



Opaque Envelopes

What Does This Fact Sheet Cover?

This Fact Sheet addresses building envelope components, such as framing material, masonry or concrete, insulation, vapor retarders, sheathing, etc. which make up opaque envelope assemblies for roof/ceilings, walls and floors.

Mandatory Requirements

Residential buildings need to meet several mandatory requirements under 2013 Building Energy Efficiency Standards (Energy Standards), covering envelope components such as joints and openings, fenestration, air barriers, insulation placement, and assembly U-factors.

★ **Joints and Openings:** must be caulked, gasketed, weatherstripped, or otherwise sealed to minimize energy loss through infiltration or exfiltration, per [Section 110.7](#) of the Energy Standards. This includes joints around window and door frames, and openings for plumbing, electrical conduit, and gas lines. [Chapter 3.6 of the Residential Compliance Manual](#) provides more details for this requirement.

Some alternative techniques also meet mandatory requirements for sealing joints and openings. These include the use of building wraps, spray foam cavity fill, and continuous rigid wall insulation on the exterior of a building, as well as others.

★ **Vapor Retarders:** In climate zones 14 and 16, a class II vapor retarder shall be installed on the conditioned-space side of insulation at all exterior walls, and at attics having air permeable insulation. Additional requirements related to vapor retarders in crawl spaces can be found in [Section 150.0\(g\)](#) of the Energy Standards.

★ **Fenestration:** Refer to the [Residential Fenestration Fact Sheet](#) for a detailed discussion of mandatory requirements for these components.

★ **Insulation Requirements:** [Section 110.8](#) of the Energy Standards includes mandatory requirements for all buildings, related to insulation products (certification, flame spread rating and use of urea-formaldehyde), placement of insulation on roofs and ceilings, and insulation for heated slab floors. This section also includes requirements for **radiant barriers** and for roofing reflectance & emittance.

Additional residential-only mandatory requirements for insulation can be found in [Section 150.0\(a-d\)](#) of the Energy Standards, summarized below. This Section also includes requirements for insulating and sealing attic access doors as well as installation requirements for loose-fill insulation.

Assembly	Newly Constructed and Additions	Alterations
Ceiling/Rafter Roof	≥ R-30 (wood framed, max U-factor* = 0.031)	≥ R-19 (rafter roof)
Above Grade Wall	≥ R-13 (2x4 frame, max U-factor* = 0.102) ≥ R-19 (2x6 frame, max U-factor* = 0.074)	≥ R-11 (existing walls already insulated)
Bay Windows Roofs and Floors	Meet the wall insulation requirements of Table 150.1-A	
Raised Floor	≥ R-19 (max U-factor* = 0.037)	

Table 1: Mandatory Residential Insulation Requirement

* Max U-factors presented are weighted averages

Prescriptive Requirements

In addition to meeting mandatory requirements, projects can either meet the prescriptive requirements in the Energy Standards, or show compliance with the performance path through energy modeling.

Projects complying prescriptively must meet the following prescriptive requirements. Projects seeking compliance under the performance path are compared against the same projects meeting prescriptive requirements (baseline), per [Section 150.1\(b\)](#) of the Energy Standards.

[Section 150.1\(c\)](#) of the Energy Standards includes prescriptive requirements for insulation and radiant barriers in [Table 150.1-A](#). Energy Code Ace has summarized these requirements in the Quick Reference Sheets, by climate zone (organized by similar climates*):

- ★ [Climate Zones 1 & 16](#)
- ★ [Climate Zones 2, 3 & 4](#)
- ★ [Climate Zones 5, 6, 7, 8, 9 & 10](#)
- ★ [Climate Zones 7, 10, 14 & 15](#)
- ★ [Climate Zones 11, 12, 13 & 16](#)

*Climate zones 10 and 16 can use either sheet.

		cz 1	cz 16	Comments		
Insulation (1) ^a	Roofs / Ceilings	U 0.025, R 38	U 0.025, R 38	or lower or higher		
	Walls	2x4 Framed (2)	U 0.065, R 15-4	U 0.065, R 15-4	or lower or higher	
		Above Grade	Mass Wall Interior (3)	U 0.070, R 13	U 0.059, R 17	or lower or higher
		Mass Wall Exterior (3)	U 0.125, R 8	U 0.070, R 13	or lower or higher	
		Below Grade	Below Grade Interior (3)	U 0.070, R 13	U 0.066, R 15	or lower or higher
	Below Grade Exterior (3)	U 0.200, R 5	U 0.053, R 19	or lower or higher		
	Floors	Slab Perimeter	NR	U 0.58, R 7	or lower or higher	
		Raised	U 0.037, R 19	U 0.037, R 19	or lower or higher	
		Concrete Raised	U 0.092, R 8	U 0.092, R 8	or lower or higher	
	Radiant Barrier		NR	NR		
Roofing Products	Low-sloped	Aged Solar Reflectance	NR	NR		
	Steep-sloped	Thermal Emittance	NR	NR		
		Aged Solar Reflectance	NR	NR		
	Thermal Emittance	NR	NR			
Fenestration	Maximum U factor (4)	0.32	0.32	or lower		
	Maximum SHGC (5)	NR	0.25	or lower		
	Maximum Total Area	20%	20%	or lower		
	Maximum West Facing Area	NR	5%	or lower		
Space Heating (8) (9)	Electric-Resistance Allowed	No	No			
	If gas, AFUE	MIN	MIN	Central furnace <225,000 kBtu/h: 80% AFUE or higher ^a		
Space Cooling	If Heat Pump, HSPF (6)	MIN	MIN	Single-phase air source Split: <65 kBtu/h: 8.2 HSPF or higher ^a Packaged: <65 kBtu/h: 8.2 HSPF or higher ^a		
	SEER	MIN	MIN	Central air conditioner or central air source heat pump Split: <45 kBtu/h 14.0 SEER/12.2 EER >45 but <65 kBtu/h 14 SEER/11.7 EER Packaged: <65 kBtu/h 14 SEER/11 EER or higher ^a		
Central System Air Handlers	Central Fan Integrated Ventilation System Fan Efficiency	NR	NR			
Ducts (10)	Whole House Fan (7)	REQ	REQ			
	Duct Insulation	R 6	R 8	or higher		
Water Heating	All Buildings	Gas Storage <55 gallons; <75 Btu/h	Jan 1, 2014: 0.67 (0.0815") EF or higher Apr 16, 2015: 0.675 (0.0015") EF or higher			

Figure 1: Example Energy Code Ace Quick Reference Sheet

Definitions

U Factor: The overall coefficient of thermal transmittance of a fenestration, wall, floor, or roof/ceiling component, including air film resistance at both surfaces. This is the inverse of R-value. "Weighted" is a term applied to U factor to average out the effects of framing.

R Value: The measure of the thermal resistance of insulation or any material or building component.

Cool Roof: According to [Chapter 3.4.1\(c\) in the Residential Compliance Manual](#), a "cool roof" is a roofing product with a high solar reflectance and thermal emittance.

Roof Reflectance & Emittance

Cool Roofs are one way to comply with the roof reflectance and emittance code requirements. [Energy Code Ace](#) has a [Residential Cool Roof Fact Sheet](#) which addresses reflectance and emittance values of roofs for newly constructed buildings as well as re-roofs. The fact sheet details:

- ✦ What qualifies as a cool roof
- ✦ What triggers cool roof requirements (& exceptions)
- ✦ Solar Reflectance Index (SRI), Thermal Emittance & Solar Reflectance
- ✦ Documentation requirements including product labels

Envelope Compliance Credits

Those pursuing the performance compliance option can take advantage of several strategies for compliance credit. Strategies related to envelope include minimizing air leakage and quality insulation installation (QII).

These options require field verification by a HERS Rater and registration of compliance documents with a HERS Provider. More information can be found on HERS Providers and Raters through the [California Energy Commissions website](#) or in the Energy Code Ace HERS Fact Sheet.

Compliance Credit: Quality Insulation Installation (QII)

QII is not just “doing a good job” when installing insulation. It is a specific procedure that requires coordination with a HERS Rater to verify proper insulation installation. QII applies to the entire thermal envelope of the building, including both insulation and the air barrier. [Residential Appendix \(RA\) 3.5](#) includes key terms, installation details, material specifications and compliance documentation related to QII. More details on the QII process can be found in Energy Code Ace’s [Crack the Code](#) tool.

Some components of QII to highlight include:



Sealing the Air Barrier: Seal all gaps around windows, doors, behind tubs and showers, etc. Caulk or seal all gaps in the air barrier greater than 1/8” with foam.



Correctly Sized Batts: Batt insulation should be cut to fit snugly at the sides and ends without gaps or buckling. It should not double over or be compressed and should be friction fit to cavities, or otherwise supported. Batt insulation should be split to fit around wiring or plumbing, and trimmed to fit around junction boxes.



Required U-factors (& associated R-Values equivalents) for Envelope Systems: Designers shall specify U-factors for assemblies shown in the Residential Appendix. Installers must follow specifications in order to meet QII requirements.

Both Installation Certificates ([CF2R](#)) and Verification Certificates ([CF3R](#)) will be reviewed by the inspector during the QII process. There are pre-insulation and post-insulation forms & instructions that should be reviewed prior to framing, to ensure that actions are properly completed and verified during the appropriate stage of construction.

Compliance Credit: Envelope Air Leakage

Taking steps to minimize energy lost through air leakage can earn compliance credit using the performance approach. The required HERS testing process consists of closing all windows and doors, pressurizing the house using blower door testing equipment, and measuring the air leakage rate. When the building’s air leakage rate is less than the leakage rate assumed for the standard design building, the credit can be taken. If not, the project has to be remodeled, without presumption of the credit (which is difficult to achieve). Performing this test and others is a topic of [Decoding HERS: Let’s Talk 2013 HERS Measures](#).

What’s New for the 2016 Standards?

The 2016 Standards are scheduled to go into effect on January 1, 2017. Any permit applications submitted to an enforcement agency on or after that date will need to comply with the 2016 Standards.

The following requirements are updates to the 2013 residential opaque envelope requirements presented in this fact sheet. More detail on these requirements can be found on the [California Energy Commissions Standards Rulemaking page](#).

Section 110.8 Mandatory Requirements for Insulation, Roofing Products and Radiant Barriers

- ✦ Language related to placement of insulation on roofs/ceilings is removed.

Section 150.0 Mandatory Features and Devices for Low-Rise Residential Buildings

- ✦ The mandatory U-factor for ceiling and rafter roof insulation has been updated to a maximum of 0.043 or a minimum installed thermal resistance of R-22. The U-factor for alterations involving ceiling or rafter roof insulation has been updated to a maximum of 0.054.
- ✦ Opaque non-framed assemblies shall have an overall assembly U-factor not exceeding 0.102, equivalent to installing R-13 in a wood framed assembly.
- ✦ Slab edge insulation requirements have been added to 150.0(f). These requirements address water absorption rates, water vapor permeance and protection from physical damage and UV light deterioration.

Section 150.1 Performance and Prescriptive Compliance Approaches for Newly Constructed Low-rise Residential Buildings

- ✦ Options for meeting roof and ceiling insulation requirements in Table 150.1-A has been added to Section 150.1(c)1 in addition to clarification language in this section.
- ✦ Updates have been made to Table 150.1-A which specifies prescriptively required R-values and radiant barriers by climate zone.

Several envelope insulation options are available:

- ✦ High Performance Attics using spray foam, batt, blown-in insulation or SIP panels:
 - ✦ Insulation below roof deck equivalent to R-13 (with air space under roofing) and ceiling insulation varying by Climate Zone (R-38 or R-30).
 - ✦ Insulation below deck equivalent to R-18 (with no air space under roofing) and ceiling insulation varying by Climate Zone (R-38 or R-30).

Other high performing attics:

- ✦ R-6 or R-8 continuous insulation above roof deck plus radiant barrier (depends on air space under roofing and Climate Zone)
- ✦ Hybrid roof systems combining insulation and higher roof reflectance
- ✦ High Performance Walls—R-19 cavity insulation plus R-5 continuous insulation on exterior of cavity (U-factor ~ 0.051) for all Climate Zones

