Residential

Opaque Envelopes

What is an Opaque Envelope?

Opaque envelope assemblies are those that do not transmit solar radiation. The 2016 Building Energy Efficiency Standards (Energy Standards) 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 roof/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 impact comfort of the occupants.

Relevant Code Sections

2016 California Building Energy Efficiency Standards, Title 24, Part 6:

- 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
  - 150.0(q) – Fenestration Products
- 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
- Joint 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
- CF1R-ALT-05-E: Prescriptive Alterations Non HERS Compliance Form
- CF1R-ENV-02-E: Area Weighted Average Work Sheet
- 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 Standards include both Mandatory and Prescriptive requirements for residential opaque surfaces.

Mandatory Requirements

Fenestration and Exterior Doors Section 110.6

Exterior doors that are not NFRC-rated must use default U-factor and SHGC assumptions found in Table 110.6-A and Table 110.6-B. If the fenestration area of exterior doors exceedes 3ft^2, the weighted-average fenestration solar heat gain coefficient includes the exterior doors. A new maximum air leakage limit of 0.3 cfm/ft^2 when tested at 75 Pa applies to pet doors. Refer to the Energy Code Ace Residential Fenestration Fact Sheet for a detailed discussion of Mandatory requirements for these components.

Why? By including fenestration area of exterior doors in the building's fenestration performance, the Energy Standards restrict solar heat gain entering the building and moderate cooling loads.

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 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.

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 Standards require minimum solar reflectance and thermal emittance for steep-sloped roofs in Climate Zones 10 through 15. Cool roofing products may prescriptively comply either by meeting required solar reflectance and thermal emittance levels, or by meeting a minimum Solar Reflectance Index. In order for insulation to comply with the Energy Standards it must be certified to BHFTI and listed in their directory.

Why? Cool roofs reduce cooling loads for residential buildings in warmer climates, and also reduce attic temperatures, which helps maintain the conditioned air when ducts are located in unconditioned space.

Roof Reflectance & Emittance

Cool Roofs are one way to comply with the roof reflectance and emittance code requirements. According to Chapter 3.4.1(J) in the Residential Compliance Manual, a "cool roof" is a roofing product with high solar reflectance and thermal emittance properties. Energy Code Ace's Residential Cool Roof Fact Sheet 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

Vapor Retarders Section 150.0(g)

In Climate Zones 1 through 16, the earth floor of unvented crawl space shall 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 shall 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 Standards.

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

Joint Appendix JA4 provides data tables which contain effective U-factors for common roof/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 Joint Appendix JA4 tables by finding the row for the framing size, spacing, and cavity insulation R-value, then 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; so if the product insulation value falls between two adjacent values, use the less efficient of the two assemblies.

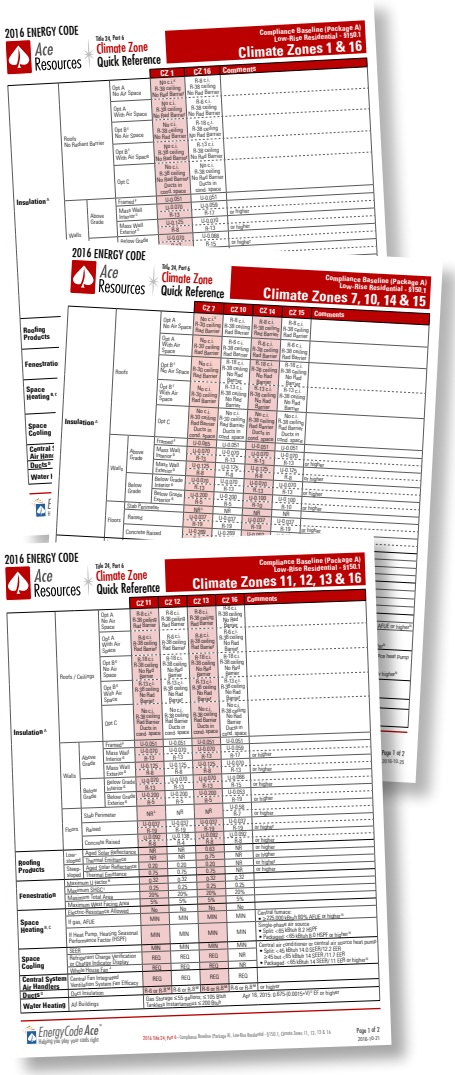


Figure 1: Examples of Energy Code Ace Quick Reference Sheets

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.

Insulation Sections 150.0(a-f)

Additional residential-only Mandatory requirements for insulation can be found in Sections150.0(a-f) of the Energy Standards (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 R19, for wood framed assemblies
- The Mandatory U-factor for 2x4 walls must be at a maximum of 0.102 equivalent to an installed R-value of 13 in a wood framed assembly
- The Mandatory U-factor for 2x6 or greater walls must be at a maximum of 0.074 or an installed R-value of 19 in a wood framed assembly
- Opaque non-framed wall assemblies shall have an overall assembly U-factor not exceeding 0.102, equivalent to installing R-13 in a wood framed assembly
- 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, 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).

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 A: Ceiling Insulation and Above Roof Deck Insulation in Ventilated Attic
  - Continuous Insulation (c.i.) Above Roof Rafters: R-6 (with air space), R-8 (without air space)
  - Ceiling Insulation R-30 or R-38 (varies by Climate Zone)
  - Radiant Barrier: Required in all Climate Zones except 1 and 16
- Option B: Ceiling Insulation and Below Roof Deck Insulation in Ventilated Attic
  - Insulation Below Roof Deck: R-13 (with air space), R-18 (without air space)
  - 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 0.051 (~R-19 cavity plus R-5 c.i.) except for Climate Zones 6 and 7, which have a maximum U-factor of 0.065 (~R-13 plus R-5 c.i.)

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 Standards.

Envelope Compliance Credits

Those pursuing the Performance path 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 Commission 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.

QII Requirements of note 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 (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.

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 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 leakage rate assumed for the standard design building, the credit can be taken. If not, the building model must be rerun without presumption of the credit (which is difficult to achieve). Performing this test and others is a topic of Decoding HERS: Let's Talk Res & Nonres HERS Measures.

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
- CF1R-ALT-05-E: Prescriptive Alterations Non HERS Compliance Form
- CF1R-ENV-02-E: Area Weighted Average Work Sheet
- 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:

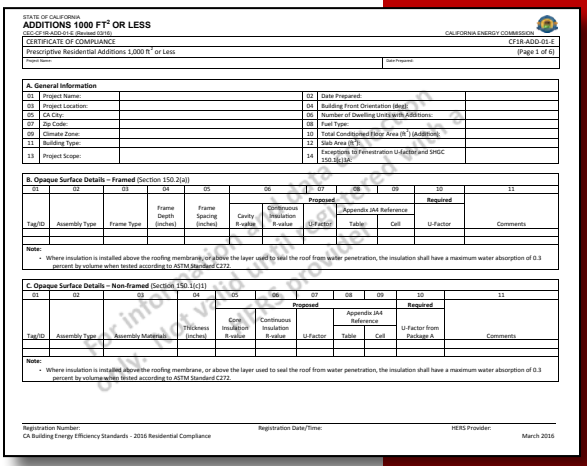
- The CF1R forms that are required are based on project specifics and will vary

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


STATE OF CALIFORNIA
ADDITIONS 1000 FT² OR LESS
CALIFORNIA ENERGY COMMISSION
CERTIFICATE OF COMPLIANCE — CF1R-ADD-01-E
Prescriptive Residential Additions 1,000 ft² or Less (Page 1 of 6)

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 (ft²) (Addition):	
11	Building Type:		12	Slab Area (ft²):	
13	Project Scope:		14	Exceptions to Fenestration U-factor and SHGC 150.1(c)1A:	

B. Opaque Surface Details – Framed (Section 150.2(a))

01	02	03	04	05	06	07	08	09	10	11
					Proposed				Required	
Tag/ID	Assembly Type	Frame Type	Frame Depth (inches)	Frame Spacing (inches)	Cavity R-value	Continuous Insulation R-value	U-Factor	Appendix JA4 Reference Table:	Appendix JA4 Reference Cell:	U-Factor	Comments

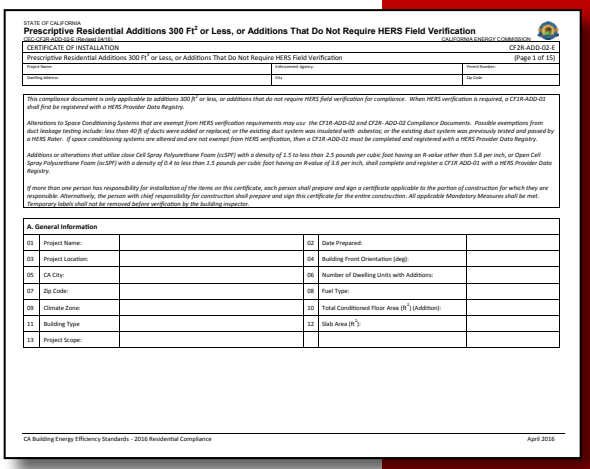
Note:
- Where insulation is installed above the roofing membrane, or above the layer used to seal the roof from water penetration, the insulation shall have a maximum water absorption of 0.3 percent by volume when tested according to ASTM Standard C272.

C. Opaque Surface Details – Non-framed (Section 150.1(c1))

01	02	03	04	05	06	07	08	09	10	11
				Proposed					Required	
Tag/ID	Assembly Type	Assembly Materials	Thickness (inches)	Cont. Insulation R-value	Continuous Insulation R-value	U-Factor	Appendix JA4 Reference Table:	Appendix JA4 Reference Cell:	U-Factor from Package A	Comments

Note:
- Where insulation is installed above the roofing membrane, or above the layer used to seal the roof from water penetration, the insulation shall have a maximum water absorption of 0.3 percent by volume when tested according to ASTM Standard C272.

Registration Number: | Registration Date/Time: | HERS Provider:
CA Building Energy Efficiency Standards - 2016 Residential Compliance — March 2016


STATE OF CALIFORNIA
Prescriptive Residential Additions 300 Ft² or Less, or Additions That Do Not Require HERS Field Verification
CALIFORNIA ENERGY COMMISSION
CERTIFICATE OF INSTALLATION — CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft² or Less, or Additions That Do Not Require HERS Field Verification (Page 1 of 15)

This compliance document is only applicable to additions 300 ft² or less, or additions that 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 Data Registry.

Alterations to Space Conditioning Systems that are exempt from HERS verification requirements may use the CF1R-ADD-02 and CF2R- ADD-02 Compliance Documents. Possible exemptions from duct leakage testing include: less than 40 ft of ducts were added or replaced; or the existing duct system was insulated with asbestos; or the existing duct system was previously tested and passed by a HERS Rater. If space conditioning systems are altered and are not exempt from HERS verification, then a CF1R-ADD-01 must be completed and registered with a HERS Provider Data Registry.

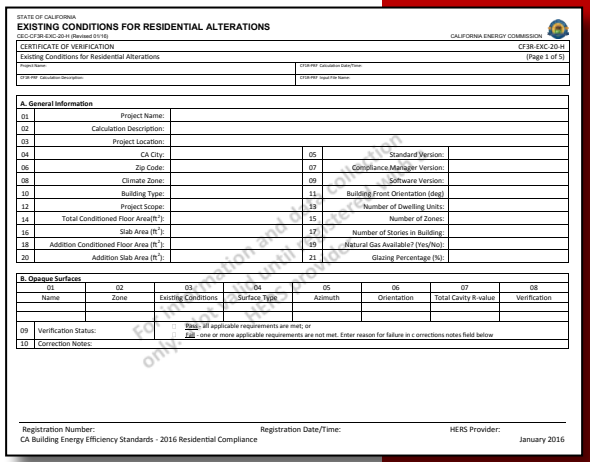
Additions or alterations that utilize close Cell Spray Polyurethane Foam (ccSPF) with a density of 1.5 to less than 2.5 pounds per cubic foot having an R-value other than 5.8 per inch, or Open Cell Spray Polyurethane Foam (ocSPF) with a density of 0.4 to less than 1.5 pounds per cubic foot having an R-value of 3.6 per inch, shall complete and register a CF1R ADD-01 with a HERS Provider Data 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 (ft²) (Addition):	
11	Building Type		12	Slab Area (ft²):	
13	Project Scope:				

CA Building Energy Efficiency Standards - 2016 Residential Compliance — April 2016


STATE OF CALIFORNIA
EXISTING CONDITIONS FOR RESIDENTIAL ALTERATIONS
CALIFORNIA ENERGY COMMISSION
CERTIFICATE OF VERIFICATION — CF3R-EXC-20-H
Existing Conditions for Residential Alterations (Page 1 of 5)

A. General Information

01	Project Name:				
02	Calculation Description:				
03	Project Location:				
04	CA City:		05	Standard Version:	
06	Zip Code:		07	Compliance Manager Version:	
08	Climate Zone:		09	Software Version:	
10	Building Type:		11	Building Front Orientation (deg)	
12	Project Scope:		13	Number of Dwelling Units:	
14	Total Conditioned Floor Area(ft²):		15	Number of Zones:	
16	Slab Area (ft²):		17	Number of Stories in Building:	
18	Addition Conditioned Floor Area (ft²):		19	Natural Gas Available? (Yes/No):	
20	Addition Slab Area (ft²):		21	Glazing Percentage (%):	

B. Opaque Surfaces

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

09 Verification Status: Pass - all applicable requirements are met; or Fail - one or more applicable requirements are not met. Enter reason for failure in c orrections notes field below
10 Correction Notes:

Registration Number: | Registration Date/Time: | HERS Provider:
CA Building Energy Efficiency Standards - 2016 Residential Compliance — January 2016

For More Information

Primary Documents

- Energy Standards Residential Compliance Manual Chapter 3.6, Envelope Features:
  www.energy.ca.gov/2015publications/CEC-400-2015-032/chapters/chapter_3-Building_Envelope_Requirements.pdf
  - Addresses the requirements for the building shell, excluding fenestration. Components of the building shell include walls, floors, and roofs and/or ceilings.
- Energy Standards Residential Compliance Manual Chapter 3.4.1(J):
  energy.ca.gov/2015publications/CEC-400-2015-032/chapters/chapter_3-Building_Envelope_Requirements.pdf
  - Provides definitions and information on cool roofs
- Energy Standards Residential Appendix RA 3.5:
  energycodeace.com/site/custom/public/reference-ace-2016/index.html#!Documents/ra35qualityinsulationinstallationprocedures.htm
  - Provides information on fenestration requirements
- Energy Standards Joint Appendix JA4:
  energycodeace.com/site/custom/public/reference-ace-2016/index.html#!Documents/appendixja4ufactorcfactorandthermalmassdata.htm
  - Provides data tables which contain effective U-factors for common roof/ceilings, walls, and floor assemblies.

California Energy Commission Information & Services

- Energy Standards Hotline: 1-800-772-3300 (Free) or Title24@energy.ca.gov
- Online Resource Center:
  energy.ca.gov/title24/orc/
  - The Energy Commission's main web portal for Energy Standards, including information, documents, and historical information

Additional Resources

- Solar Rating & Certification Corporation (SRCC):
  solar-rating.org
- 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:
    - Decoding HERS: Let's Talk Res & Nonres HERS Measures
      EnergyCodeAce.com/content/training-ace/training_event_type=course-type-decoding-talk
    - Crack the Code tool on QII
      EnergyCodeAce.com/content/resources-crack-the-code/
    - Title 24, Part 6 Fact Sheets
      EnergyCodeAce.com/content/resources-fact-sheets/
      Fenestration:
      - Residential Fenestration Fact Sheet

      Roof Reflectance & Emittance:
      - Residential Cool Roofs Fact Sheet

      HERS:
      - Residential and Nonresidential HERS Fact Sheet ("Just the Basics")
      - Residential HERS Measures Quick Reference Sheet
    - Climate Zone Compliance Baseline Quick Reference Sheets
      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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This program is funded by California utility customers under the auspices of the California Public Utilities Commission and in support of the California Energy Commission.