

What is an Opaque Envelope?

Opaque envelope assemblies are those that do not transmit solar radiation. The 2019 California Building Energy Efficiency Standards (Energy Code), Title 24, Part 6 include requirements for residential building envelope components, such as framing material, masonry or concrete, insulation, vapor retarders and sheathing which make up opaque envelope assemblies for roofs/ceilings, walls and floors.

Why? The envelope design drives the energy performance of a house and is a long-lasting feature because it is not often replaced like a furnace or water heater. Energy-efficient envelopes reduce heating and cooling loads, which allow for smaller heaters and air conditioners. They also help improve building occupant comfort.

Relevant Code Sections

2019 California Building Energy Efficiency Standards, Title 24, Part 6:

- [Section 10-111](#) – Certification And Labeling Of Fenestration Product And Exterior Door U-Factors, Solar Heat Gain Coefficients, Visible Transmittance And Air Leakage
- [Section 10-112](#) – Criteria For Default Tables
- [Section 110.6](#) – Mandatory Requirements for Fenestration Products and Exterior Doors
- [Section 110.7](#) – Mandatory Requirements to Limit Air Leakage
- [Section 110.8](#) – Mandatory Requirements for Insulation, Roofing Products, and Radiant Barriers
- [Section 150.0](#) – Mandatory Features and Devices
 - 150.0(a-f) – Insulation
 - 150.0(g) – Vapor Retarder
- [Section 150.1](#) – Performance and Prescriptive Compliance Approaches for Low-Rise Residential Buildings
- [Section 150.2](#) – Energy Efficiency Standards for Additions and Alterations
- [Residential Compliance Manual Section 3.6](#) – Envelope Features
- [Residential Reference Appendix RA 3.5](#) – Quality Insulation Installation Procedures
- [Joint Reference Appendix JA4](#) – U-factor, C-factor, and Thermal Mass Data

Relevant Compliance Forms

- CF1R-ADD-01-E: Prescriptive Additions Compliance Form
- CF1R-ADD-02-E: Prescriptive Additions Non HERS Compliance Form
- CF1R-ALT-01-E: Prescriptive Alterations Compliance Form (when HERS is triggered)
- CF1R-ALT-05-E: Prescriptive Alterations Non HERS Compliance Form (Simple projects that do not trigger HERS)
- CF1R-ENV-02-E: Area Weighted Average Work Sheet
- CF1R-ENV-06-E: Interior/Exterior Insulation Worksheet
- CF1R-NCB-01-E: Prescriptive Newly Constructed Building Compliance Form
- CF2R-ADD-02-E: Prescriptive Additions Non HERS Installation Compliance Form
- CF2R-ALT-05-E: Prescriptive Alterations Non HERS Installation Compliance Form
- CF2R-ENV-03: Insulation Installation Compliance Form
- CF2R-ENV-20 (Tables a-e): Air Leakage Tests
- CF3R-ENV-20 (Tables a-e): Air Leakage HERS Verification
- CF3R-ENV (21-24): HERS QII Verification
- CF3R-EXC-20-H: HERS Verification of Existing Conditions for Alterations

Compliance Requirements

The Energy Code includes both Mandatory and Prescriptive requirements for residential opaque envelope components and assemblies.

Mandatory Requirements

Opaque Exterior Doors Section 110.6

Opaque exterior doors are defined as having less than 25% glass. For the 2019 Energy Code, they must be NFRC rated and labeled per [Section 10-111](#), and must have a Prescriptive maximum U-Factor of 0.20 per [Section 150.1\(c\)5](#) and [Tables 150.1-A](#) and [150.1-B](#). The default U-factor for doors can be found in [Joint Reference Appendix JA4 Table 4.5.1](#).

A maximum air leakage limit of 0.3 cfm/ft² when tested at 75 Pa applies to all exterior doors, including pet doors.

Joints and Openings Section 110.7

All 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 Code. This includes joints around window and door frames, 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.

Why? Air leakage through joints, penetrations, cracks, holes and openings around windows, doors, walls, roofs and floors can result in higher energy use for home heating and cooling than necessary.

Insulation, Roofing Products, and Radiant Barriers Section 110.8

The Energy Code requires that all insulation is certified by the Department of Consumer Affairs, [Bureau of Household Goods and Services \(BHGS\)](#). Heated slab floors must be insulated according to the requirements in [Table 110.8-A](#) and radiant barriers need to have an emittance of 0.05 or less and also be certified to the Department of Consumer Affairs.

For more information about Roof Reflectance & Emittance, see the Residential Cool Roof Fact Sheet.

Vapor Retarders Section 150.0(g)

In all Climate Zones, the earth floor of unvented crawl space must be covered with a Class I or Class II vapor retarder.

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

Additional requirements related to vapor retarders in crawl spaces can be found in [Section 150.0\(g\)](#) of the Energy Code.

Why? Vapor retarders or barriers are special coverings over framing and insulation or coverings over the ground of a crawl space that protects the assembly components from moisture condensation. Water build up due to condensation can cause structural damage, create mold that may contribute to indoor air quality problems, and can cause the insulation to lose effectiveness.

U-factor? R-value?

The **U-factor** is the overall coefficient of thermal transmittance of a fenestration, wall, floor, or roof/ceiling assembly, including air film resistance at both surfaces. "Weighted" is a term applied to U-factor to allow different performance for different sections of a wall or roof, as long as the area-weighted average performance complies.

The **R-value** is the measure of the **thermal resistance** of insulation or any material or building component.

Determining Envelope U-factor

[JA4](#) provides data tables which contain effective U-factors for common roofs/ceilings, walls, and floor assemblies. U-factors found in these tables can be used only for the Prescriptive approach. CBECC-Res (the California Building Energy Code Compliance modeling software for residential buildings) calculates assembly U-factors for the Performance approach.

U-factors can be determined using the [JA4](#) tables by finding the row for the framing size, spacing and cavity insulation R-value, and by identifying the continuous insulation R-value (columns A through G) to find the U-factor at the intersection between the row and column. Interpolation is not allowed; if the product insulation value falls between two adjacent values, use the less efficient of the two assemblies.

Insulation Sections 150.0(a-f)

Additional residential-only Mandatory requirements for insulation can be found in [Sections 150.0\(a-f\)](#) of the Energy Code (examples of the types of requirements are included below). These Sections also include requirements for insulating and sealing attic access doors, as well as installation requirements for loose-fill insulation.

- The Mandatory U-factor for ceiling and rafter roof insulation shall be at a maximum of 0.043 or a minimum installed thermal resistance of R-22, for wood framed assemblies
 - The U-factor for alterations involving ceiling or rafter roof shall be at a maximum of 0.054 or minimum R-19, for wood framed assemblies
- The Mandatory U-factor for 2x4 walls must be at a maximum of 0.102
- The Mandatory U-factor for 2x6 or greater walls must be at a maximum of 0.071
- Masonry walls shall be insulated to meet the Prescriptive wall insulation requirements of [Table 150.1-A](#) or [B](#)
- [Section 150.0\(f\)](#) includes slab edge insulation material requirements which address water absorption rates, water vapor permeance and protection from physical damage and UV light deterioration

Prescriptive Requirements

Options for meeting roof and ceiling insulation requirements are in [Table 150.1-A](#), for single family and [Table 150.1-B](#) for low-rise multifamily, including prescriptively required R-values and radiant barriers by Climate Zone. Energy Code Ace has summarized these requirements in its [Quick Reference Sheets](#) (organized by similar climates). HERS-verified Opaque exterior doors must have a Prescriptive maximum U-Factor of 0.20 per [Section 150.1\(c\)5](#) and [Tables 150.1-A](#) and [150.1-B](#). The default U-factor for doors can be found in [JA4 Table 4.5.1](#)

Why? To improve energy efficiency by lessening conduction losses through building envelope components.

High Performance Attics

Several options are available to meet Prescriptive opaque envelope requirements in [Section 150.1\(c\)1A](#):

- Option B: Ceiling Insulation and Below Roof Deck Insulation in Ventilated Attic
 - Insulation Below Roof Deck: R-19 (with air space between the roofing and roof deck), for climate zones 4 and 8-16 (varies by Climate Zone)
 - Ceiling Insulation R-30 or R-38 (varies by Climate Zone)
 - Radiant Barrier: Required in Climate Zones 2, 3, 5, 6 and 7
- Option C: Ducts and Air Handler in Conditioned Space
 - Ceiling Insulation R-30 or R-38 (varies by Climate Zone)
 - Radiant Barrier: Required in all Climate Zones except 1 and 16

High Performance Walls

[Table 150.1-A](#) also includes Prescriptive requirements for opaque wall assemblies, including:

- Above-grade framed walls must have maximum U-factor of 0.048 except for Climate Zones 6 and 7, which have a maximum U-factor of 0.065. U-factor values for common framed wall assemblies may be found in [JA4](#).

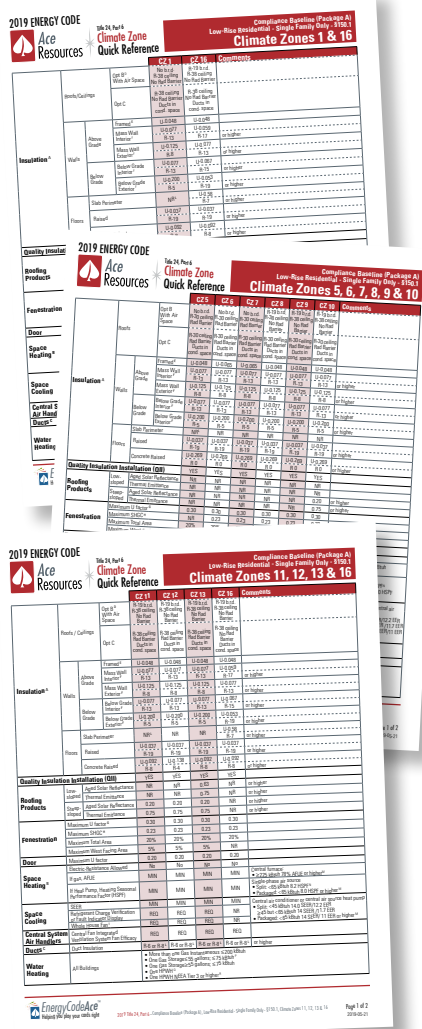


Figure 1: Examples of Energy Code Ace Quick Reference Sheets

Quality Insulation Installation (QII)

Where QII was a strategy for compliance credit under the 2016 Energy Standards, it is now a Prescriptive requirement in all Climate Zones. 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 Reference Appendix RA 3.5](#) includes key terms, installation details, material specifications and compliance documentation related to QII.

QII Requirements of note include:

Door and Window Headers: All single-member window and door headers shall be insulated to a minimum of R-3 for a 2x4 framing, or equivalent width and a minimum of R-5 for all other assemblies. Insulation must be placed between the interior face of the header and inside surface of the interior wall finish.

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 (and associated R-Value 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 [Certificates of Installation \(CF2R\)](#) and [Certificates of Verification \(CF3R\)](#) 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.

Performance Path

Projects seeking compliance under the Performance path are compared against a reference building meeting Prescriptive requirements (baseline), per [Section 150.1\(b\)](#) of the Energy Code.

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 ([Residential Reference Appendix RA 3.8](#)) 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 target leakage rate for the standard design building, the credit can be taken. If not, the building model must be rerun without presumption of the credit.

Sealing the Air Barrier



Correctly Sized Batts



Required U-factors for Envelope Systems

Forms – Which & When

During Design:

- **CF1R-ADD-01-E:** Prescriptive Additions Compliance Form
- **CF1R-ADD-02-E:** Prescriptive Additions Non HERS Compliance Form
- **CF1R-ALT-01-E:** Prescriptive Alterations Compliance Form – Used when HERS is triggered
- **CF1R-ALT-05-E:** Prescriptive Alterations Non HERS Compliance Form – Used for simple projects that do not trigger HERS
- **CF1R-ENV-02-E:** Area Weighted Average Work Sheet
- **CF1R-ENV-06-E:** Interior/Exterior Insulation Worksheet
- **CF1R-NCB-01-E:** Prescriptive Newly Constructed Building Compliance Form
 - All forms completed and signed by permit applicant (designer, installing contractor or building owner)
 - All forms submitted to the building department during permit application

Notes:

- The CF1R forms that are required are based on project specifics and will vary

During Construction

- **CF2R-ADD-02-E:** Prescriptive Additions Non HERS Installation Compliance Form
- **CF2R-ALT-05-E:** Prescriptive Alterations Non HERS Installation Compliance Form
- **CF2R-ENV-03-E:** Insulation Installation Compliance Form
- **CF2R-ENV-20 (Tables a-e):** Air Leakage Tests
- **CF3R-ENV-20 (Tables a-e):** Air Leakage HERS Verification
- **CF3R-ENV (21-24):** HERS QII Verification
- **CF3R-EXC-20-H:** HERS Verification of Existing Conditions for Alterations
 - All forms completed and signed by installing contractor
 - All forms should be made available for the inspector when onsite

Notes:

- The CF2R forms that are required are based on project specifics and will vary

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CF1R-ADD-01-E
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ADDITIONS 1000 FT² OR LESS
CERTIFICATE OF COMPLIANCE
Prescriptive Residential Additions 1,000 FT² or Less

A. General Information

01	Project Name:	02	Date Prepared:
03	Project Location:	04	Building Front Orientation (deg):
05	CA City:	06	Number of Dwelling Units with Additions:
07	Zip Code:	08	Fuel Type:
09	Climate Zone:	10	Total Conditioned Floor Area (ft ²) (Additions):
11	Building Type:	12	Slab Area (ft ²):
13	Project Scope:	14	Emergency Situations (U-Factor and SHGC):

B. Opaque Surface Details – Framed (Section 150.3(c))

Tag ID	Assembly Type	Frame Type	Frame Depth (inches)	Frame Spacing (inches)	Cavity R-Value	Continuous Insulation R-Value	Proposed		Required		Comments
							U-Factor	SHGC	U-Factor	SHGC	
01	02	03	04	05	06	07	08	09	10	11	

C. Opaque Surface Details – Non-Framed (Section 150.1(c))

Tag ID	Assembly Type	Assembly Materials	Thickness (inches)	Core Insulation R-Value	Continuous Insulation R-Value	Proposed		Required		Comments
						U-Factor	SHGC	U-Factor	SHGC	
01	02	03	04	05	06	07	08	09	10	11

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Prescriptive Residential Additions That Do Not Require HERS Field Verification
CERTIFICATE OF COMPLIANCE
Prescriptive Residential Additions That Do Not Require HERS Field Verification

This compliance document is only applicable to additions less than or equal to 1,000 FT² and do not require HERS field verification for compliance. When HERS verification is required, a CF1R-ADD-01 shall first be registered with a HERS Provider State Registry.

Alterations to Space Conditioning Systems that are exempt from HERS verification requirements may use the CF1R-ADD-02 and CF1R-ADD-02 Compliance Documents. Possible exemptions from direct testing include less than 400 ft² of ducts never added or replaced or the existing duct system was installed with separate, or the existing duct system was previously tested and passed by a HERS Tester. If space conditioning systems are altered and are not exempt from HERS verification, then a CF1R-ADD-01 and CF1R-ALT-02 must be completed and registered with a HERS Provider State Registry.

Additions or alterations that utilize closed Cell Spray Polyurethane Foam (cSPF) with a density of 2.5 to less than 3.5 pounds per cubic foot having an R-value greater than 5.8 per inch, or Open Cell Spray Polyurethane Foam (oSPF) with a density of 0.4 to less than 2.5 pounds per cubic foot having an R-value of 3.6 per inch, shall complete and register a CF1R-ADD-02 with a HERS Provider State Registry.

If more than one person has responsibility for installation of the items on this certificate, each person shall prepare and sign a certificate applicable to the portion of construction for which they are responsible. Alternatively, the person with chief responsibility for construction shall prepare and sign this certificate for the entire construction. All applicable Mandatory Measures shall be met. Temporary labels shall not be removed before verification by the building inspector.

A. General Information

01	Project Name:	02	Date Prepared:
03	Project Location:	04	Building Front Orientation (deg):
05	CA City:	06	Number of Dwelling Units with Additions:
07	Zip Code:	08	Fuel Type:
09	Climate Zone:	10	Total Conditioned Floor Area (ft ²) (Additions):
11	Building Type:	12	Slab Area (ft ²):
13	Project Scope:	14	Emergency Situations (U-Factor and SHGC):

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EXISTING CONDITIONS FOR RESIDENTIAL ALTERATIONS
CERTIFICATE OF VERIFICATION
Existing Conditions for Residential Alterations

A. General Information

01	Project Name:	02	Standard Compliance Version:
03	Calculation Description:	03	Software Version:
04	Project Location:	04	Standard Version:
05	CA City:	05	Compliance Manager Version:
06	Zip Code:	06	Software Version:
07	Climate Zone:	07	Building Front Orientation (deg):
08	Building Type:	08	Number of Dwelling Units:
09	Project Scope:	09	Number of Zones:
10	Total Conditioned Floor Area (ft ²):	10	Number of Stories in Building:
11	Slab Area (ft ²):	11	Natural Gas Available? (Yes/No):
12	Addition Conditioned Floor Area (ft ²):	12	Glazing Percentage (%):
13	Addition Slab Area (ft ²):	13	

B. Opaque Surfaces

Tag	Zone	Existing Conditions	Surface Type	U-Factor	Orientation	Total Cavity R-value	Verification
01	02	03	04	05	06	07	08

09 Verification Status: Pass: All applicable requirements are met, or Fail: One or more applicable requirements are not met. Enter reason for failure in corrections notes field below.

10 Correction Notes:

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For More Information

Primary Documents

- Energy Code Section 10-111 – Certification And Labeling Of Fenestration Product And Exterior Door U-Factors, Solar Heat Gain Coefficients, Visible Transmittance And Air Leakage
energycodeace.com/site/custom/public/reference-ace-2019/Documents/10111certificationandlabelingoffenestrationproductandexteriordoo.htm
- Energy Code Section 10-112 – Criteria For Default Tables
energycodeace.com/site/custom/public/reference-ace-2019/Documents/10112criteriafordefaulttables.htm
- Energy Code Section 110.6 – Mandatory Requirements for Fenestration Products and Exterior Doors
energycodeace.com/site/custom/public/reference-ace-2019/Documents/section1106mandatoryrequirementsforfenestrationproductsandexteri.htm
- Energy Code Section 110.7 – Mandatory Requirements to Limit Air Leakage
energycodeace.com/site/custom/public/reference-ace-2019/Documents/section1107mandatoryrequirementstolimitairleakage.htm
- Energy Code Section 150.0 – Mandatory Features and Devices
energycodeace.com/site/custom/public/reference-ace-2019/Documents/section1500mandatoryfeaturesanddevices.htm
 - 150.0(a-f) – Insulation
 - 150.0(g) – Vapor Retarder
- Energy Code Section 150.1 – Performance and Prescriptive Compliance Approaches for Low-Rise Residential Buildings
energycodeace.com/site/custom/public/reference-ace-2019/Documents/section1501performanceandprescriptivecomplianceapproachesforlowr.htm
- Energy Code Section 150.2 – Energy Efficiency Standards for Additions and Alterations
energycodeace.com/site/custom/public/reference-ace-2019/Documents/section1502energyefficiencystandardsforadditionsandalterationsto.htm
- Energy Code Residential Compliance Manual Chapter 3, Envelope Features
energycodeace.com/site/custom/public/reference-ace-2019/index.html#!Documents/3buildingenveloperequirements.htm
 - Addresses the requirements for the building shell, excluding fenestration. Components of the building shell include walls, floors, and roofs and/or ceilings.
- Energy Code Residential Compliance Manual Chapter 3.4.1(J)
energycodeace.com/site/custom/public/reference-ace-2019/Documents/34opaqueenvelope.htm
 - Provides definitions and information on Cool Roofs
- Energy Code Residential Reference Appendix RA 3.5
energycodeace.com/site/custom/public/reference-ace-2019/Documents/ra35qualityinsulationinstallationprocedures.htm
 - Provides information on fenestration requirements

- Energy Code Joint Reference Appendix JA4
energycodeace.com/site/custom/public/reference-ace-2019/Documents/appendixja4ufactorfactorandthermalmassdata.htm
 - Provides data tables which contain effective U-factors for common roof/ceilings, walls, floor assemblies and doors

California Energy Commission Information & Services

- Energy Standards Hotline: 1-800-772-3300 (Free) or Title24@energy.ca.gov
- Online Resource Center:
energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/online-resource-center
 - The Energy Commission's main web portal for the Energy Code, including information, documents and historical information

Additional Resources

- Energy Code Ace:
EnergyCodeAce.com
 - An online “one-stop-shop” providing free resources and training to help appliance and building industry professionals decode and comply with Title 24, Part 6 and Title 20. The site is administered by California's investor-owned utilities.

Of special interest:

- Training
EnergyCodeAce.com/content/training-ace/
 - Decoding QII: Let's Talk What's Coming for HERS Quality Insulation Installation
- Fact Sheets
EnergyCodeAce.com/content/resources-fact-sheets/
 - Residential Fenestration 2019
 - Residential Cool Roofs 2019
 - Just the Basics - HERS for Residential and Nonresidential Projects 2019
- Climate Zone Compliance Baseline Quick Reference Sheets for 2019
EnergyCodeAce.com/content/resources-fact-sheets/
 - 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

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