



Source: California Energy Commission

The CBC requires a minimum vent area to be provided in roofs with attics, including enclosed rafter roofs that create cathedral or vaulted ceilings. Check with the local building jurisdiction to determine which of the two CBC ventilation requirements are to be followed:

1. CBC, Title 24, Part 2, Vol. 1, Section 1203.2 requires that the net-free ventilating area must not be less than 1/300 of the area of the space ventilated.
2. CBC, Title 24, Part 2.5, Section R806.2 requires that the net-free ventilating area must not be less than 1/150 of the area of the space ventilated. This ratio may be reduced to 1/300 if a ceiling vapor retarder is installed in Climate Zones 14 and 16.

If meeting number 1 above, a minimum of 40 percent and not more than 50 percent of the vents must be located at least 3 feet (ft.) above the eave or cornice vents in the upper portion of the space being ventilated.

Insulation must not block the free flow of air, and a minimum 1-inch air space must be provided between the insulation and the roof sheathing and at the location of the vent.

Ventilated openings are covered with corrosion-resistant wire cloth screening or similar mesh material. When part of the vent area is blocked by meshes or louvers, the resulting net-free area of the vent must be considered to determine if ventilation requirements are met.

Many jurisdictions in California are covered by Wildland Urban Interface (WUI) regulations where specific requirements for construction materials must be used to improve building fire resistance. These regulations require special vents that are expressly tested to resist the intrusion of flame and embers. Check with the AHJ to ensure compliance with local codes.

Ducts and Air Handlers Located in Conditioned Space

Ducts may be located and verified to be in conditioned space instead of installing insulation at the roof deck. If complying with this option, ceiling and duct insulation must be installed at the values specified in Table 170.2-B for Option C, and a radiant barrier is required in most climate zones.

Energy Code Compliance (ECC) Verification (Option C)

Locating ducts in conditioned space does not alone qualify for this requirement; an ECC-Rater must test and verify for low-leakage ducts within conditioned space and verify that the ducts are insulated to a level required in Table 170.2-K of the Energy Code.

Design strategies that can be used to prescriptively comply with Option C include dropped ceilings (dropped soffit), plenum, or scissor truss to create a conditioned plenum box, and open-web floor truss. The ducts and equipment must be within the air barrier of the building. Locating ducts within an unvented attic does not meet Option C requirements.

Ceiling Insulation (Options B and C)

Insulation coverage should extend far enough to the outside walls to cover the bottom chord of the truss. However, insulation should not block eave vents in attics because the flow of air through the attic space helps remove moisture that can build up in the attic and condense on the underside of the roof deck. This condensation can cause structural damage and reduce the effectiveness of the insulation.

Based on area-weighted averaging, ceiling insulation may be tapered near the eave, but it must be applied at a rate to cover the entire ceiling at the specified level. An elevated truss, or raised heel truss, is not required but may be desirable in some applications. **«»**

C. Radiant barrier. A radiant barrier required in Table 170.2-A shall meet the requirements specified in Section 110.8(j) and shall meet the installation criteria specified in Reference Residential Appendix RA4**.**

«» Commentary for Section 170.2(a)1C:

The prescriptive requirements call for Option C vented attics to have a radiant barrier in Climate Zones 2 through 15, while Option B vented attics require a radiant barrier in Climate Zones 2, 3, and 5 through 7.

Installation

The most common way of meeting the radiant barrier requirement is to use roof sheathing that has a radiant barrier bonded to it by the manufacturer. Some oriented strand board (OSB) products have a factory-applied radiant barrier. The sheathing is installed with the radiant barrier (shiny side) facing down toward the attic space.

Alternatively, a radiant barrier material that meets the same ASTM test and moisture perforation requirements that apply to factory-laminated foil can be field-laminated. Field lamination must use a secure mechanical means of holding the foil-type material to the bottom of the roof decking such as staples or nails that do not penetrate all the way through the roof deck material. Roofs with gable ends must have a radiant barrier installed on the gable ends to meet the radiant barrier requirement.

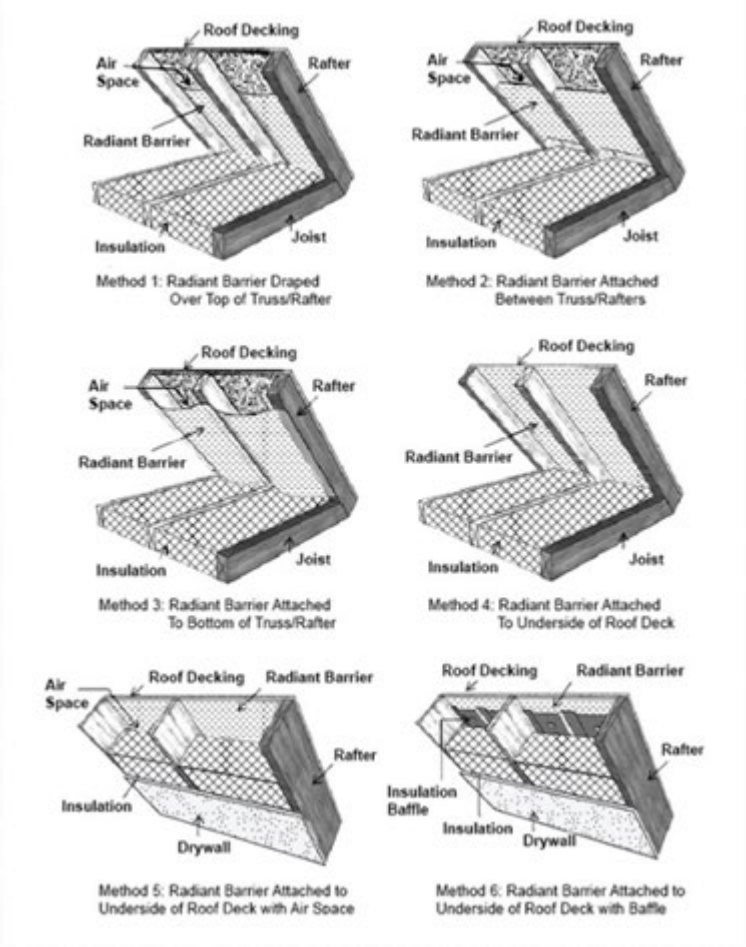
Other acceptable methods are to drape a foil type radiant barrier over the top of the top chords before the sheathing is installed, stapling the radiant barrier between the top chords after the sheathing is installed, and stapling the radiant barrier to the underside of the

truss/rafters (top chord). For these installation methods, the foil must be installed with spacing requirements as described in Reference Appendices, Residential Appendix RA4.2.1.

Installation of radiant barriers is somewhat more challenging in the case of closed rafter spaces, particularly when roof sheathing is installed that does not include a laminated foil-type radiant barrier. Radiant barrier foil material may be field-laminated after the sheathing has been installed by laminating the foil to the roof sheathing between framing members. This construction type is described in the Residential Reference Appendices RA4.2.1.1. Figure 3-15: Methods of Installation for Radiant Barriers for drawings of radiant barrier installation methods.

If a radiant barrier is installed in closed rafter spaces, such as a cathedral ceiling, the required air space for radiant barriers must be provided and must meet the ventilation requirements of the CBC, Title 24, Part 2.5, Section R806.1.

Figure 3-15: Methods of Installation for Radiant Barriers



Source: California Energy Commission

«»

2. **Wall insulation.**

   A. Exterior walls shall have an overall assembly U-factor no greater than the applicable value in Table 170.2-A.

   B. Demising walls shall meet the requirements of Section 160.1(b)7. Vertical windows in demising walls between conditioned and unconditioned spaces shall have an area-weighted average U-factor no greater than the applicable value in Table 170.2.

«» Commentary for Section 170.2(a)2B:

Requirements for wall U-factor and insulation are grouped by a combination of factors: wall assembly fire rating and construction type. In prescriptive requirements, all framed walls regardless of the framing material (wood, metal, or others) are subdivided into those with one-hour or lower fire rating and those with higher than one-hour fire rating. This differentiation in the Energy Code allows high-fire rating (one-hour or higher) wall types, which have constructability limitations and are more costly to insulate, to adhere to less stringent U-factor requirements than walls with lower fire ratings (lower than one hour).

The fire-resistance rating of a wall's is determined by the fire code and is measured in hours. Chapter 6 of the CBC describes fire-resistance rating in detail, and the specific rating of a building's is ultimately decided upon by the local building official. The fire rating for the exterior walls of a building depends on the construction type, based on the number of stories, building height, occupancy type, and fire-suppression system type. A wall's fire-resistance rating can also vary due to fire-separation distance, though for residential occupancy types, fire-separation distance never changes a wall's rating from 1-hour to 2-hour (or more). Code officials use CBC Tables 601, 602, 504.3 and 504.4 in combination to make the wall fire-rating determinations. The determination method is generally well understood, and fire-resistance rating info is readily available from the building architect. Generally, buildings with six or more stories and heavy-timber buildings have high fire-ratings, while buildings of five or fewer stories have a low-fire rating. In most cases, all walls of a specific building will fall under one of the two categories used in Table 170.2-A.

There are five common classes of wall constructions: wood-framed, metal-framed, metal building walls, light mass, and heavy mass (Figure 3-16: Classes of Wall Construction). 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 2022 California Building Code, Type V 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 to 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. From Reference Appendices, Joint Appendix

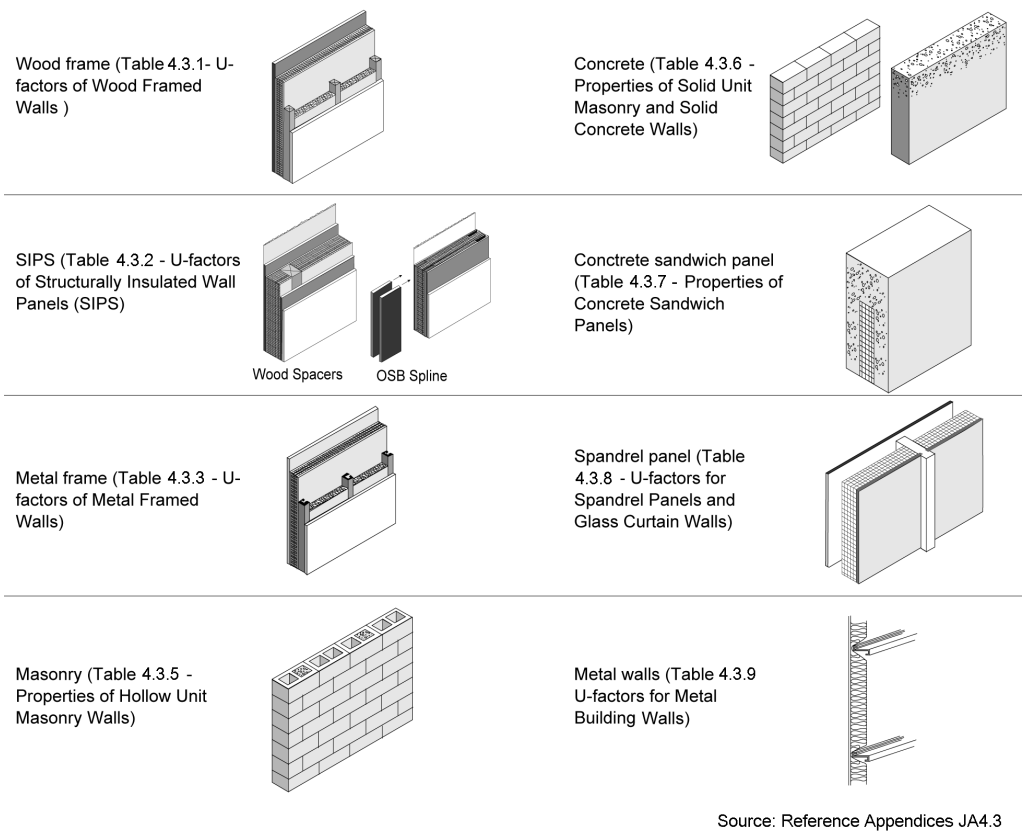
JA4, Tables 4.3.5 and 4.3.6 have U-factor, C-factor, and heat capacity data for hollow unit masonry walls, solid unit masonry and concrete walls, and concrete sandwich panels.

Heavy-mass walls

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

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.

Figure 3-16: Classes of Wall Construction



Source: California Energy Commission

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3. **Fenestration.**

   A. Vertical fenestration and glazed doors in exterior walls shall comply with Subsections i, ii and iii:

      i. Percent fenestration area shall be limited in accordance with the applicable requirements of a and b below:

         a. A total fenestration area no greater than 20 percent of the conditioned floor area; and

         b. A total fenestration area no greater than 40 percent of the gross exterior wall area.

         Note: Demising walls are not exterior walls, and therefore demising wall area is not part of the gross exterior wall area, and fenestration in demising walls is not part of the fenestration area limitation.

«» Commentary for Section 170.2(a)3A:

Multifamily buildings have three prescriptive fenestration area limitations. All three must be met for prescriptive compliance.

1. Total combined vertical fenestration and skylight area may not exceed 20 percent of the conditioned floor area (CFA).
2. Total vertical fenestration may not exceed 40 percent of the gross exterior wall area.
3. Total skylight area may not exceed 5 percent of the gross exterior roof area.

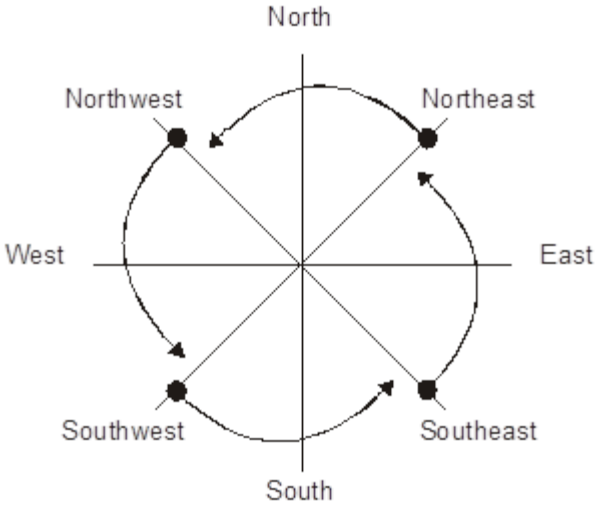
Glazing in a demising wall does not count toward the total building allowance. There is no limit to the amount of glazing allowed in demising walls, but it must meet the prescriptive U-factor requirements for the climate zone.

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 3-17: 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 3-17: Four Surface Orientations



Source: California Energy Commission

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ii. Fenestration properties. Installed fenestration products, including glazed doors, shall have an area-weighted average U-factor, Relative Solar Heat Gain Coefficient (RSHGC), and Visible Transmittance (VT) meeting the applicable fenestration values in Table 170.2-A and shall be determined in accordance with Sections 110.6(a)2 and 110.6(a)3.

Vertical fenestration in demising walls between conditioned and unconditioned spaces is only required to comply with the area-weighted average U-factor requirement in Table 170.2-A.

Exception 1 to Section 170.2(a)3Aii: For each dwelling unit, up to 3 square feet of new glazing area installed in doors shall not be required to meet the U-factor and RSHGC requirements of Table 170.2-A.

Exception 2 to Section 170.2(a)3Aii: For fenestration containing chromogenic type glazing:

a. The lower-rated labeled U-factor and SHGC shall be used with automatic controls to modulate the amount of solar gain and light transmitted into the space in multiple steps in response to daylight levels or solar intensity;

b. Chromogenic glazing shall be considered separately from other fenestration; and

c. Area-weighted averaging with other fenestration that is not chromatic shall not be permitted and shall be determined in accordance with Section 110.6(a).

Exception 3 to Section 170.2(a)3Aii: For dwelling units containing unrated site-built fenestration that meets the maximum area restriction, the U-factor and SHGC can be determined in accordance with Nonresidential Reference Appendix NA6 or using default values in Table 110.6-A and Table 110.6-B.

Exception 4 to Section 170.2(a)3Aii: Fenestration in dwelling units of buildings in Climate Zones 1, 3, 5 and 16 is not required to comply with the RSHGC requirements.

Exception 5 to Section 170.2(a)3Aii: Fenestration in dwelling units is not required to comply with the VT requirements.

«» Commentary for Section 170.2(a)3Aii:

There are several fenestration types and fenestration categories as described below.

Windows

A window is a vertical fenestration product that is an assembled unit consisting of a frame and sash component holding one or more pieces of glazing. Window performance is measured with the U-factor, solar heat gain coefficient (SHGC), and visible transmittance (VT).

Windows are considered part of an exterior wall when the slope is 60° or more. When the slope of fenestration is less than 60°, the glazing is considered a skylight and part of the roof.

Skylights and tubular daylight devices

Skylights and tubular daylight devices (TDD) are an exceptional source of daylight and passive solar heating, illuminating rooms with direct and indirect sunlight. In addition, when used appropriately, daylighting can increase the quality of light in a room and reduce dependence upon electrical lighting. Skylights and TDDs don't typically have the same thermal properties as vertical fenestration and can be prone to greater heat loss in winter and solar heat gain during the summer. When a building designer optimizes the whole envelope glazing arrangement for daylight and thermal control, significant heating and cooling energy savings can be realized, especially when skylights and TDDs are energy efficient.

Glazed doors

Glazed door is an exterior door having a glazed area of 25 percent or more of the area of the door. When the door has less than 25 percent glazing material, it is no longer considered a glazed door. (See exterior doors in previous section). All glazed areas will be counted toward the overall glazed area of the conditioned space in any calculations.

Manufactured fenestration

Manufactured fenestration is a fenestration product constructed of materials that are factory-cut or otherwise factory-formed with the specific intention of being used to fabricate a fenestration product. Knocked down or partially assembled products may be sold as a fenestration product when provided with temporary and permanent labels, as described in Section 10-111, or as a site-built fenestration product when not provided with temporary and permanent labels, as described in Section 10-111.

Site-built fenestration

Site-built fenestration is designed to be field-glazed or field-assembled units, using specific factory-cut or other factory-formed framing, and glazing units that are manufactured with the intention of being assembled at the construction site. These include storefront systems, curtain walls or large-track sliding glass walls, and atrium roof systems.

Field-fabricated fenestration

Field-fabricated fenestration is when the windows are fabricated at the building site from elements that are not sold together as a fenestration product (that is, separate glazing, framing, and weather stripping elements). Field-fabricated does not include site-assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked-down products, sunspace kits, and curtain walls).

Prescriptive multifamily fenestration requirements depend on which of the following window types are installed.

Curtainwall, window wall, or storefront

Curtain wall, window wall, or storefront windows consist of metalized or glass panels often hung outside structural framing to create exterior wall elements around fenestration and between floors.

NAFS Performance Class AW (architectural windows)

NAFS Performance Class AW adhere to industry standard – AAMA/ WDMA/ CSA 101/ I.S.2/ A440 NAFS-2017 North American Fenestration Standard/ Specification, which includes testing requirements for fenestration products based on air leakage resistance, water penetration resistance, uniform load resistance and forced-entry resistance. The Performance Classes are designated R, LC, CW, and AW in order of performance. Higher rated products typically rely on metal window framing materials which lead to high thermal bridging in the window frame and thus higher U-factors. Windows must be certified as NAFS rated to qualify for the category.

The architect calculates the building's wind loads to determine if Class AW windows are needed.

All other fenestration

All other fenestration includes operable windows, punched fixed windows, glass doors, and skylights that do not qualify as NAFS Performance Class AW.

Prescriptive Fenestration Requirements

For vertical and skylight fenestration, for multifamily buildings refer to Table 170.2-A. The maximum fenestration U-factor and maximum relative solar heat gain coefficient (RSHGC), and minimum visible transmittance (VT) depend on window type and climate zone. In heating dominant climate zones 1,3,5, and 16 there is no maximum RSHGC requirement to allow building designers the flexibility to achieve ideal RSHGC levels for annual energy efficiency based on building fenestration orientation and local heating and cooling demand. There is no

longer a distinction between buildings with four or more habitable stories and those with three or less habitable stories. VT requirements apply to multifamily building common use areas.

The requirements apply to fenestration products without consideration of insect screens or interior shading devices. With some exceptions, some fenestration products may exceed the prescriptive requirement as long as the U-factor and RSHGC of windows, glazed doors, and skylights can be area weight-averaged together to meet the prescriptive requirement. **«»**

iii. Shading. Where Table 170.2-A requires a maximum RSHGC, the requirements shall be met with an area-weighted average RSHGC excluding the effects of interior shading, no greater than the applicable value in Table 170.2-A.

For the purposes of this paragraph, the RSHGC of a vertical window is:

a. The solar heat gain coefficient of the window; or

b. Relative solar heat gain coefficient is calculated using Equation 170.2-A, if the window has an overhang that extends beyond each side of the window jamb by a distance equal to the overhang's horizontal projection.

Exception 1 to Section 170.2(a)3Aiiib: An area-weighted average relative solar heat gain coefficient of 0.56 or less shall be used for windows:

I. That are in the first story of exterior walls that form a display perimeter; and

II. For which codes restrict the use of overhangs to shade the windows.

Exception 2 to Section 170.2(a)3Aiiib: For vertical glazing containing chromogenic type glazing:

I. the lower-rated labeled RSHGC shall be used with automatic controls to modulate the amount of heat flow into the space in multiple steps in response to daylight levels or solar intensity; and

II. chromogenic glazing shall be considered separately from other glazing; and

III. area-weighted averaging with other glazing that is not chromogenic shall not be permitted.

Note: Demising walls are not exterior walls, and therefore fenestration in demising walls is not subject to SHGC requirements.

$$RSHGC = SHGC \times [1 + a \times (2.72^{-PF} - 1) \times (\sin(b \times Az) + c)] \quad \text{(Equation 170.2-A)}$$

WHERE:

Component	**a**	**b**	**c**

Overhang	0.150	0.008727	5.67
Exterior Horizontal Slat	0.144	0.008727	5.13

RSHGC = Relative Solar Heat Gain Coefficient.

SHGC = Solar Heat Gain Coefficient of the vertical fenestration.

Az = Azimuth of the vertical fenestration I degrees.

PF = Projection factor as calculated by Equation 140.3-C.

EQUATION 140.3-C PROJECTION AND DISTANCE FACTOR CALCULATION

Projection Factor = Projection / Spacing

Distance Factor – D / (H_{AS} x Projection Factor)

Where:

Projection = The horizontal distance between the base edge and the projected edge of the overhang, slat, or light shelf..

Spacing = For overhangs, the vertical distance between the projected edge of the overhang and sill of the vertical fenestration below it.
For horizontal slats, the vertical distance between the projected edge of a slat to the base edge of the slat below it.
For interior light shelves, the vertical distance between the projected edge of the light shelf and head of the clerestory fenestration above it.
For exterior light shelves, the vertical distance between the projected edge of the light shelf and sill of the vertical fenestration below it.

D = Distance between the existing structure or nature object and the fenestration

H_{AS} = Height difference between the top of the existing structure or nature object and the bottom of the fenestration

NOTE: The base edge is the edge of an overhang, slat, or light shelf that is adjacent to the vertical fenestration. The projected edge is the opposite edge from the base edge.

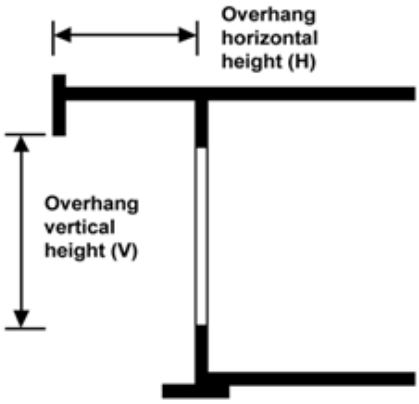
«» Commentary for Section 170.2(a)3Aiii:

Relative solar heat gain coefficient (RSHGC) allows for an external shading correction from exterior shading devices and overhangs. A fenestration product with an SHGC greater than prescriptively required may qualify if an opaque exterior shading device or overhang is used and the combined area-weighted average complies with the prescriptive requirements. Balconies that extend above glazing are common overhangs in multifamily buildings.

For credit, exterior shading devices must be permanently attached as opposed to being attached using clips, hooks, latches, snaps, or ties.

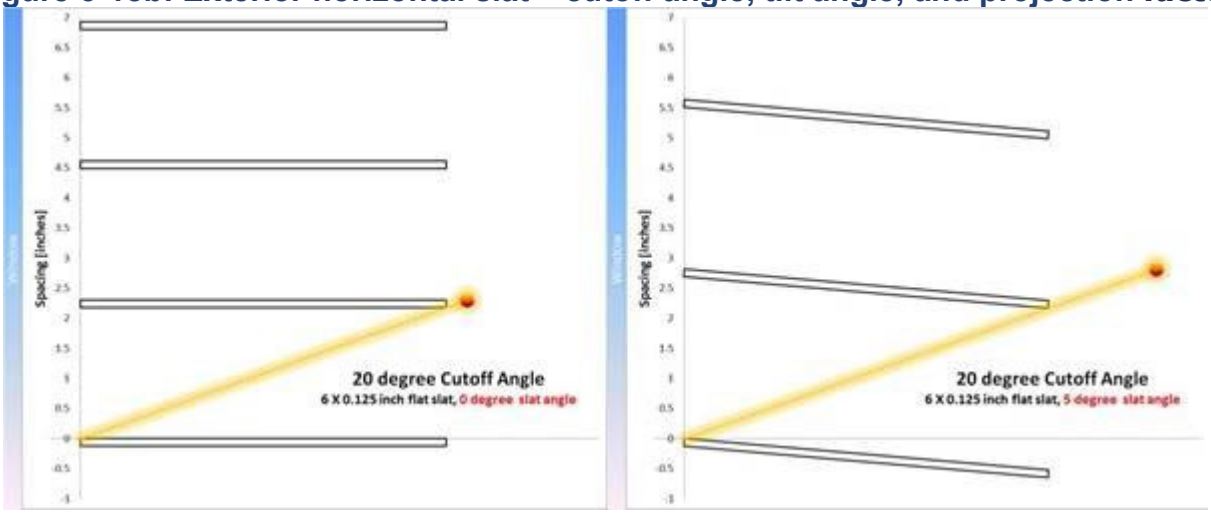
Shading factors depend upon the projection factor (PF) from Equation 140.3-C which is the ratio of the projection (P) and the spacing (s). These dimensions are measured from the vertical and horizontal planes passing through the bottom edge of the window glazing for overhangs or the slat below for horizontal slats, as shown in Figure 3-18a: Overhang Dimensions and Figure 3-18b: 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)5), 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 3-18a: Overhang Dimensions



Source: California Energy Commission

Figure 3-18b: Exterior horizontal slat – cutoff angle, tilt angle, and projection factor



$$RSHGC = SHGC \times [1 + a \times (2.72^{-PF} - 1) \times (\sin(b \times Az) + c)]$$

Where:

RSHGC = Relative solar heat gain

SHGC = NFRC SHGC of the window

Az = Azimuth (orientation) of the window in degrees clockwise from north

PF = Project factor of the exterior shade

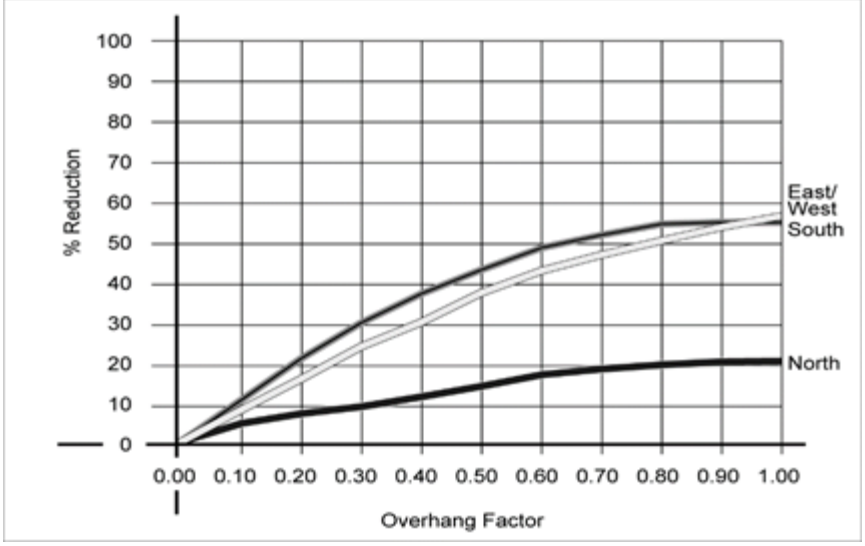
a = 0.170 for overhang or 0.144 for horizontal slat

b = 0.008727 for overhang and horizontal slat

c = 5.67 for overhang or 5.13 horizontal slat

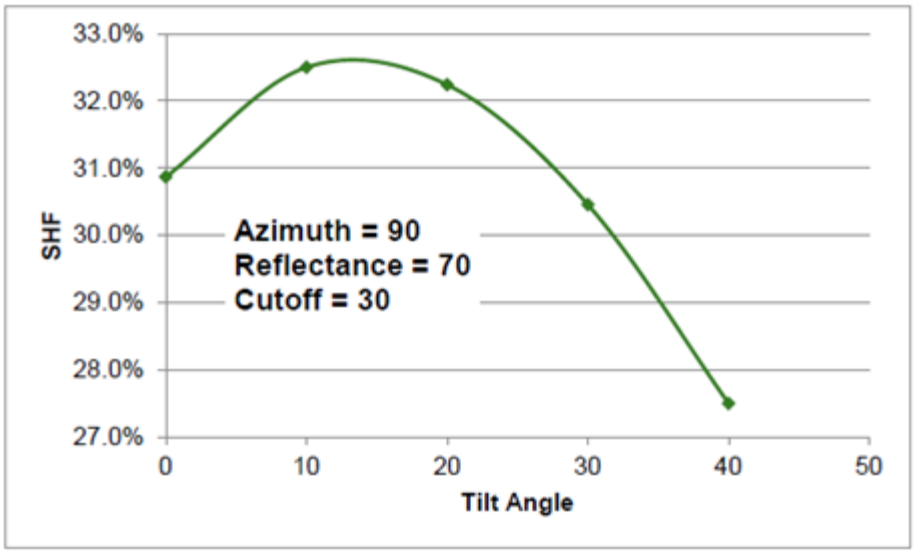
Figure 3-19a: Graph of Shading Factors for Overhangs and Figure 3-19b: Graph of Shading Factors for Horizontal Slats illustrate the benefits of shading factors of the various projection factors as a function of azimuth (orientation) for overhangs and as a function of tilt angle for horizontal slats. 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 towards a southerly direction and also increase as overhangs or slats project more (i.e., have a higher projection factor).

Figure 3-19a: Graph of Shading Factors for Overhangs



Source: California Energy Commission

Figure 3-19b: Graph of Shading Factors for Horizontal Slats



Source: California Energy Commission

Chromogenic Glazing

If a multifamily building includes chromogenic type glazing that is automatically controlled, the lowest U-factor and lowest SHGC must meet the prescriptive requirements. This type of product cannot be weight averaged with nonchromogenic products as per Exception to Section 170.2(a)3Bii and Section 170.2(a)3Biii, Exception 2 to Section 170.2(a)3Aiiib and Exception 3 to Section 170.2(a)3Aiv. **«»**

iv. Vertical fenestration shall have an area-weighted average Visible Transmittance (VT) no less than the applicable value in Table 170.2-A, or Equation 170.2-B, as applicable.

Exception 1 to Section 170.2(a)3Aiv: When the window's primary and secondary sidelit daylit zones are completely overlapped by one or more skylit daylit zones, then the window need not comply with Section 170.2(a)3Aivw.

Exception 2 to Section 170.2(a)3Aiv: If the window's VT is not within the scope of NFRC 200 or ASTM E972, then the VT shall be calculated according to Reference Nonresidential Appendix NA6.

Exception 3 to Section 170.2(a)3Aiv: For vertical windows containing chromogenic type glazing:

a. The higher rated labeled VT shall be used with automatic controls to modulate the amount of light transmitted into the space in multiple steps in response to daylight levels or solar intensity;

b. Chromogenic glazing shall be considered separately from other glazing; and

c. Area-weighted averaging with other glazing that is not chromogenic shall not be permitted.

Exception 4 to Section 170.2(a)3Aiv: Fenestration in dwelling units is not required to comply with the VT requirements.

NOTE: Demising walls are not exterior walls, and therefore windows in demising walls are not subject to VT requirements.

$$VT \geq 0.11/WWR \qquad \text{(Equation 170.2-B)}$$

where:

WWR = Window Wall Ratio, the ratio of (i) the total window area of the entire building to (ii) the total gross exterior wall area of the entire building. If the WWR is greater than 0.40, then 0.40 shall be used as the value for WWR in Equation 170.2-B.

VT = Visible Transmittance of framed window.

«» Commentary for Section 170.2(a)3Aiv:

Fenestration in multifamily common areas 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. This allows daylight to enter the space through the high VT glazing making a better daylighting design.

Fenestration in multifamily dwelling units does not have to comply with the prescriptive VT requirements. **«»**

B. **Skylights shall**:

i. Have an area no greater than 5 percent of the gross exterior roof area Skylight Roof Ratio (SRR); and

Exception 1 to Section 170.2(a)3Bi: Buildings with an atrium over 55 feet high shall have a skylight area no greater than 10 percent of the gross exterior roof area.

ii. Have an area-weighted performance rating U-factor no greater than the applicable value in Table 170.2-A.

Exception 2 to Section 170.2(a)3Bii: For each dwelling unit up to 16 square feet of new skylight area with a maximum U-factor of 0.55 and a maximum SHGC of 0.30.

iii. Solar heat gain coefficient. Have an area-weighted performance rating solar heat gain coefficient no greater than the applicable value in Table 170.2-A.

Exception to Sections 170.2(a)3Bii and 170.2(a)3Biii: For skylights containing chromogenic type glazing:

a. the lower-rated labeled SHGC shall be used with automatic controls to modulate the amount of heat flow into the space in multiple steps in response to daylight levels or solar intensity; and

b. chromogenic glazing shall be considered separately from other glazing; and

c. area-weighted averaging with other glazing that is not chromogenic shall not be permitted.

iv. Haze value. Have a glazing material or diffuser that has a measured haze value greater than 90 percent, determined according to ASTM D1003 or other test method approved by the Energy Commission.

Exception to Section 170.2(a)3Biv: Skylights designed and installed to exclude direct sunlight entering the occupied space by the use of fixed or automated baffles or the geometry of the skylight and light well.

«» Commentary for Section 170.2(a)3Biv:

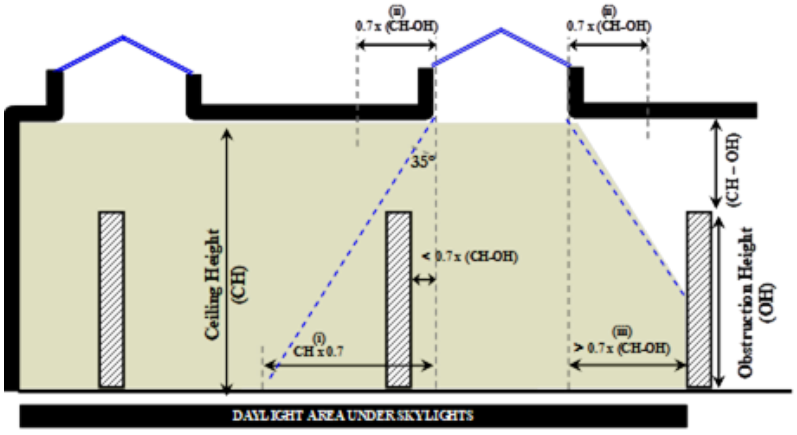
Skylight area is defined in Reference Appendices, Joint Appendix JA1 as the area of the rough opening of a skylight. The area limit for skylights is 5 percent of the gross exterior roof area, called the skylight roof ratio (SRR). The limit increases to 10 percent for buildings with an atrium more than 55 feet high. The 55-foot height is the threshold at which the California Building Code requires a mechanical smoke-control system for atriums (CBC Sec. 909). This means that the 10 percent SRR is not allowed for atriums unless they also meet the smoke control requirement.

Skylights shall have a glazing material or diffuser that has a measured haze value greater than 90 percent, tested according to ASTM D1003 (notwithstanding its scope) or other test method approved by the Energy Commission.

When the skylights are above unconditioned spaces (as per Section 170.2(b)), there is no limitation placed on the maximum skylight area or the U-factor or SHGC. Regardless of whether the space is conditioned, the Energy Code requires that the skylights diffuse and bring in enough sunlight so that, when the electric lights are turned off, the occupants have relatively uniform daylight in the space. If the space is unconditioned, single-glazed skylights will comply with the code requirements as long as the glazing or diffuser material has a haze rating greater than 90 percent. Products that have such a rating include prismatic diffusers, laminated glass with diffusing interlayers, pigmented plastics, and so forth. This requirement assures that light is diffused over all sun angles. Any unconditioned space that later becomes conditioned must meet the newly constructed building envelope requirements. Therefore, if the space may become conditioned in the future, it is recommended that the envelope meet the conditioned envelope thermal requirements.

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

Figure 3-20: Daylit Area Under Skylights



Source: California Energy Commission

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4. All exterior doors, excluding glazed doors, that separate conditioned space from unconditioned space or from ambient air shall have a U-factor not greater than the applicable value in Table 170.2-A. Glazed doors must comply with the requirements of Section 170.2(a)3A.

   Exception to Section 170.2(a)4: Swinging doors that are required to have fire protection are not required to meet the applicable door value in Table 170.2-A.

«» Commentary for Section 170.2(a)4:

An opaque door is an installed swinging door separating conditioned space from outside or adjacent unconditioned space with less than 25 percent glazed area. A door that has 25 percent or more glazed area is a glazed door and is treated like a fenestration product. The requirement is applicable to doors for individual dwelling units and in common use area.

Opaque dwelling unit entry doors between conditioned and unconditioned space are prescriptively required to have an area-weighted average U-factor no greater than U-0.20, per Table 170.2-A. Swinging common use entry doors on separating conditioned and unconditioned space prescriptively require a 0.70 U-factor. Swinging doors between unconditioned and conditioned space that are required to have fire protection are exempt from the prescriptive requirement. As an example, this may include a fire protection door that separates a conditioned dwelling unit and unconditioned corridor space. Non-swinging entry doors for common use areas must have a 1.45 U-factor requirement to meet prescriptive requirements, except in climate zones 1 and 16 where the U-factor requirement is 0.50. 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.

At the field inspection, the field inspector verifies that the door U-factor meets the energy compliance values by checking the NFRC label sticker on the product. When manufacturers do not rate the thermal efficiencies by NFRC procedures, the Energy Commission default values must be used and documented on a temporary default label. Default U-factors values for various door types are shown in Table 3-7: Default U-Factors for Doors per JA Table 4.5.1.

Table 3-7: Default U-Factors for Doors per JA Table 4.5.1

Description	U-factor (Btu/ °F-ft2)
Uninsulated single-layer metal swinging doors or non-swinging doors, including single-layer uninsulated access hatches and uninsulated smoke vents:	1.45
Uninsulated double-layer metal swinging doors or non-swinging doors, including double-layer uninsulated access hatches and uninsulated smoke vents:	0.70
Insulated metal swinging doors, including fire-rated doors, insulated access hatches, and insulated smoke vents:	0.50

Wood doors, minimum nominal thickness of 1-3/4 in. (44 mm), including panel doors with minimum panel thickness of 1-1/8 in. (28 mm), and solid core flush doors, and hollow core flush doors:	0.50
Any other wood door:	0.60
Uninsulated single layer metal roll up doors including fire rated door	1.45
Insulated single layer metal sectional doors, minimum insulation nominal thickness of 1-3/8 inch; expanded polystyrene (R-4 per inch).	0.179

Source: California Energy Commission

«»

5. Floors shall meet the following requirements:

   A. Raised floors shall be insulated such that the floor assembly has an assembly U-factor equal to or less than shown in Table 170.2-A, or shall be insulated between wood framing with insulation having an R-value equal to or greater than shown in Table 170.2-A.

   B. Slab floors shall have perimeter insulation installed with an F-factor equal to or less than or R-value equal to or greater than shown in Table 170.2-A. The minimum depth of concrete slab floor perimeter insulation shall be 16 inches or the depth of the footing of the building, whichever is less.

   Exception to Section 170.2(a)5: Raised-floor insulation may be omitted if the foundation walls are insulated to meet the wall insulation minimums shown in Table 170.2-A.

«» Commentary for Section 170.2(a)5B:

Raised-Floor Prescriptive Requirements

The prescriptive requirements differ for concrete raised floors and wood-framed floors. While the requirements for framed floors are the same in all climate zones, the requirements for (concrete) raised mass floors differ.

Wood Framed Raised Floors

The prescriptive U-factor requirement is the same as the mandatory level, at a maximum area-weighted U-factor of 0.037. Alternatively, the prescriptive requirement can be met by having a minimum of R-19 insulation installed between wood framing for framed raised floors in all climate zones.

Concrete Raised Floors

Concrete floors separating multifamily habitable space from a parking garage or other unconditioned spaces are considered exterior raised floors. Insulation requirements for

concrete raised floors differ by climate zone, summarized in Table 3-8: Insulation Requirements for Concrete Raised Floors per Table 170.2-A.

Table 3-8: Insulation Requirements for Concrete Raised Floors per Table 170.2-A

Climate Zone	1,2,11,13,14,16	12,15	3-10
U-Factor	< 0.092	< 0.138	< 0.269
R-Value of Continuous Insulation	> R-8	> R-4	No Req.

Source: California Energy Commission

Other Raised Floors

Other raised floors including metal framed floors. The prescriptive U-factor is 0.048 in climate zone 1, and 0.39 in climate zones 2 and 14 – 16. In climate zones 3 – 13, the prescriptive requirement matches the mandatory requirement at 0.071 U-factor.

Installation

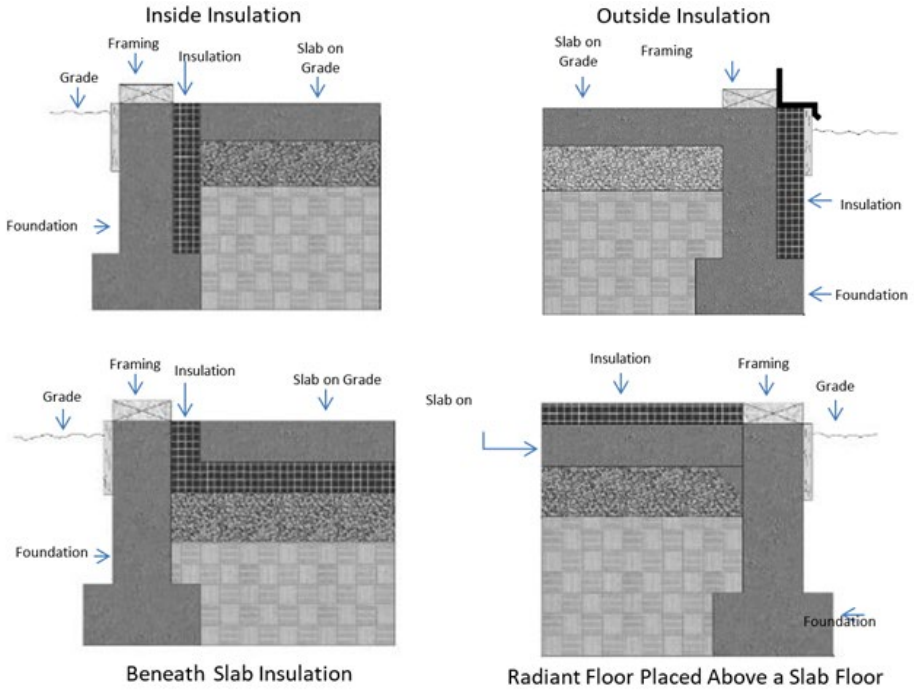
Floor insulation should be installed in direct contact with the subfloor so that there is no air space between the insulation and the floor. Support is needed to prevent the insulation from falling, sagging, or deteriorating. Options for support include netting stapled to the underside of floor joists, insulation hangers running perpendicular to the joists, or other suitable means. Insulation hangers should be spaced at 18 inches or less before rolling out the insulation. Insulation hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration. Netting or mesh should be nailed or stapled to the underside of the joists. Floor insulation should not cover foundation vents.

Slab on Grade Floors.

The 2025 Energy Code has updated Table 170.2-A to require slab insulation for unheated slabs in multifamily buildings in climate zone 16. All heated slabs must meet mandatory insulation requirements in Section 110.8(g).

For unheated slabs in climate zone 16, a minimum of R-7 slab-edge insulation or a maximum F-factor of 0.58 must be achieved. The insulation must be installed to a minimum depth of 16 inches or to the bottom of the footing, whichever is less. The depth is measured from the top of the insulation, as near the top of slab as practical, to the bottom edge of the insulation.

Figure 3-21: Allowed Slab Edge Insulation Placement



Source: California Energy Commission

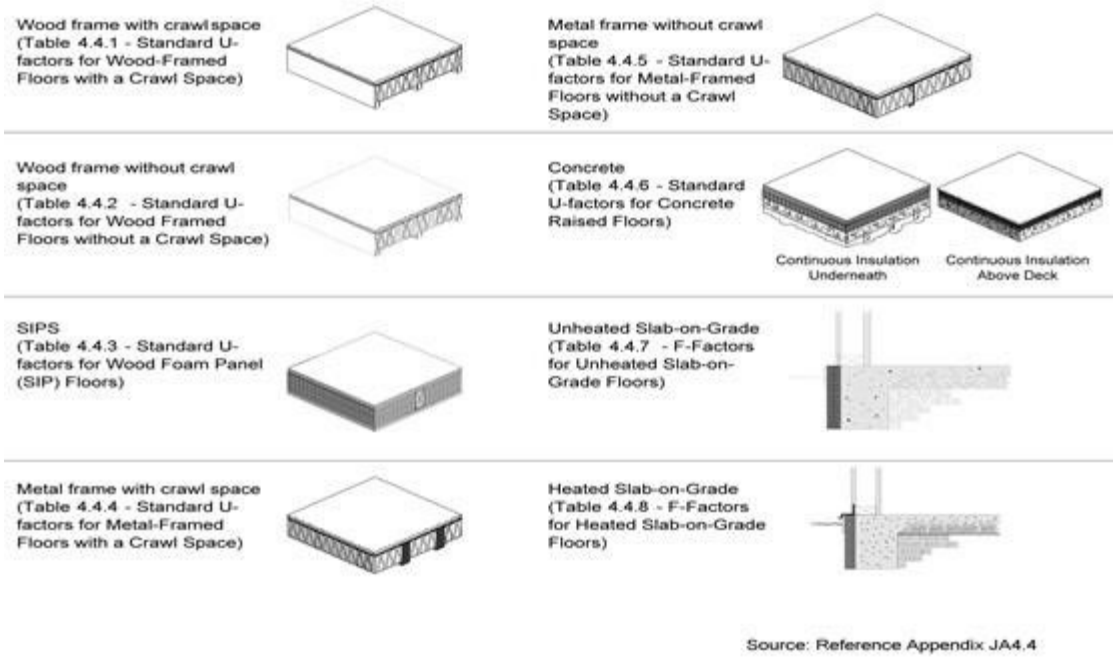
Perimeter insulation is not required along the slab edge between conditioned space and the concrete slab of an attached unconditioned enclosed space such as a garage or covered patio.

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

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

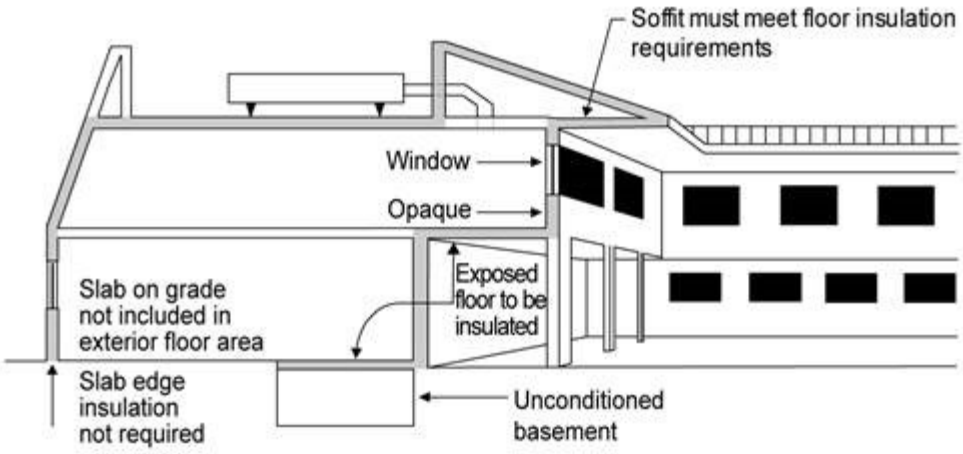
Table 4.4.6 from Reference Appendices, Joint Appendix JA4 is used with mass floors while Tables 4.4.1 through 4.4.5 are used for non-mass floors. (See Figure 3-22: Classes of Floor Constructions.)

Figure 3-22: Classes of Floor Constructions



Source: California Energy Commission

Figure 3-23: Requirements for Floor/Soffit Surfaces



Source: California Energy Commission

«»

6. All buildings up to three habitable stories shall comply with the quality insulation installation (QII) requirements shown in Table 170.2-A. When QII is required, insulation installation shall meet the criteria specified in Reference Appendix RA3.5.

«» Commentary for Section 170.2(a)6:

All insulation must be installed according to manufacturer specifications, throughout the building. In multifamily buildings up to three habitable stories in climate zones 1 – 6 and 8 – 16, a third-party ECC-Rater is required to verify the integrity of the installed insulation. The installer must provide evidence to the ECC-Rater using compliance documentation that all insulation specified is installed to meet specified R-values and assembly U-factors.

To meet QII, two primary installation criteria must be adhered to, and they both must be field-verified by an ECC-Rater. They include air sealing of the building enclosure (including walls, ceiling/roof, and floors), as well as proper installation of insulation. Refer to Reference Appendices, Residential Appendix RA3.5 for more details.

Many multifamily insulation installations have flaws that degrade thermal performance. Four problems are generally responsible for this degradation

1. There is an inadequate air barrier in the building envelope or holes and gaps within the air barrier system that allow air leakage.
2. Insulation is not in contact with the air barrier, creating air spaces that short-circuit the thermal break of the insulation.
3. The insulation has voids or gaps, resulting in portions of the construction assembly that are not properly insulated and, therefore, have less thermal resistance than other portions of the assembly.
4. The insulation is compressed, creating a gap near the air barrier and/or reducing the thickness of the insulation.

QII requires third-party ECC inspection to verify that an air barrier and insulation are installed correctly. Guidance for QII is provided in the Reference Appendices, Residential Appendix RA3.5. QII applies to framed and non-framed assemblies, including the following:

Table 3-9: Framed Assemblies vs. Non-Framed Assemblies

Framed Assemblies	Framed assemblies include wood and steel construction insulated with batts of mineral fiber, mineral and natural wool, or cellulose; loose-fill insulation of mineral fiber, mineral and natural wool, cellulose, or spray polyurethane foam (SPF). Rigid board insulation may be used on the exterior or interior of framed or non-framed assemblies.
Non-framed Assemblies	Non-framed assemblies include structural insulated panels (SIP), insulated concrete forms (ICF), and mass walls of masonry, concrete and concrete sandwich panels, log walls, and straw bale.

Source: California Energy Commission

Table 3-10: Installer Tips for Implementing QII provides information on applicability and installation tips and examples for QII practices.

Table 3-10: Installer Tips for Implementing QII

QII Scheduling	In a multifamily building, it is typically necessary to coordinate and schedule multiple site visits to capture the totality of both the air-sealing, and installed insulation portions of the QII inspection requirements. The ECC-Rater must see the entirety of the envelope twice. Once to inspect air-sealed cavities before insulation is installed and again to inspect insulation before it is covered with drywall or other internal finishes. QII coordination and scheduling should account for the following: Staged construction timing between floors or building-zones for hanging insulation and covering it with internal finishes.

	Special interior finishes or structures that may close wall cavities off. For example – bathtubs, tiling, cabinets, and stairwells. Interior finishes being installed soon after insulation is installed. At some sites, contractors will hang drywall on the same day the insulation is installed. The ECC-Rater must inspect the insulation in that small time window.
Applies to all Insulation	QII applies to the whole building (roof/ceilings, walls, and floors). Combinations of insulation types (hybrid systems) are allowed.
Air Barriers	An air barrier must be installed for the entire envelope.
Insulated Headers	Headers must meet one of the following criteria for QII: Two-member header with insulation in between. The header and insulation must fill the wall cavity. There are prefabricated products available that meet this assembly. Example: a 2x4 wall with two 2x nominal headers, or a 2x6 wall with a 4x nominal header and a 2x nominal header. Insulation is required to fill the wall cavity and must be installed between the headers. Two-member header, less than the wall width, with insulation on the interior face. The header and insulation must fill the wall cavity. Example: a 2x6 wall with two 2x nominal headers. Insulation is required to fill the wall cavity and must be installed to the interior face of the wall. Single-member header, less than the wall width, with insulation on the interior face. The header and insulation must fill the wall cavity. Example: a 2x4 wall with a 3-1/8-inch-wide header, or 2x6 wall with a 4x nominal header. Insulation is required to fill the wall cavity and must be installed to the interior face of the wall. Single-member header, same width as wall. The header must fill the wall cavity. Example: a 2x4 wall with a 4x nominal header or a 2x6 wall with a 6x nominal header. No additional insulation is required because the header fills the cavity, provided that the entire wall has at least R-2 insulation.
Panel Box Headers	Wood structural panel box headers may also be used as load-bearing headers in exterior wall construction, when built in accordance with 2019 California Residential Code (CRC) Figure R602.7.3 and Table R602.7.3.
Structural Bracing, Tie-Downs, Steel Structural Framing	Metal bracing, tie-downs, or steel structural framing can be used to connect to wood framing for structural or seismic purposes, and comply with QII if:

	Metal bracing, tie-downs, or steel structural framing is identified on the structural plans. Insulation is installed in a manner that minimizes the thermal bridging through the structural framing assembly. Insulation fills the entire cavity and/or adheres to all six sides and ends of structural assemblies that separate conditioned from unconditioned space. The structural portions of assemblies are airtight.

Source: California Energy Commission

Air Barrier

When an air barrier is required, the air barrier must be installed in a continuous manner across all components of framed and non-framed envelope assemblies. The installer must provide evidence with compliance documentation that the air barrier system meets one or more of the air barrier requirements. More detailed explanation is provided in Reference Appendices, Residential Appendix RA3.5. Documentation for the air barrier includes product data sheets and manufacturer specifications and installation guidelines.

As part of QII for multifamily buildings up to three habitable stories in climate zones 1 – 6 and 8 – 16, a third-party ECC-Rater is required to verify that the air barrier has been installed properly and is integral with the insulation being used throughout the building.**«»**

Exception to Section 170.2(a): The insulation requirements of Table 170.2-A and Table 170.2-B may be met by ceiling, roof deck, wall or floor assemblies that meet the required maximum U-factors using a U-factor calculation method that considers the thermal effects of all elements of the assembly and is approved by the Executive Director.

TABLE 170.2-A ENVELOPE COMPONENT PACKAGE – Multifamily Standard Building Design

Building Component - Roofs and Ceilings	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Option B[9] Below Roof Deck Insulation [1,2] (with air space)	NR	NR	NR	R19	NR	NR	NR	R19	R19	R13	R19	R19	R19	R19	R19	R13
Option B[9] Ceiling Insulation	R 38	R 38	R 30	R 38	R 30	R 30	R 30	R 38	R 38	R 38	R 38	R 38	R 38	R 38	R 38	R 38
Option B[9] Radiant Barrier	NR	REQ	REQ	NR	REQ	REQ	REQ	NR	NR	NR	NR	NR	NR	NR	NR	NR
Option B[9] Low-Slope-Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.63	NR	0.63	NR
Option B[9] Low-Sloped-Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.75	NR	0.75	NR
Option B[9] Low-Sloped-Solar Reflectance Index	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	75	NR	75	NR
Option B[9] Steep-Sloped-Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.25	0.25	0.20	0.25	0.20	0.25	NR
Option B[9] Steep-Sloped-Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0. 75	0.75	0.75	0.75	0.75	0.75	NR
Option B[9] Steep-Sloped-Solar Reflectance Index	NR	NR	NR	NR	NR	NR	NR	NR	NR	23	23	16	23	16	23	NR
Option C[10]-Ceiling Insulation	R 38	R 30	R 30	R 30	R 30	R 30	R 30	R 30	R 30	R 30	R 38	R 38	R 38	R 38	R 38	R 38
Option C[10]-Radiant Barrier	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR
Option C[10] Low-Sloped-Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.63	NR	0.63	NR
Option C[10] Low-Sloped-Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.75	NR	0.75	NR
Option C[10] Low-Sloped-Solar Reflectance Index	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	75	NR	75	NR

Building Component - Roofs and Ceilings	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Option C[10] Steep-Sloped-Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.20	0.20	0.20	0.20	0.20	0.20	NR
Option C[10] Steep-Sloped-Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0. 75	0.75	0.75	0.75	0.75	0.75	NR
Option C[10] Steep-Sloped-Solar Reflectance Index	NR	NR	NR	NR	NR	NR	NR	NR	NR	16	16	16	16	16	16	NR
Option D[11]-Metal Building U-factor	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
Option D[11]-Wood Framed and Other U-factor	0.028	0.028	0.034	0.028	0.034	0.034	0.039	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
Option D[11] Low-Sloped-Aged Solar Reflectance	NR	0.63	NR	0.63	NR	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	NR
Option D[11] Low-Sloped-Thermal Emittance	NR	0.75	NR	0.75	NR	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	NR
Option D[11] Low-Sloped-Solar Reflectance Index	NR	75	NR	75	NR	75	75	75	75	75	75	75	75	75	75	NR
Option D[11] Steep-Sloped-Aged Solar Reflectance	NR	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	NR
Option D[11] Steep-Sloped-Thermal Emittance	NR	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	NR
Option D Steep-Sloped-Solar Reflectance Index	NR	16	16	16	16	16	16	16	16	16	16	16	16	16	16	NR

TABLE 170.2-A ENVELOPE COMPONENT PACKAGE – Multifamily Standard Building Design (continued)

Building Component - Walls, Floors, Doors, and QII	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Walls - Metal Building - Any Fire Rating	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.057	0.057	0.057	0.057	0.057	0.057
Walls - Framed (wood, metal) and other - >1hr fire rating	0.059	0.059	0.059	0.059	0.059	0.065	0.065	0.059	0.059	0.059	0.051	0.059	0.059	0.051	0.051	0.051
Walls - Framed (wood, metal) and other - ≤1hr fire rating[3]	0.051	0.051	0.051	0.051	0.051	0.065	0.065	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
Walls - Mass Light[4]	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.059 R 17
Walls - Mass Heavy	0.253	0.650	0.650	0.650	0.650	0.690	0.690	0.690	0.690	0.650	0.184	0.253	0.211	0.184	0.184	0.160
Floors/Soffits - Slab Perimeter[8]	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	F 0.58 R 7.0
Floors/Soffits – Wood Framed	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19
Floors/Soffits - Raised Mass	U 0.092 R 8.0	U 0.092 R 8.0	U 0.269 R 0	U 0.269 R 0	U-0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.092 R 8.0	U 0.138 R 4.0	U 0.092 R 8.0	U 0.092 R 8.0	U 0.138 R 4.0	U 0.092 R 8.0
Floors/Soffits - Other	0.048	0.039	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.039	0.071	0.071	0.039	0.039	0.039
Exterior Doors[6] - Max U-Factor Dwelling Unit Entry	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Building Component - Walls, Floors, Doors, and QII	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Exterior Doors[6] - Max U-Factor Common Use Area Entry Non-Swinging	0.50	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	0.50
Exterior Doors[6] - Max U-Factor Common Use Area Entry Swinging	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Quality Insulation Installation up to 3 habitable stories	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

TABLE 170.2-A ENVELOPE COMPONENT PACKAGE – Multifamily Standard Building Design (continued)

Building Component - Fenestration	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Curtain Wall/ Storefront[7] - Maximum U-factor	0.38	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.38
Curtain Wall/ Storefront[7] - Maximum RSHGC	NR	0.26	NR	0.26	NR	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.26	NR
Curtain Wall/ Storefront[7] - Minimum VT, common use area	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
NAFS 2017 Performance Class AW[5] - Maximum U-factor	0.38	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.38
NAFS 2017 Performance Class AW[5] - Maximum RSHGC	NR	0.24	NR	0.24	NR	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	NR
NAFS 2017 Performance Class AW[5] - Minimum VT, common use areas	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
All Other Fenestration - Maximum U-factor	0.28	0.30	0.28	0.28	0.28	0.34	0.34	0.30	0.30	0.30	0.28	0.30	0.28	0.28	0.28	0.28
All Other Fenestration - Maximum RSHGC	NR	0.23	NR	0.23	NR	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	NR
Maximum Window to Floor Ratio	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Maximum Window to Wall Ratio	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
Maximum Skylight Roof Ratio	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%

Footnote requirements to TABLE 170.2-A:

1. Install the specified R-value with an air space present between the roofing and the roof deck. Such as standard installation of concrete or clay tile.
2. R-values shown for below roof deck insulation are for wood-frame construction with insulation installed between the framing members. Alternatives including insulation above rafters or above roof deck shall comply with the performance standards.
3. Assembly U-factors for exterior framed walls can be met with cavity insulation alone or with continuous insulation alone, or with both cavity and continuous insulation that results in an assembly U-factor equal to or less than the U-factor shown. Use Reference Joint Appendices JA4 Table 4.3.1, 4.3.1(a), or Table 4.3.4 to determine alternative insulation products to be less than or equal to the required maximum U-factor.
4. Mass wall has a heat capacity greater than or equal to 7.0 Btu/h-ft^2.
5. Product must be certified to meet the North American Fenestration Standard/Specification for an Architectural Window (AW).
6. Glazed doors must meet the fenestration requirements.
7. Requirements apply to doors included in the Curtainwall/Storefront construction assembly.
8. If using F-factor to comply, use Reference Joint Appendices JA4, Table 4.4.7 to determine alternate depth and R-value to be less than or equal to the required maximum F-factor.
9. Option B meets §170.2(a)1Bii
10. Option C meets §170.2(a)1BIiii
11. Option D meets §170.2(a)1Biv

(b) **Minimum daylighting requirement for large enclosed spaces.** In Climate Zones 2 through 15, conditioned enclosed spaces and unconditioned enclosed spaces that are greater than 5,000 ft² and that are directly under a roof with ceiling heights greater than 15 feet shall meet the following requirements:

1. A combined total of at least 75 percent of the floor area, as determined in building floor plan (drawings) view, shall be within one or more of the following:
   A. Primary sidelight daylight zone in accordance with Section 160.5(b)4Dib, or
   B. The total floor area in the space within a horizontal distance of 0.7 times the average ceiling height from the edge of rough opening of skylights.
2. All skylit daylit zones and primary sidelit daylit zones shall be shown on building plans.
3. General lighting in daylit zones shall be controlled in accordance with Section 160.5(b)4D.
4. The total skylight area is at least 3 percent of the total floor area in the space within a horizontal distance of 0.7 times the average ceiling height from the edge of rough opening of skylights; or the product of the total skylight area and the average skylight visible transmittance is no less than 1.5 percent of the total floor area in the space within a horizontal distance of 0.7 times the average ceiling height from the edge of rough opening of skylights.
5. All skylights shall have a glazing material or diffuser that has a measured haze value greater than 90 percent, tested according to ASTM D1003 (notwithstanding its scope) or another test method approved by the Commission.

Exception 1 to Section 170.2(b): In buildings with unfinished interiors, future enclosed spaces for which there are plans to have:

A. A floor area of less than or equal to 5,000 square feet; or
B. Ceiling heights of less than or equal to 15 feet. This exception shall not be used for S-1 or S-2 (storage), or for F-1 or F-2 (factory) occupancies.

Exception 2 to Section 170.2(b): Enclosed spaces having a designed general lighting system with a lighting power density less than 0.5 watts per square foot.

Exception 3 to Section 170.2(b): Enclosed spaces where it is documented that permanent architectural features of the building, existing structures or natural objects block direct beam sunlight on at least half of the roof over the enclosed space for more than 1500 daytime hours per year between 8 a.m. and 4 p.m.

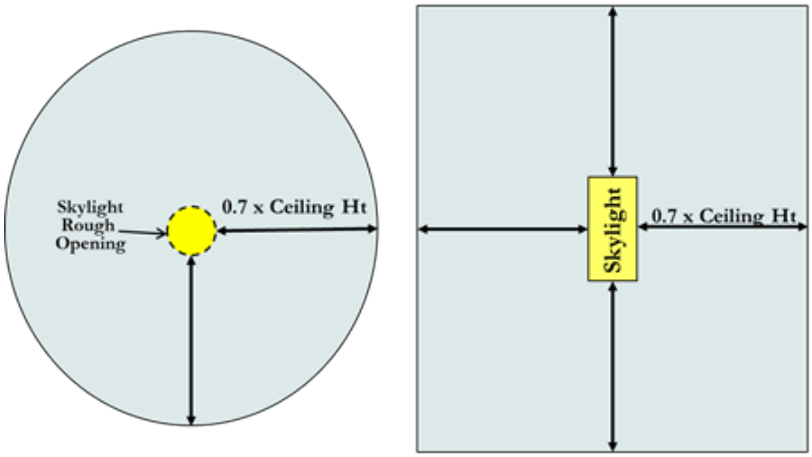
«» Commentary for Section 170.2(b):

Appropriately sized skylight systems can dramatically reduce the lighting energy consumption of a building when combined with appropriate daylighting controls.

Sizing is important; since too little skylight area has insufficient light available to turn off electric lighting; where too much skylight area, solar gains and heat losses through skylights negate the lighting savings by adding heating and cooling loads.

Skylights and automatic daylighting controls are most cost-effective in large open spaces and are prescriptively required in enclosed spaces (rooms).

Figure 3-24: Area Within 0.7 Times Ceiling Height of Rough Opening of Circular Skylight and Rectangular Skylight



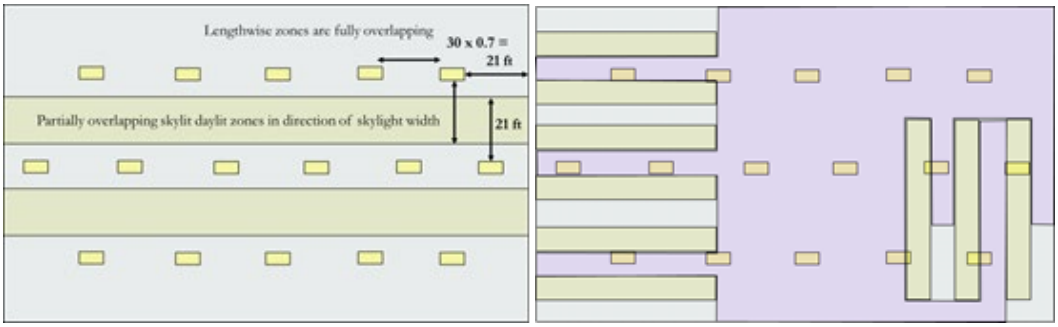
Source: California Energy Commission

The shape of the skylit daylit zone will be similar in shape to the rough opening of the skylight (Figure 3-24: Area Within 0.7 Times Ceiling Height of Rough Opening of Circular Skylight and Rectangular Skylight).

For example, if the skylight is circular, the area that is within a horizontal distance 0.7 times the average ceiling height from the edge of the rough opening, is also a circle, with the radius of the circle being the radius of the skylight + 0.7 x the ceiling height.

If the skylight is rectangular, the zone is rectangular, with the edges increased in each direction by 0.7 times the ceiling height.

Figure 3-25: Comparison of Skylit Area for Calculating Minimum Skylit Area (left) and the Skylit Daylit Zone for Controlling Luminaires in Section 160.5(b)4D (right)



Source: California Energy Commission

The specifications for daylighting controls in Section 160.5(b)4D describe which luminaires must be controlled, and consider the daylight obstructing effects of tall racks, shelves, and partitions taller than one-half the distance from the floor to the bottom of the skylight when determining if daylight will reach a given space. As shown in Figure 3-25: Comparison of Skylit Area for Calculating Minimum Skylit Area (left) and the Skylit Daylit Zone for Controlling Luminaires in Section 160.5(b)4D (right), it is considerably easier to calculate.

1. The total floor area in the space within a horizontal distance of 0.7 times the average ceiling height from the edge of rough opening of skylights. This is represented by the left example in Figure 3-25: Comparison of Skylit Area for Calculating Minimum Skylit Area (left) and the Skylit Daylit Zone for Controlling Luminaires in Section 160.5(b)4D (right).
2. The total floor area in the space within a horizontal distance of 0.7 times the average ceiling height from the edge of rough opening of skylights, minus any area on a plan beyond a permanent obstruction that is taller than the following: A permanent obstruction that is taller than one-half the distance from the floor to the bottom of the skylight. This is represented by the right example in Figure 3-25: Comparison of Skylit Area for Calculating Minimum Skylit Area (left) and the Skylit Daylit Zone for Controlling Luminaires in Section 160.5(b)4D (right).

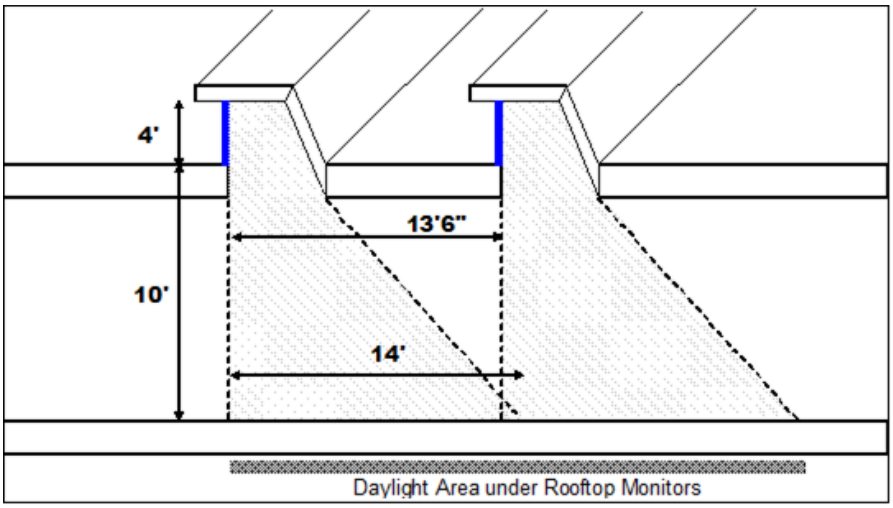
The left example in Figure 3-25: Comparison of Skylit Area for Calculating Minimum Skylit Area (left) and the Skylit Daylit Zone for Controlling Luminaires in Section 160.5(b)4D (right) is required to be calculated to comply with minimum skylight area requirements of Section 170.2, and (b) is required to comply with the automatic daylighting control requirements of Section 160.5(b) (essentially, to ensure that daylighting controls are not installed where they would not be effective).

In Section 160.5(b)4D, the skylit daylit areas are required to be drawn on the plans, and any general lighting luminaires that are in the daylit zones must be separately controlled by automatic daylighting controls.

Rooftop Monitors

Rooftop monitors are considered vertical fenestration, and the daylight area next to them is the same as the daylit area next to other vertical fenestration. The daylit area is from the inward facing plane of the fenestration one window head height and in the direction parallel to the fenestration 0.5 window head heights on either side.

Figure 3-26: Daylight Area Under Rooftop Monitors (Primary Sidelit Daylit Zone)



Source: California Energy Commission

Exceptions for Shading

Minimum daylighting requirements are exempted for spaces where permanent architectural features of the building, existing structures, or natural objects, block direct beam sunlight on at least half of the roof over the enclosed space for more than 1,500 daytime hours per year between 8 a.m. and 4 p.m. This can be documented to the local building official using a variety of tools including equipment that superimposes the sun path diagram on a photograph of the sky taken at the site, hand calculation tools such as the sun path calculator, and computer-aided design software tools that automate this calculation. **«»**

SECTION 180.0 – GENERAL

Additions, alterations and repairs to existing attached dwelling units and common use areas in multifamily buildings, existing outdoor lighting for these occupancies, and internally and externally illuminated signs shall meet the requirements specified in Sections 100.0 through 110.10, 160.1, and 160.3 through 170.2 that are applicable to the building project, and either the performance compliance approach (energy budgets) in Section 180.1(b) (for additions) or 180.2(c) (for alterations), or the prescriptive compliance approach in Section 180.1(a) (for additions) or 180.2(b) (for alterations), for the climate zone in which the building is located. Climate zones are shown in Figure 100.1-A.

Covered process requirements for additions, alterations and repairs to existing multifamily buildings are specified in Section 141.1.

Nonresidential occupancies in mixed occupancy buildings shall comply with nonresidential requirements in Sections 120.0 through 141.1.

NOTE: For alterations that change the occupancy classification of the building, the requirements specified in Section 180.2 apply to the occupancy after the alterations.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8 and 25943, Public Resources Code.

«» Commentary for Section 180.0:

The Energy Code offers prescriptive approaches and a performance approach to additions and alterations, but they do not apply to repairs. See Section 100.1(b) for detailed definitions.

Addition

Addition is a change to an existing building that increases conditioned floor area and volume. When an unconditioned building or unconditioned part of a building adds heating or cooling so that it becomes newly conditioned for the first time, this area is treated as an addition. Following are examples of an addition.

1. Obtaining a permit to legalize an existing, habitable, conditioned space that was previously added to a residential building without a permit.
2. Adding a bay window that extends from floor to ceiling, thereby increasing both floor area and volume.

Alteration

Alteration is a change to an existing building that is not an addition. An alteration could include a new HVAC system, lighting system, or change to the building envelope, such as a new window. Roof replacements (reroofing) and reconstructions and renewal of the

roof are considered alterations and are subject to all applicable Energy Code requirements. For alterations, the compliance procedure includes:

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

Following are examples of alterations.

1. Adding insulation to an existing ceiling, exterior roof, exterior wall, or raised floor that is over a crawl space, garage, or unheated basement.
2. Replacing or installing a new finish surface to an existing roof (reroofing) and replacing either portions of or the entire roof assembly.
3. Replacing existing fenestration or adding fenestration area (for example, windows, glazed doors, dynamic glazing, or skylights) to an existing building.
4. Replacing an existing skylight or increasing the skylight area of an existing roof.
5. Constructing an entirely new roof over an existing conditioned space.
6. Adding a loft within the conditioned volume of an existing home.
7. Adding window film.

Repair

Repair is the reconstruction or renewal of any part of an existing building for maintenance. Repairs must not increase the preexisting energy consumption of the repaired component, system, or equipment; otherwise, it is an alteration.

For example, a repair could include the replacement of a pane of glass in an existing multi-lite window without replacing the entire window.

Note: Repairs to residential buildings are not within the scope of the Energy Code.

For example, when a component, system, or equipment in an existing building breaks or is malfunctioning and maintenance fixes are needed for it to work properly again, it is considered a repair and not subject to the standards. However, if instead of fixing the break or malfunction, the component, system, or equipment is replaced with a new or different one, the scope of work is considered an alteration and not a repair and requirements of the Energy Code must be met. **«»**

SECTION 180.1 – ADDITIONS

Additions to existing multifamily buildings shall meet the applicable requirements of Sections 110.0 through 110.9; Sections 160.0, 160.1, and 160.2(c) and (d); Sections 160.3 through 160.7; and either Section 180.1(a) or 180.1(b).

Exception 2 to Section 180.1: Additions of 300 square feet or less are not required to comply with the roofing product requirements of Section 170.2(a)1A.

(a) Prescriptive approach. The envelope and lighting of the addition; any newly installed space-conditioning or ventilation system, electrical power distribution system, or water-heating system; any addition to an outdoor lighting system; and any new sign installed in conjunction with an indoor or outdoor addition shall meet the applicable requirements of Sections 110.0 through 110.12**;** 160.0, 160.1, and 160.2(c) and (d); and 160.3 through 170.2.

1. **Envelope.**
   A. Additions that are greater than 700 square feet shall meet the requirements of Section 170.2(a), with the following modifications:
      i. Framed walls extension. Extensions of existing wood-framed walls may retain the dimensions of the existing walls and shall install cavity insulation of R-15 in a 2x4 framing and R-21 in a 2x6 framing.
      ii. The maximum allowed fenestration area shall be the greater of 175 square feet or 20 percent of the addition floor area.
      iii. When existing siding of a wood-framed wall is not being removed or replaced, cavity insulation of R-15 in a 2x4 framing and R-21 in a 2x6 framing shall be installed and continuous insulation is not required.
      iv. Additions that consist of the conversion of existing spaces from unconditioned to conditioned space shall not be required to perform the air sealing part of QII when the existing air barrier is not being removed or replaced.
   B. Additions that are 700 square feet or less shall meet the requirements of Section 170.2(a), with the following modifications.
      i. Roof and ceiling insulation in a ventilated attic shall meet one of the following requirements:
         a. In Climate Zones 1, 2, 4, and 8 through 16, achieve an overall assembly U-factor not exceeding 0.025. In wood framed assemblies, compliance with U-factors may be demonstrated by installing insulation with an R-value of R-38 or greater.

b. In Climate Zones 3 and 5 through 7, achieve an overall assembly U-factor not exceeding 0.031. In wood framed assemblies, compliance with U-factors may be demonstrated by installing insulation with an R-value of R-30 or greater.

ii. Radiant barrier. For buildings three habitable stories or less, radiant barriers shall be installed in attics with exposed attic deck undersides in Climate Zones 2–15.

iii. Extensions of existing wood-framed walls may retain the dimensions of the existing walls and shall install cavity insulation of R-15 in a 2x4 framing and R-21 in a 2x6 framing; and

iv. Fenestration products must meet the U-factor, RSGHC and VT requirements of Table 180.2-B.

v. Quality Insulation Installation (QII) requirements of Section 170.2(a)6 do not apply.

Exception to Section 180.1(a)1B: Insulation in an enclosed rafter ceiling shall meet the requirements of Section 160.1(a).

Exception to Section 180.1(a)1: Additions that increase the area of the roof by 2,000 square feet or less are not required to comply with the solar ready requirements of Section 160.8.

«» Commentary for Section 180.1:

Wood-framed Wall Extensions in Multifamily Additions

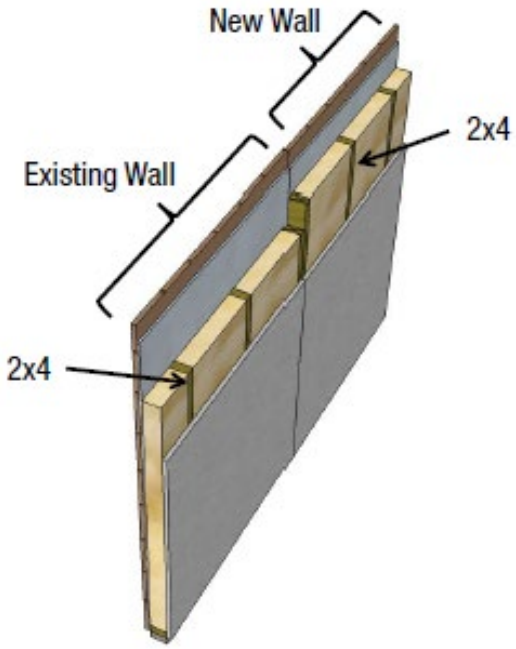
Figure 3-27: The new wall extends out straight from the existing wall through Figure 3-29: The new wall extends out perpendicularly from the existing wall are examples of common ways new walls are connected to existing walls.

In Figure 3-27: The new wall extends out straight from the existing wall and Figure 3-28: The new wall extends out straight from one of the existing walls, the new wall extends out straight from an existing wall. These are considered wall extensions. The new walls in Figure 3-27: The new wall extends out straight from the existing wall and Figure 3-28: The new wall extends out straight from one of the existing walls are 2x4 wood-framing, and are required to have R-15 cavity insulation.

Examples are not shown for 2x6 wood-framing. If the existing wall has 2x6 wood-framing, the new wall will also have 2x6 wood-framing and will require R-21 cavity insulation.

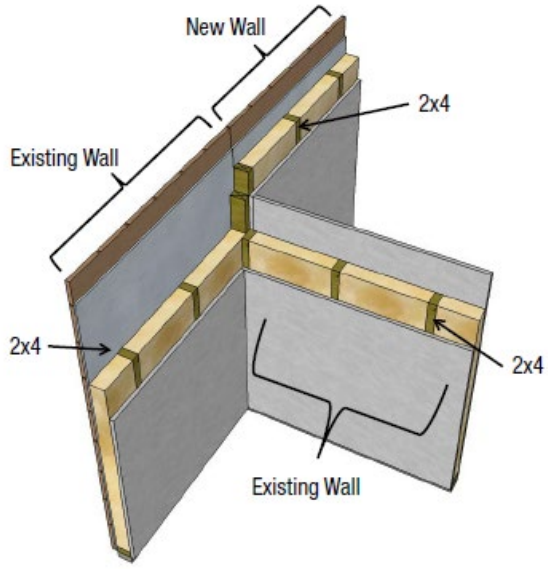
In Figure 3-29: The new wall extends out perpendicularly from the existing wall, the new wall is perpendicular to the existing wall. This is not a wall extension, and is subject to the prescriptive insulation requirements of Section 170.2(a)2A. In most cases, this will require 2x6 framing with both cavity and continuous insulation.

Figure 3-27: The new wall extends out straight from the existing wall



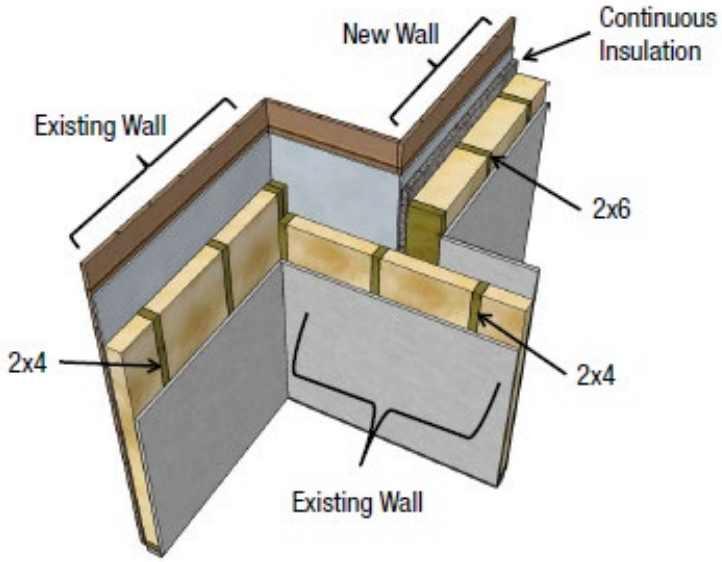
Source: California Energy Commission

Figure 3-28: The new wall extends out straight from one of the existing walls



Source: California Energy Commission

Figure 3-29: The new wall extends out perpendicularly from the existing wall



Source: California Energy Commission

NOTE: The figures show horizontal wall extensions. These requirements are also applicable to vertical wall extensions such as a second floor addition. «»

(b) Performance approach. Performance calculations shall meet the requirements of Sections 170.0 through 170.2(a), pursuant to the applicable requirements in Items 1, 2 and 3 below.

1. **For additions alone.** The addition complies if the addition alone meets the energy budgets expressed in terms of Long-Term System Cost (LSC) energy.
2. **Existing plus alteration plus addition.** The standard design for existing plus alteration plus addition energy use is the combination of the existing building's unaltered components to remain; existing building altered components that are the more efficient, in LSC energy, of either the existing conditions or the requirements of Section 180.2(c); plus the proposed addition's energy use meeting the requirements of Section 180.1(a). The proposed design energy use is the combination of the existing building's unaltered components to remain and the altered components' energy features, plus the proposed energy features of the addition.

   Exception to Section 180.1(b)2: Existing structures with a minimum R-11 insulation in framed walls showing compliance with Section 180.1(b) are not required to show compliance with Section 160.1(b).

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 180.2 – ALTERATIONS

Alterations to components of existing multifamily buildings, including alterations made in conjunction with a change in building occupancy to a multifamily occupancy, shall meet Item (a), and either Item (b) or (c) below:

(a) Mandatory requirements. Altered components in a multifamily building shall meet the minimum requirements in this section.

1. **Roof/ceiling insulation.** The opaque portions of the roof/ceiling that separate conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of Section 180.2(b)1B.
2. **Wall insulation. For the altered** opaque portion of walls separating conditioned spaces from unconditioned spaces or ambient air shall meet the applicable requirements of Items A through D below:
   A. **Metal building.** A minimum of R-13 insulation between framing members, or the area-weighted average U-factor of the wall assembly shall not exceed U-0.113.
   B. **Metal framed.** A minimum of R-13 insulation between framing members, or the area-weighted average U-factor of the wall assembly shall not exceed U-0.217.
   C. **Wood framed and others.** A minimum of R-11 insulation between framing members, or the area-weighted average U-factor of the wall assembly shall not exceed U-0.110.
   D. **Spandrel panels and curtain walls.** A minimum of R-4, or the area-weighted average U-factor of the wall assembly shall not exceed U-0.280.

   Exception to Section 180.2(a)2: Light and heavy mass walls.
3. **Floor insulation.** For the altered portion of raised floors that separate conditioned spaces from unconditioned spaces or ambient air shall meet the applicable requirements of Items A through B below:
   A. **Raised framed floors.** A minimum of R-11 insulation between framing members, or the area-weighted average U-factor of the floor assembly shall not exceed U-0.071.
   B. **Raised mass floors.** A minimum of R-6 insulation, or the area-weighted average U-factor of the floor assembly shall not exceed U-0.111.

(b) Prescriptive approach. The altered component and any newly installed equipment serving the alteration shall meet the applicable requirements of Sections 110.0 through 110.9 and all applicable requirements of Sections 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c) and 160.5; and

1. **Envelope.**

   A. **Roof alterations**. Existing roofs being replaced, recovered or recoated of a multifamily building shall meet the requirements of Section 110.8(i). For roofs with more than 50 percent of the roof area or more than 2,000 square feet of roof, whichever is less, being altered, the requirements of i through iii below apply:

      i. Low-sloped roofs in Climate Zones 2, 4, and 6 through 15 shall have a minimum aged solar reflectance of 0.63 and a minimum thermal emittance of 0.75, or a minimum SRI of 75.

         Exception to Section 180.2(b)1Ai: The aged solar reflectance requirement can be met by using insulation at the roof deck specified in Table 180.2-A.

Table 180.2-A Roof/Ceiling Insulation Tradeoff for Low-Sloped Aged Solar Reflectance

Minimum Aged Solar Reflectance	Roof Deck Continuous Insulation R-value (Climate Zones 6-7)	Roof Deck Continuous Insulation R-value (Climate Zones 2, 4, 8-15)
0.60	2	16
0.55	4	18
0.50	6	20
0.45	8	22
No requirement	10	24

      ii. Steep-sloped roofs in Climate Zones 4 and 8 through 15 shall have a minimum aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum SRI of 16.

         Exception to Section 180.2(b)1Aii: The following shall be considered equivalent to Subsection ii:

         a. Buildings with ceiling assemblies with a U-factor lower than or equal to 0.025 or that are insulated with at least R-38 ceiling insulation in an attic; or

b. Buildings with a radiant barrier in the attic, where the radiant barrier is not installed directly above spaced sheathing, meeting the requirements of Section 170.2(a)1C; or

c. Buildings that have no ducts in the attic in Climate Zones 2, 4, 9, 10, 12 and 14; or

d. Buildings with R-2 or greater continuous insulation above or below the roof deck.

Exception 1 to Sections 180.2(b)1Ai and ii: Roof area covered by building integrated photovoltaic panels and building integrated solar thermal panels is not required to meet the minimum requirements for solar reflectance, thermal emittance or SRI.

Exception 2 to Sections 180.2(b)1Ai and ii: Roof constructions with a weight of at least 25 lb/ft² are not required to meet the minimum requirements for solar reflectance, thermal emittance or SRI.

«» Commentary for Section 180.2(b)1Aii:

Existing roofs being replaced, recovered, or recoated on multifamily 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, non-process spaces even if the building has a portion that is a process space. These roof areas can be delineated by the fire separation walls between process areas and conditioned, non-process areas.

The 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. **«»**

iii. For low-sloped roofs, the area of the roof recover or roof replacement shall be insulated to R-14 continuous insulation or a U-factor of 0.039 in Climate Zones 1, 2, 4, and 8 through 16.

Exception 1 to Section 180.2(b)1Aiii: Roof recovers with new R-10 insulation added above deck do not need to be insulated to meet R-14.

Exception 2 to Section 180.2(b)1Aiii: When existing mechanical equipment located on the roof will not be disconnected and lifted, insulation added may be 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 to remain in accordance with the manufacturer's instructions.

Exception 3 to Section 180.2(b)1Aiii: At the drains and other low points, tapered insulation with a thermal resistance less than R-14 may be used, provided that insulation thickness is increased at the high points of the roof so that the average thermal resistance equals or exceeds R-14.

Exception 4 to Section 180.2(b)1Aiii: The area of the roof recoat is not required to be insulated.

«» Commentary for Section 180.2(b)1Aiii:

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 Section 180.2(b)1Aiii 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.

If a roof has an existing coating, the application of a coating for the purposes of renewal or maintenance (i.e., a roof recoat) is exempt from the low-sloped roof insulation requirements of 180.2(b)1Aiii. Roof recoats that are part of a roof recover are

considered a roof recover as defined in Section 100.1 and are required to meet the insulation requirements for roof recovers in Section 180.2(b)1Aiii.

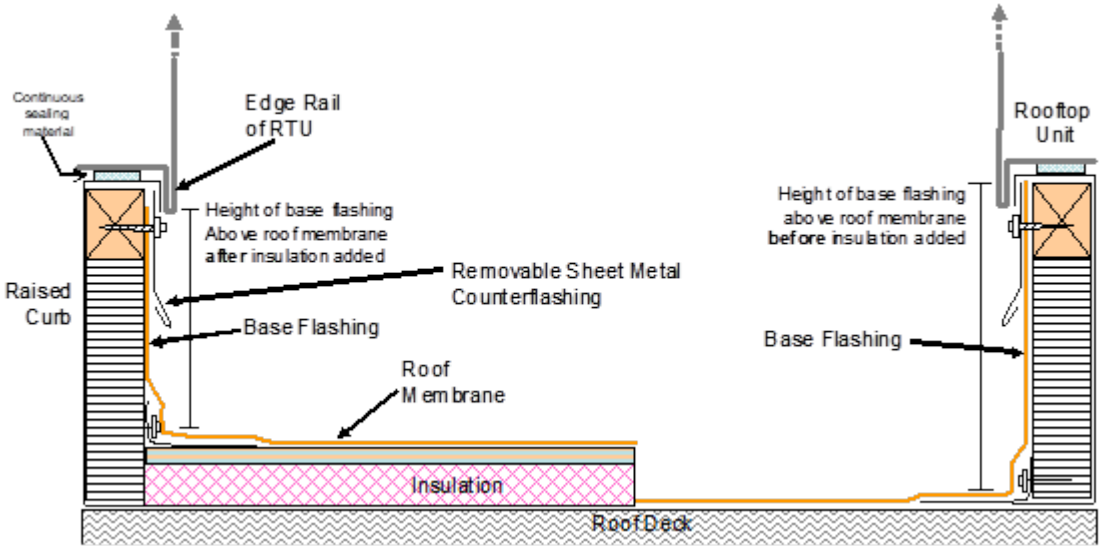
When mechanical equipment located on the roof will not be disconnected and lifted as part of the roof replacement, insulation added may be the greater of R-10 or the maximum installed thickness that will allow the distance between the height of the roof membrane surface to the top of the base flashing 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 Section 180.2(b)1Aiii 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 Section 180.2(b)1Aiii.

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 3-30: 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 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 under-insulated 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 3-30: Base Flashing on Rooftop Unit Curb Detail



Source: California Energy Commission

«»

B. **Roof/ceiling insulation**.

i. **Attic roof**. Vented attics shall meet the following:

a. In Climate Zones 1 through 4 and 8 through 16, insulation shall be installed to achieve a weighted U-factor of 0.020 or insulation installed at the ceiling level shall result in an installed thermal resistance of R-49 or greater for the insulation alone; and

Exception to Section 180.2(b)1Bia: In Climate Zones 1, 3, 4 and 9, dwelling units with at least R-19 existing insulation installed at the ceiling level**.**

b. In Climate Zones 2 and 11 through 16, air seal all accessible areas of the ceiling plane between the attic and the conditioned space in accordance with Section 110.7; and

Exception 1 to Section 180.2(b)1Bib: Dwelling units with at least R-19 existing insulation installed at the ceiling level.

Exception 2 to Section 180.2(b)1Bib: Dwelling units with atmospherically vented space heating or water-heating combustion appliances located inside the pressure boundary of the dwelling unit.

c. In Climate Zones 1 through 4 and 8 through 16, recessed downlight luminaires in the ceiling shall be covered with insulation to the same depth as the rest of the ceiling. Luminaires not rated for insulation

contact must be replaced or fitted with a fireproof cover that allows for insulation to be installed directly over the cover; and

Exception to Section 180.2(b)1Bic: In Climate Zones 1 through 4 and 8 through 10, dwelling units with at least R-19 existing insulation installed at the ceiling level.

d. Attic ventilation shall comply with the California Building Code requirements.

Exception 1 to Section 180.2(b)1Bi: Dwelling units with at least R-38 existing insulation installed at the ceiling level.

Exception 2 to Section 180.2(b)1Bi: Dwelling units where the alteration would directly cause the disturbance of asbestos unless the alteration is made in conjunction with asbestos abatement.

Exception 3 to Section 180.2(b)1Bi: Dwelling units with knob and tube wiring located in the vented attic.

Exception 4 to Section 180.2(b)1Bi: Where the accessible space in the attic is not large enough to accommodate the required R-value, the entire accessible space shall be filled with insulation, provided such installation does not violate Section 806.3 of Title 24, Part 2.5.

Exception 5 to Section 180.2(b)1Bi: Where the attic space above the altered dwelling unit is shared with other dwelling units and the requirements of Section 180.2(b)1Bi are not triggered for the other dwelling units.

«» Commentary for Section 180.2(b)1Bi:

Vented Attics

Attic insulation and air sealing prescriptive requirements in vented attics apply when the ceiling above a conditioned space is altered or when an entirely new duct system is installed in the vented attic. A ceiling may be considered altered under various conditions including when the existing attic insulation is replaced, new attic insulation is added, or the ceiling plane is replaced.

On hot days, a typical vented attic is hotter than outside and if poorly ventilated the temperature difference between the attic and outdoors can be substantial. In homes with little or no attic insulation, this temperature difference can result in significant total heat gain or loss through the ceiling. High levels of attic insulation and an air barrier at the ceiling is an important approach to minimize those gains and losses and result in considerable energy savings.

A common circumstance that results in the disruption of existing attic insulation occurs when a new duct system is installed in a vented attic. At minimum, existing insulation is moved to access certain areas and then replaced. Sometimes, insulation is disturbed

and left unfixed. In cases where penetrations are added to the ceiling layer for new registers, air sealing is critical to limit gains or losses to and from the home. By requiring insulation improvements and proper air sealing at duct replacement, vented attics are addressed as a system saving energy and improving comfort for the occupant.

When an attic is altered or a new duct system is installed, there are four primary sets of requirements as listed below.

1. Air seal the ceiling between conditioned spaces and the unconditioned attic.
2. Insulate the attic floor over any conditioned spaces to R-49.
3. Insulate over all recessed can lighting fixtures. Any recessed can lighting fixtures not rated for insulation contact (IC-rated) must be replaced with IC-rated fixtures or have a fire rated cover installed over the attic side of the fixture to allow for insulation to be installed over the fixtures.
4. Ensure attic ventilation meets California Building Code requirements.

An ECC-Rater is not required to verify any of these prescriptive requirements. All requirements will be verified by an official from the building department.

These components combine to form a package that addresses many issues in existing attics. They provide a much greater benefit than any of these measures do on their own. If an attic is insulated without first air sealing the ceiling assembly, the opportunity to seal any penetrations between the attic and conditioned space below is lost, and sealing can only be performed in the future if the insulation is removed. Once installed, R-49 insulation is 16-20” deep and it becomes a challenge to maneuver around the attic space. Air infiltration through the ceiling plane between the attic and conditioned space also reduces the effectiveness of attic insulation.

Items #1 through #3 above may or may not be required depending on climate zone and the existing attic insulation level. For projects that are subject to all or a portion of these requirements, the first step is to identify which requirements apply. Air sealing, recessed cans, and attic ventilation must be addressed prior to adding attic insulation. Table 3-11: Altered Attic Requirements by Climate Zone summarizes when these prescriptive requirements apply.

Table 3-11: Altered Attic Requirements by Climate Zone

Climate Zones	Building with < R-19 existing attic insulation	Building with ≥ R-19 existing attic insulation
5, 7	Attic ventilation only1	Attic ventilation only
6	R-49, attic ventilation	Attic ventilation only
1, 3	R-49, recessed cans, attic ventilation	Attic ventilation only
2, 4, 8-10	R-49, recessed cans & air sealing, attic ventilation	R-49, attic ventilation
11-16	R-49, recessed cans & air sealing, attic ventilation	R-49 & recessed cans, attic ventilation

[1]Mandatory minimum R-19 insulation requirements still apply if the ceiling is being altered.

Source: California Energy Commission

If any of the following four conditions are met, the project is exempt from all of the four requirements:

1. Existing attic insulation of R-38 or better.
2. Alteration directly causes the disturbance of asbestos located in the ceiling, attic, or ductwork and remediation of asbestos is not being done as part of the scope of work.
3. Knob and tube wiring located in the attic, which is not being removed as part of the scope of work.
4. Altered attic space is shared with other dwelling units whose attic space is not considered altered.

Below is additional detail on each of the four prescriptive requirements.

Air Sealing

In climate zones 2 and 11 – 16, where existing attic insulation is less than R-19, all accessible areas of the attic floor between the attic and the conditioned space must be air sealed (Table 3-12: Attic Air Sealing Requirements by Climate Zone). Homes with atmospherically vented space heating or water heating combustion appliances located inside the building pressure boundary are exempt from this requirement. This exception does not cover combustion appliances located in a vented attic, garage, or crawlspace.

Table 3-12: Attic Air Sealing Requirements by Climate Zone

Climate Zones	< R-19 existing attic insulation	≥ R-19 existing attic insulation
1, 3, 5-7	No requirement	No requirement
2, 4, 8-10	Yes	No requirement
11-16	Yes	No requirement

Source: California Energy Commission

Addressing air leakage requires removing or temporarily moving any existing insulation around the attic to access the attic floor. Most air sealing can be completed with caulking or foam. Areas where large holes might exist, such as at soffits and dropped ceilings, will require an air barrier to be installed if not already in place and the perimeter will need to be secured and fully sealed. Areas that present sources of air leakage that should be inspected when sealing the attic include:

1. Soffits, dropped ceilings, and chases connected to conditioned space
2. Gaps around chimneys and combustion venting
3. Along the top plate
4. Electric and plumbing penetrations
5. Ceiling mounted duct boots
6. Ceiling mounted exhaust fans and exhaust ducts
7. Attic hatches
8. Kneewalls
9. Recessed lighting fixtures

Recessed Can Lighting

In climate zones 1 – 4 and 8 – 16 any recessed can fixtures in the ceiling shall be covered with insulation to the same depth as the rest of the attic floor. Fixtures not rated for insulation contact must be replaced or retrofitted with a fire-proof cover that allows for insulation to be installed directly over the cover. Homes in climate zones 1 – 4 and 8 – 10 with existing attic insulation of R-19 or greater are exempt from this requirement. Table 3-13: Recessed Can Lighting Requirements by Climate Zone summarizes the recessed can lighting requirements by climate zone and existing insulation value.

Table 3-13: Recessed Can Lighting Requirements by Climate Zone

Climate Zones	< R-19 existing attic insulation	≥ R-19 existing attic insulation
5-7	No requirement	No requirement
1-4, 8-10	Yes	No requirement
11-16	Yes	Yes

Source: California Energy Commission

For recessed can fixtures to be directly covered with insulation the fixtures must be rated for Insulation Contact (IC). Fixtures that are IC rated usually have an Underwriters Laboratory (UL) sticker or stamp on the inside of the housing that says "IC" in some form. The lamp will likely need to be removed to properly view the housing. If the housing has slits or holes in it, it is not IC rated. If it cannot be determined whether a fixture is IC rated or not, it should be assumed that it is not. Recessed cans that are not IC rated present a serious fire hazard if they are surrounded by any flammable material because of the heat generated by the fixture. In these cases, the fixtures must be dammed to maintain separation between them and the attic insulation. This results in areas of the attic floor with minimal or no insulation where heat gains and losses are high, contributing to degraded insulation performance across the entire attic.

When present, older recessed can lighting can be a significant contributor to air leakage through a ceiling plane. Existing recessed cans typically are not airtight, and their perimeter can present a path for conditioned air to flow into the attic or unconditioned attic air to enter the conditioned space below. In addition to an IC rating, recessed can fixtures can also be rated to be "Airtight". This prescriptive standard does not require that existing fixtures be airtight. However, if existing recessed fixtures are being entirely replaced with new luminaires, the requirements of Section 160.5(a)1C must be met which requires the fixtures be certified as airtight with air leakage tested in accordance with ASTM E283 to be less than 2 cfm at 75 Pascals. Existing fixtures that are IC rated but not airtight can be retrofit with a retrofit trim kit which provides an airtight enclosure. Recessed cans that are not IC or AT rated may be replaced with IC rated housing units designed for retrofit applications.

In some cases, a fire-rated attic recessed light cover, shaped as domes or boxes, can be installed over the fixture allowing for insulation to be installed directly up to and over the cover. The recessed can fixture must have a thermal switch, which disconnect the electricity to the light if the temperature exceeds unsafe levels. The covers are to be installed over existing fixtures and sealed around the perimeter to the ceiling floor. Example covers are shown in Figure 3-31: Example fire rated cover products.). Products

that act as dams for the can lighting but do not allow insulation to cover the area over the fixture are not acceptable for meeting these prescriptive requirements. If it cannot be determined whether the fixture has a thermal switch, assume that it does not, and a fire-rated recessed light cover cannot be used.

Figure 3-31: Example fire rated cover products.

(1) https://www.recessedlightcover.com/product-selection/tenmat-ff130e-recessed-light-draft-stop-cover/

(2) https://insulation4us.com/products/recessed-light-cover-solid-insullite-all-sizes?variant=32508051849265&gclid=CjwKCAjwqcKFBhAhEiwAfEr7zfAPOJY7SqKTCmwahDo05n7klkNhzihRNF6K_VJccWpRpaDuLdEyXhoCVgUQAvD_BwE

Attic Insulation

In all climate zones, except 5, 6 and 7, attic insulation shall be installed at the attic floor to a level of R-49 or to achieve a weighted U-factor of 0.020. Table 3-14: Attic Insulation Requirements by Climate Zone summarizes the insulation requirements by climate zone, based on whether the existing attic insulation meets a minimum R-19 or not.

Table 3-14: Attic Insulation Requirements by Climate Zone

Climate Zones	< R-19 existing attic insulation	≥ R-19 existing attic insulation
5 - 7	No requirement	No requirement
1, 3, 4, 9	R-49	No requirement
2, 8, 10-16	R-49	R-49

In cases where there is limited vertical height in an attic (preventing the installation of the required insulation R-value), an exception allows for the installation of a lower R-value. Insulation must still be installed to maximize the depth of insulation while still meeting code requirements for roof ventilation as specified in Section 806.3 of the California Residential Code (Title 24, Part 2.5). A minimum of 1 inch air gap must be provided between the insulation and roof deck as well as at all vent locations. The use of blocking, bridging and insulation must not block the free flow of air.

Attic insulation is either batt, loose fill (blown-in), rigid, or spray foam and can be made of various materials. Most new and retrofit attics use blown-in fiberglass or cellulose insulation. Blown-in insulation is a loose fill product installed using a blowing machine with a large, attached hose. While both blown-in and batt insulation have similar properties, it is much easier to achieve a consistent installation with loose fill since the particles more easily fill in small gaps and hard to reach areas. R-value ratings per inch vary somewhat by product type and across manufacturers. Manufacturers provide coverage charts which specify how many bags of insulation are needed to cover a certain square footage based on the ceiling framing spacing and depth. The charts account for settling of the insulation due to compression under its own weight.

Insulation must be installed evenly throughout the attic space and insulation levels must be documented on the certificate of installation (LMCI or NRCI, as applicable). The insulation level can be verified by checking that the depth of insulation conforms to the manufacturer's coverage chart for achieving the required R-value. The insulation also must meet the manufacturer's specified minimum weight per ft² for the corresponding R-value. When using loose fill insulation at the ceiling, baffles should be installed at eaves or soffit vents to keep the insulation from blocking ventilation and prevent air movement under the insulation. Attic access doors shall have permanently attached insulation using adhesive or mechanical fasteners.

Attic ventilation

When any work is conducted in an existing attic, ventilation is required to be reviewed and altered as necessary to ensure compliance with current code requirements per the California Building Code. Ventilation allows the natural flow of air that removes

accumulated warm air and moisture from the attic. The relevant requirements that usually need to be addressed from Title 24, Part 2.5 Section R806 are listed below.

1. A minimum net free ventilating area of 1/150 of the area of the attic space.
2. Ventilation openings shall be no smaller than 1/16” and no greater than 1/4".

Ridge baffles should be installed when ceiling insulation is next to eave or soffit vents. The baffles should be placed at the top plate to direct ventilation air up and over the ceiling insulation. It is important to ensure the baffle extends sufficiently beyond the height of the ceiling insulation so as not to disturb the insulation. **«»**

C. Fenestration alterations other than repair shall meet the requirements of Items i and ii below:

Note: Glass replaced in an existing sash and frame or sashes replaced in an existing frame are considered repairs. In these cases, Section 180.2(b) requires that the replacement be at least equivalent to the original in performance.

i. Fenestration installed to replace existing fenestration of the same total area shall meet either a or b:

a. The maximum U-factor, RSHGC and VT requirements of Table 180.2-B, or

b. The area-weighted U-factor and RSHGC of Table 170.2-A.

Exception 1 to Section 180.2(b)1Ci: In an alteration, where 150 square feet or less of the entire building's vertical fenestration is replaced, RSHGC and VT requirements of Table 180.2-B shall not apply.

ii. Alterations that add vertical fenestration and skylight area shall meet the total fenestration area requirements of Section 170.2(a)3 and the U-factor, RSHGC and VT requirements of Table 180.2-B.

Exception 1 to Section 180.2(b)1Cii: Alterations that add vertical fenestration area of up to 50 square feet shall not be required to meet the total fenestration area requirements of Sections 170.2(a)3, nor the RSHGC and VT requirements of Table 180.2-B.

Exception 2 to Section 180.2(b)1Cii: Alterations that add up to 16 square feet of new skylight area per dwelling unit with a maximum U-factor of 0.55 and a maximum RSHGC of 0.30 shall not be required to meet the total fenestration area requirements of Section 170.2(a)3.

D. **Exterior doors.** Alterations that add exterior door area shall meet the U-factor requirement of Section 170.2(a)4.

Table 180.2-B Altered Fenestration Maximum U-Factor and Maximum SHGC and RSHGC, Minimum VT

Building Type	Feature	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Curtainwall / Storefront / Window Wall[1]	U-factor	0.38	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.38
Curtainwall / Storefront / Window Wall[1]	RSHGC	NR	0.26	NR	0.26	NR	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	NR
Curtainwall / Storefront / Window Wall[1]	VT[2]	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
NAFS 2017 Performance Class AW Window – Fixed	U-factor	0.38	0.38	0.38	0.38	0.38	0.47	0.47	0.41	0.41	0.38	0.38	0.38	0.38	0.38	0.38	0.38
NAFS 2017 Performance Class AW Window – Fixed	RSHGC	NR	0.25	NR	0.25	NR	0.31	0.31	0.26	0.26	0.25	0.25	0.25	0.25	0.25	0.25	NR
NAFS 2017 Performance Class AW Window – Fixed	VT[2]	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
NAFS 2017 Performance Class AW Window – Operable	U-factor	0.43	0.43	0.43	0.43	0.43	0.47	0.47	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
NAFS 2017 Performance Class AW Window – Operable	RSHGC	NR	0.24	NR	0.24	NR	0.31	0.31	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	NR
NAFS 2017 Performance Class AW Window – Operable	VT[2]	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37

Building Type	Feature	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
All Other Windows and Glazed Doors	U-factor	0.28	0.30	0.28	0.28	0.28	0.30	0.34	0.30	0.30	0.30	0.28	0.30	0.28	0.28	0.30	0.28
All Other Windows and Glazed Doors	RSHGC	NR	0.23	NR	0.23	NR	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	NR

Table 180.2-B Altered Fenestration Maximum U-Factor and Maximum SHGC and RSHGC, Minimum VT (Continued)

Building Type	Feature	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Skylights	U-factor	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Skylights	SHGC	NA	0.25	NA	0.25	NA	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	NA
Skylights, Serving Common Areas	VT[2]	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49

Footnotes to TABLE 180.2-B:

1. Requirements apply to glazed doors included in the Curtainwall/Storefront construction assembly.
2. Minimum VT requirements for fenestration other than Skylights do not apply to multifamily buildings 3 habitable stories or less.

«» Commentary for Section 180.2(b)1Bi:

Fenestration Alterations

The area-weighted U-factor of all fenestration, including skylights, may not exceed the mandatory maximum of 0.58.

Alterations that replace existing fenestration of the same total area can meet prescriptive requirements by meeting the U-factor, RSHGC, and VT requirements of Table 180.2-B for each window replaced or an area weighted U-factor and RSHGC across all replaced windows from Table 170.2-A. Note that U-factor and RSHGC values in the table are maximum values, and VT values are minimums. Where 150 square feet or less of the building's vertical fenestration is replaced, the building is exempt from the RSHGC and VT requirements.

Replacement Fenestration

Any fenestration (i.e., windows, skylights, clerestories, and glazed doors) that is being removed and replaced in an exterior wall or roof is considered "replacement fenestration."

Replacement fenestration is an area of new fenestration that replaces an equal or lesser area of glazing removed in the same existing wall or roof area. It is labeled as "altered" fenestration, and it need not occur in the same openings as the glazing being removed as long as it is being installed in the same existing wall or roof surface that remains a part of the existing building. Any added fenestration area that is larger than the total altered glazing area is labeled as "new." **«»**

(c) Performance approach. The altered component(s) and any newly installed equipment serving the alteration shall meet the applicable requirements of Subsections 1, 2 and 3 below. The energy budget for alterations is expressed in terms of Long-Term System Cost (LSC) energy.

1. The altered components shall meet the applicable requirements of Sections 110.0 through 110.9, 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c), and 160.5. Entirely new or complete replacement mechanical ventilation systems as these terms are used in Section 180.2(b)5A shall comply with the requirements in Section 180.2(b)5A. Altered mechanical ventilation systems shall comply with the requirements of Sections 180.2(b)5B. Entirely new or complete replacement space-conditioning systems, and entirely new or complete replacement duct systems, as these terms are used in Sections 180.2(b)2Ai and 180.2(b)2Aiia, shall comply with the requirements of Sections 160.2(a)1 and 160.3(b)5L.
2. The standard design for an altered component shall be the higher efficiency of existing conditions or the requirements of Section 180.2(b). For components not being altered, the standard design shall be based on the unaltered existing conditions such that the standard and proposed designs for these components

are identical. When the third-party verification option is specified, all components proposed for alteration for which the additional credit is taken, must be verified by a certified ECC-rater.

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

NOTES TO SECTION 180.2(c):

1. If an existing component must be replaced with a new component, that component is considered an altered component for the purpose of determining the standard design altered component energy budget and must meet the requirements of Section 180.2(c)2.
2. The standard design shall assume the same geometry and orientation as the proposed design.
3. The "existing efficiency level" modeling rules, including situations where nameplate data is not available, are described in Section 10-109(c) and Section 10-116.

EXCEPTION 1 to Section 180.2(c): Any dual-glazed greenhouse or garden window installed as part of an alteration complies with the U-factor requirements in Section 170.2.

EXCEPTION 2 to Section 180.2(c): Where the space in the attic or rafter area is not large enough to accommodate the required R-value, the entire space shall be filled with insulation provided such installation does not violate Section 1203.2 of Title 24, Part 2.

Note: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.