DOCKETED

Docket Number:	15-BSTD-02
Project Title:	Residential Compliance Manual and Documents
TN #:	205481
Document Title:	Comments: VELUX suggested edits to 2016 Residential Compliance Documents
Description:	N/A
Filer:	System
Organization:	Roger LeBrun
Submitter Role:	Other Interested Person
Submission Date:	7/24/2015 10:21:21 AM
Docketed Date:	7/24/2015

Comment Received From: Roger LeBrun
Submitted On: 7/24/2015
Docket Number: 15-BSTD-02

VELUX suggested edits to 2016 Residential Compliance Documents

Attached is a combined pdf file containing annotated portions of the proposed 2016 Residential Compliance Manual, and some of the compliance forms, where we noted suggested edits. Adobe Acrobatâ€™s â€œCommentâ€ utility was used to mark-up the downloaded CEC pdf files directly, prior to combining them.

The bulk of the edits relate to issues related to consistent use of language associated with fenestration compliance, along with some miscellaneous clean-up edits. We also believe the Area-Weighted Average calculation form should be adapted to allow requirements to be area-weighted averaged when exceptions are in play for some of the affected elementâ€™s total area.

Additional submitted attachment is included below.

~~3.~~ Table of Contents

~~4.~~3. ~~3.~~ Building Envelope Requirements

This chapter describes the requirements that affect the design of the building envelope for residential buildings. The building's design and choices made for individual components can significantly impact the energy demand needed to meet heating and cooling loads to maintain the building's desired inside comfort temperature. Heating and Cooling load calculations are used to determine the mechanical system design needed for space heating and cooling. The principal components of heating loads are infiltration and conduction losses through building envelope components, including walls, roofs, floors, slabs, windows and doors. Cooling loads, on the other hand, are dominated by solar gains through windows and skylights.

3.1 Organization

This chapter is organized by building system or building envelope component, and includes the following subject areas:

Section ~~3.2 What's~~3.2 What's New for ~~2013~~2016

- ~~Highlights of significant c~~Changes for 2016~~3~~ include more flexibility for prescriptive compliance and changing the minimum mandatory insulation level to R-22 for roof/ceiling.~~affecting the building envelope Compliance Options~~
- Provisions allowing the Energy Commission to approve new products, methods, and procedures for compliance

Section 3.3 Compliance Options

- A summary of the general requirements affecting compliance with the *2016~~3~~ Building Energy Efficiency Standards*

Section 3.4 Key Envelope Compliance Terms

- Terms used most often related to the building envelope for compliance purposes

Section 3.5 Fenestration

- Detailed explanation of the mandatory requirements, and prescriptive and performance compliance approaches for fenestration

Section 3.6 Envelope Features

- Detailed explanation of the mandatory requirements, and prescriptive and performance compliance approaches for the building envelope

Section 3.7 Advanced Assembly Systems

- Discussion of design techniques that when used in more innovative ways can improve building energy efficiency and receive compliance energy credit

Section 3.8 Compliance and Enforcement

- Discussion of issues to aid compliance and enforcement for elements of the building envelope

Section 3.9 Glossary/References

- Key terms and reference information most often used for the building envelope

~~3.2~~ What's New for ~~2013~~2016
3.2

The ~~2013~~ 2016 Building Energy Efficiency Standards for residential buildings include increased efficiencies for several envelope measures, and there are improvements that have been made to better aid the designer, builder, and building official.

1. ~~An updated equation to calculate the aged solar reflectance for cool roofing product, §110.8(i)2.~~
2. Mandatory minimum roof/ceiling construction insulation level must be at least R-22 (maximum U-factor of 0.043).~~s installed between 2x6 inch and greater wall framing, §150.0(c).~~
3. ~~Introduced assembly U-factor to meet the prescriptive insulation requirement, TABLE 150.1-A.~~
4. ~~Increased the prescriptive requirement for low- and steep-sloped roofing products (cool roof) and removed the designations of roof weight, §150.1(c)11.~~
5. ~~For alterations, a prescriptive tradeoff is allowed between insulation and cool roofs, §150.2(b)1H.~~
6. ~~More efficient fenestration (lower U-factor) and higher levels of shading (lower SGHC) are required in specific climate zones.~~
7. ~~Dynamic Glazing also known as smart windows can now be accounted for energy compliance.~~
8. 1. ~~Window Films can be used to meet the shading requirements for alterations to existing buildings.~~
2. Increased flexibility for prescriptive compliance.
   Increased the prescriptive roof assembly requirements to include insulation installed either above or below the roof deck. Verified ducts in conditioned space will also satisfy this requirement.

~~Prescriptive component packages C and E have been removed. There is now only one prescriptive component package, Package A (previously component package D).~~

3.

3.3 Compliance Options

Public Resources Code, Section 25402.1 (b) requires the California Energy Commission to establish a formal process for certification of compliance options of new products, materials, designs or procedures that can improve building efficiency levels established by the *Building Energy Efficiency Standards*. §10-109 ~~of the Standards~~ allows for the introduction of new calculation methods and measures which cannot be properly accounted for in the current approved compliance approaches. This process for approval of new products, materials, procedures, and calculation methods is called compliance options and helps to improve building efficiency levels set by the Energy Standards.

The Energy Commission encourages the use of energy-saving techniques and designs for showing compliance with the S~~s~~tandards. The compliance options process allows the Energy Commission to review and gather public input regarding the merits of new compliance techniques, products, materials, designs, or procedures to demonstrate compliance for newly constructed buildings, additions, and alterations to existing buildings. Approved compliance options are generally carried for use with the newer energy code when revisions are made to the Energy S~~s~~tandards, and information regarding their use and eligibility and/or installation criteria are incorporated in compliance and reference manuals.

When the Energy Commission approves a new compliance option it is listed in the Special Cases section of the Energy Commission's website based on the adoption year of the Energy ~~s~~Standards: http://www.energy.ca.gov/title24/2008standards/special_case_appliance/

3.3.1 *Mandatory Features and Devices*

§150.0

Mandatory requirements are necessary to support the long-term goal of zero net energy buildings. When compliance is being demonstrated with either the prescriptive or performance compliance paths, there are *mandatory measures* that must be installed. Minimum mandatory measures must be met regardless of the method of compliance being used. For example, a building may comply using performance computer modeling software with ~~only~~ a U-factor of U-0.~~41~~ 065 insulation in a wood-framed attic roof, but a U-factor of at least U-0.043~~1~~ must be installed. ~~because that is the mandatory minimum.~~

3.3.2 *Prescriptive Compliance Approach*

Energy Standards Table 150.1-A

The *prescriptive ~~requirements~~ approach* ~~are~~ is the simplest way to comply with the building envelope requirements, but generally offers ~~little~~ limited flexibility; however, the 2016 revisions have added increased flexibility for prescriptive compliance. If each and every prescriptive requirement is met, the building envelope complies with the Energy ~~standards~~Standards. The prescriptive envelope requirements are prescribed in §150.1 which includes §Table 150.1-A.

A.

~~A.~~B. The prescriptive compliance approach consists of meeting specific requirements for each envelope component, plus meeting all minimum mandatory requirements, such as mandatory levels of insulation. Prescriptive requirements apply to:

1. fenestration

~~1.~~2. roofs and ceilings, including exterior roofing products

~~2.~~3. exterior walls

~~3.~~4. floors

~~Fenestration must meet prescriptive efficiency values and have a maximum area of 20% of the window-to-wall ratio conditioned floor area (CFA). The efficiency values are specified for the maximum U-factor, maximum Solar Heat Gain Coefficient (SHGC) and maximum west facing area of 5% of the CFA. Specific requirements are made for glazing in doors, tubular skylights, non-tubular skylights, and chromatic type glazing (§150.1(c)3A).~~

3.3.3 *Performance Compliance Approach*

§150.1

A. The prescribed mandatory measures and prescriptive requirements affect the design and operation of the building. Mandatory measures, prescriptive requirements and operational schedules establish a minimum performance level which can be exceeded by other design measures and construction practices resulting in greater energy savings.

~~A.~~B. The *performance approach* is a more sophisticated compliance method and it offers greater design flexibility than the prescriptive approach. The performance approach may be used for any unique design element(s) that the user of a compliance modeling software believes ~~can~~ could contribute to the building's overall energy use.

~~B.~~C. The performance approach allows for more energy tradeoffs between building features, such as increasing HVAC equipment efficiency in order to allow more fenestration area. See Section 3.8 and Chapter ~~9~~ 8 for a more complete discussion of the performance approach.

3.4 Key Envelope Compliance Terms

Elements of the building envelope significantly contribute to its energy efficiency. Several features are important to note when a method is chosen to demonstrate compliance. Components of the building envelope include walls, floors, the roof and/or ceiling, and fenestration. Details for compliance of fenestration are addressed in Section 3.5 below.~~,~~ ~~Fenestration.~~ Envelope and other building components are listed in §100.1 of the 2016 Energy Standards and the Reference Appendices (RA).

~~A. **Walls and Space(s) Surrounding Occupancy Uses**~~

~~B. Envelope and other building component definitions are listed in §100.1 of the 2013 2016 Standards, and the Reference Appendices.~~

~~C.~~A. **Envelope** requirements vary by envelope component and are a function of their type of construction, their orientation and the space conditions on either side of the envelope surface. Additional envelope component definitions are: ~~as follows:~~

~~D.~~1. ~~An~~ ~~**e**~~**Exterior partition or wall** is an envelope component (roof, wall, floor, window etc.) that separates conditioned space from ambient (outdoor) conditions.

~~E.~~2. ~~A~~ ~~**d**~~**Demising partition or wall** is an envelope component that separates conditioned space from an unconditioned space.

~~F.~~B. ~~A~~ ~~**c**~~**Conditioned space** is either directly conditioned or indirectly conditioned (see ~~Section~~ §100.1 for full definition). An indirectly conditioned space has less thermal resistance to a directly conditioned space than to the outside. An unconditioned space is enclosed space within a building that is not directly conditioned, or indirectly conditioned.

~~G.~~C. ~~A~~ ~~**p**~~**Plenum** is a space below an insulated roof and above an uninsulated ceiling. It is an indirectly conditioned space as there is less thermal resistance to the directly conditioned space below than to the ambient air outside. By~~In~~ comparison, an attic is a space below an uninsulated roof ~~and having~~that has insulation on the attic floor, and is an unconditioned space because there is less thermal resistance to the outside than across the insulated ceiling to the conditioned space below. A plenum can also be the space between the underside of a raised floor and the ~~crawl space~~

~~ground~~slab or grade below, and is sometimes used as an air supply for the building when the exterior foundation is sealed to the outside. A plenum can also be the space between the underside of an insulated ceiling and demising partitions or walls separating the attic from the conditioned space below.

~~H.~~D. **Sloping surfaces** are considered either a wall or a roof, depending on the slope (see Figure 3-1). 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~~skylight types in roofs.

E. Floors and roof/ceilings do not differentiate between demising and exterior. Thus an **exterior roof/ceiling** "is an exterior ~~partition~~, or ~~a~~ demising element~~partition~~, that has a slope less than 60 degrees from horizontal, and that has conditioned space below," ambient conditions or unconditioned space above. "

Note: this does ~~and that is~~ not include an exterior door or skylight."

~~I.~~F. **Roof deck** is the surface of an exterior roof that is directly above the roof ~~trusses~~rafter and below exterior roofing materials.

G. Similarly, an "exterior floor/soffit is a **horizontal exterior ~~partition~~element**, or a horizontal demising ~~partition~~element, under conditioned space" and above an unconditioned space or ~~above~~ ambient (outdoor) conditions.

H. A ~~v~~**Vapor retarder** or barrier is a special covering over framing and insulation or covering the ground of a crawl space that protects the assembly components from possible damage due to moisture condensation. During cold weather, the inside of the house is warm and moist (from breathing, showers, etc.) and the outside is cold and dry. Moisture moves from moist to drier conditions and from warm to cold. When the moisture (in vapor form) reaches a point in a wall or roof assembly that has a temperature below the dew point, it will condense into liquid water. Water build up can cause structural damage, create mold that may contribute to indoor air quality problems and can cause the insulation to lose its effectiveness.

~~J.~~ ~~s.~~

~~K.~~ ~~**Fenestration** or~~ **Windows** are considered part of ~~the~~an exterior wall because the slope is typically over 60°. Where the slope of fenestration is less than 60°, the glazing indicated as a window is considered a skylight.

I.

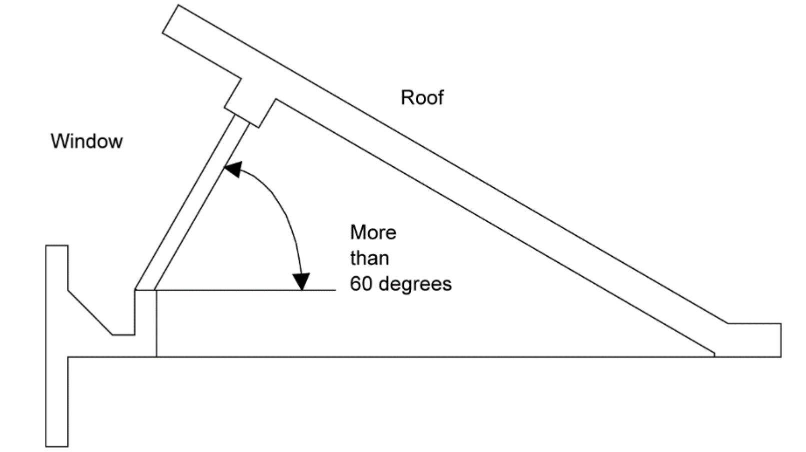


Figure 3-1 – Slope of a Wall or Window (Roof or Skylight slope is less than 60°)
Source: California Energy Commission

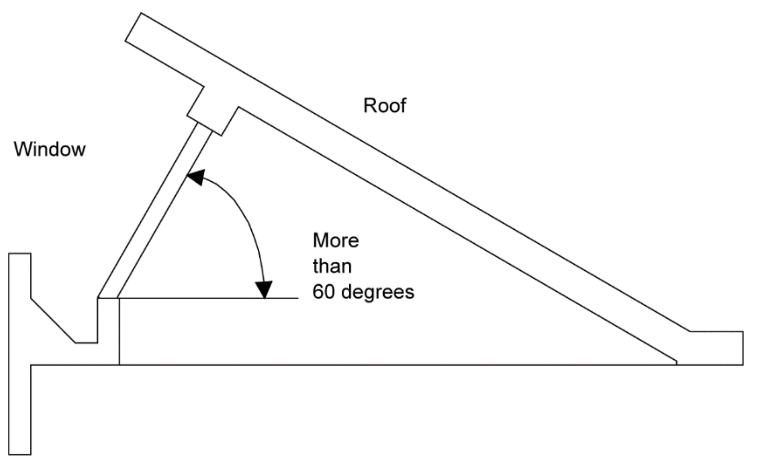
~~L.~~

~~M. Vapor Retarders and Moisture Protection~~

~~A. A **vapor retarder** or barrier is a special covering over framing and insulation or covering the ground of a crawl space that protects the assembly components from possible damage due to moisture condensation. During cold weather, the inside of the house is warm and moist (from breathing, showers, etc.) and the outside is cold and dry. Moisture moves from more to less and from warm to cold. When the moisture (in vapor form) reaches a point in the wall or roof assembly that has a temperature below the dew point, it will condense into liquid water. Water build up can cause structural damage, create mold that may contribute to indoor air quality problems and can cause the insulation to lose its effectiveness.~~

~~B. **Fenestration** or **Windows** are considered part of the exterior wall because the slope is typically over 60°. Where the slope of fenestration is less than 60°, the glazing indicated as a window is considered a skylight.~~

~~C.~~



~~Figure 3-1 – Slope of a Wall or Window (Roof or Skylight slope is less than 60°)~~
~~Source: California Energy Commission~~

~~D.~~J. **Roofing Products (Cool Roof)**

Roofing products with a high solar reflectance and thermal emittance are referred to as "*cool roofs*." These roofing types absorb less solar heat and give off more heat to their surroundings than traditional roofing material. These roofs are cooler and thus help reduce air conditioning loads by reflecting and emitting energy from the sun. Roof radiative properties are rated and listed by the Cool Roof Rating Council (CRRC) (~~http://~~www.coolroofs.org/).

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~~hot~~.

The Energy ~~s~~Standards specify radiative properties that represent minimum "cool roof performance" qualities for~~of~~ roofing products:

1. Solar reflectance—the fraction of solar energy that is reflected by the roof surface
2. Thermal emittance—the fraction of thermal energy that is emitted from the roof surface

Both solar reflectance and thermal emittance are measured from 0 to 1; the higher the value, the "cooler" the roof. There are numerous roofing materials in a wide range of colors that have ~~relatively good~~adequate cool roof properties. Excess heat can increase a~~the~~ building's air conditioning load, resulting in increased air conditioning energy needed for maintaining occupant comfort. High-emitting roof surfaces reject absorbed heat quickly (upward and out of the building) than ~~darker~~ roof surfaces with low-emitting properties.

The Energy Standards prescribe cool roof radiative properties for low-sloped and steep-sloped roofs (§150.1(c)11). A low-sloped roof is defined as a surface with a pitch less than or equal to 2:12 (9.5 degrees from the horizon), while a steep-sloped roof is a surface with a pitch greater than 2:12 (9.5 degrees from the horizon). Because solar heat gain is based on the sun's angle of incidence on a surface, low-sloped roofs receive more solar radiation than steep-sloped roofs in the summer when the sun is high in the sky.

Example 3-1

Question

I am a salesperson and represent some roofing products, and many of them are on the EPA's Energy Star list for cool roofing materials. Is this sufficient to meet Energy Standards?

Answer

No. Energy Star has different requirements for reflectance and NO requirements for emittance. Per ~~Section~~§10-113 ~~of the Energy Building Regulations~~, the Cool Roof Rating Council (~~http://~~www.coolroofs.org) is the only entity currently recognized by the Energy Commission to determine what qualifies as a cool roof.

Example 3-2

Question How does a product get CRRC cool roof certification?

Answer

Any party wishing to have a product or products certified by CRRC should contact CRRC to get started call toll-free (866) 465-2523 from inside the US or (510) 485-7176, or email info@coolroofs.org. CRRC staff will walk interested parties through the procedures. ~~-~~Working with CRRC staff is strongly recommended. In addition, CRRC publishes the procedures in "CRRC-1 Program Manual," available for free on

~~http://~~www.coolroofs.org or by calling CRRC. ~~However, working with CRRC staff is strongly recommended.~~

Example 3-3

Question

I understand reflectance, but what is emittance?

Answer

Even a material that reflects the sun's energy will still absorb some of that energy as heat; there are no perfectly reflecting materials being used for roofing. That absorbed heat undergoes a physical change (an increase in wavelength~~, for readers who remember physics)~~) and is given off – emitted – to the environment in varying amounts depending on the ~~by various~~ materials and surface types. This emittance is given a unit-less value between 0 and 1, and this value represents a comparison (ratio) between what a given material or surface emits and what a perfect blackbody emitter ~~(again, recall physics)~~ would emit at the same temperature.

A higher emittance value means more energy is released from the material or surface; scientists refer to this emitted energy as thermal radiation (as compared to the energy from the sun, solar radiation, with shorter wavelength). Emittance is a measure of the relative efficiency with which a material, surface, or body can cool itself by radiation. Lower-emitting materials become relatively hotter for not being able to get rid of the energy, which is heat. Roof materials with low emittance therefore hold onto more solar energy as heat, get hotter than high-emittance roofs, and with help from the laws of physics, offer greater opportunity for that held heat to be given off downward into the building through conduction. More heat in the building increases the need for air conditioning for comfort. A cool roof system that reflects solar radiation (has high reflectance) and emits thermal radiation well (has high emittance) will result in a cooler roof and a cooler building with lower air-conditioning costs.

~~E.~~K. **Air Leakage**

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. ~~Air leakage~~Infiltration can occur through holes and cracks in the building envelope and around doors and fenestration framing areas. Ventilation, on the other hand, is the *intentional* replacement of conditioned air with unconditioned air through open windows and skylights or mechanical ~~ventilation~~systems.

Reducing ~~air leakage~~infiltration in the building envelope can result in significant energy savings, especially in climates with more severe winter and summer conditions. It also can result in improved ~~building~~ occupant comfort, reduced moisture intrusion, and fewer air pollutants.

~~F.~~L. **Advanced Assemblies**

Common strategies for exceeding the minimum energy performance level set by the 201~~3~~6 Energy Standards include the use of better components such as: higher insulation levels, more efficient fenestration, reducing the building's ~~air leakage~~infiltration, ~~using radiant barriers,~~ use of ~~"~~*cool~~"~~ roofing* products, better framing techniques (such as the use of raised-heel trusses that accommodate more insulation) ~~(raised-heel truss) and~~ reduced thermal bridging across framing members, or greater use of non-framed assemblies or panelized systems (such as SIPs and ICFs), and more efficient heating, cooling and water heating equipment. The Energy Commission encourages the use of energy-~~-~~savings~~s~~ techniques for showing compliance with the Energy ~~s~~Standards. Innovative designs and practices are discussed in ~~the "Advanced Assembly System"~~ S~~s~~ection 3.6.3.4.

~~G.~~M. Advanced Building Design

A~~The~~ building's design, its floor plan and site design layout, impact energy use. A passive solar ~~designed~~ building uses elements of the building to ~~help~~ heat and cool itself, ~~as opposed~~~~in contrast to relying~~ on mechanical systems to provide the building's thermal energy needs. Passive solar strategies encompass several advanced high performance envelope techniques, such as:

1. Carefully choosing the size, type and placement of fenestration and shading.
2. Providing and controlling fresh air ventilation during the day and~~or~~ night.
3. Having internal and external thermal mass components that help store useful heat and cooling energy.
4. Having highly insulated envelope assemblies.
5. Using ~~radiative energy~~high performing roofing materials (cool roofs) and radiant barriers.
6. Having very low air leakage.

Some measures ~~included~~ designed as part of an Advanced Assembly System may require specific installation procedures, or field verification and diagnostic testing to ensure their proper performance. Field verification and diagnostic testing is a way to ensure that the energy efficiency features ~~that is~~ used in compliance calculations is ~~actually~~ realized as an energy benefit ~~by~~ to the homeowner.

3.5 Fenestration

Fenestration ~~P~~products such as ~~a~~ w~~W~~indows, glazed doors, dynamic glazing, window films, and skylights have a significant impact on energy u~~-2e~~se in a home. Fenestration accounts for a large impact on heating and cooling loads of residential and high-rise residential space conditioning loads.~~,~~ T~~t~~he size, orientation, and types of fenestration products can dramatically affect the overall energy performance of a house. Glazing type, orientation, shading and shading devices not only play a major role in the building's energy use, but can affect the load operation of the HVAC system and the comfort of occupants.

3.5.1 *Fenestration Types*

When choosing a window (new or replacement)~~window~~, it i~~'~~s always best to look for a National Fenestration Rating Council (NFRC) ~~rated~~ label ~~sticker~~ on the window. The *Energy Performance Ratings* label is designed to help consumers identify a rating, ~~or~~which is a measurement ~~scale that is~~ reflective of a window's energy performance. This will help the consumer, or designer, ~~to~~ compare the energy efficiency of window and glazed door products, ~~per~~ of different brands and manufacturers ~~as well~~.

The following NFRC label ~~sticker~~ provides information about the energy performance rating by listing identifiers such as: ~~;~~ U-factor~~s~~, Solar Heat Gain Coefficient (SHGC), Visible Transmittance (VT), and Air Leakage (AL) which helps provide accurate information for the consumer or designer~~.~~ : ~~The label references the following information:~~

A. **U-factor** measures the rate of heat loss through a product. ~~Therefore, the~~The lower the U-factor, the lower the amount of heat loss. In cold climates where heating bills are a concern, choosing products with lower U-factors will reduce the amount of heat that escapes from inside the house.

B. **The Solar Heat Gain Coefficient (SHGC)** measures the percentage of heat in radiant heat that passes through a fenestration product. The ~~Therefore, the~~ lower the SHGC, the ~~less~~ lower the amount of solar heat gain. In hot climates where air conditioning bills are a concern, choosing products with a lower SHGC will reduce the amount of heat that comes in from the outside.

C. **Visible Transmittance (VT)** measures the percent ~~amount~~ of light that comes through a fenestration product. The higher the VT rating, the more light is allowed through a window or glazed door. Skylight~~'~~s allow~~s~~ significantly ~~allows~~ more light~~ing and can be as efficient as vertical windows~~.

D. **Air Leakage (AL)** is a measurement of heat loss and gain by infiltration through cracks in the window assembly ~~and it affects the~~, which can affect occupant~~'~~s comfort. The lower the AL, the ~~less~~ lower the amount of air that will pass through cracks in the window assembly.

There are three primary categories of fenestration:

A. WINDOWS

A window is a vertical fenestration ~~including skylights~~product that is an assembled unit consisting of a frame and sash component holding one or more pieces of glazing. New advances in framing material such as composites, fiberglass and vinyl help improve the energy efficiency of ~~all~~ fenestration products. New technology has advanced the glass industry to include reflective coatings such as silver, gold, bronze, low-e, low-e^2, or low-e^3 which can be applied to clear and tinted glass.

B. GLAZED DOORS

Glazed door is an exterior door having a glazed area of 50% or more of the area of the door. These doors are typically installed in exterior walls that separate conditioned space from exterior ambient or unconditioned space. When the door has less than 50% glazing material, it is no longer considered a glazed door, but just a conventional door. But whatever the glazed area, it will still have to be counted toward the overall glazed area of the conditioned space in any calculations.

C. SKYLIGHTS/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. On the other hand, 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 ~~window~~ 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 ~~as efficient as~~ any vertical windows used.

The following is a list of sub-categories of fenestration:~~;~~

1. **Manufactured Fenestration** is a fenestration product constructed of materials which 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.
2. ~~A window is considered~~ **Field-fabricated** is when the windows are ~~assembled~~ fabricated at the building site from ~~the various~~ elements that are not sold together as a fenestration product (i.e., 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).
3. **Site-built Fenestration** is designed to be field-glazed or field-~~-~~assembled units, using specific factory-~~-~~cut or other~~wise~~ factory-~~-~~formed framing, and glazing units that are manufactured with the intention of being assembled at the construction site. These include store front systems, curtain walls, or large track sliding glass walls, and atrium roof systems.
4. **Dynamic Glazing** is a glazing system that has the ability to reversibly change its performance properties, including U-factor, Solar Heat Gain Coefficient (SHGC), and Visible Transmittance (VT) between well-defined end points. These may include, but are not limited to chromogenic glazing systems and integrated shading systems. Dynamic Glazing systems may include internally-~~-~~mounted or externally-~~-~~mounted shading devices that attach to the window framing/glazing, and ~~that~~ may or may not be removable~~,~~ (but only if they are part of the original window, door or skylight assembly and the assembly is labeled as such).
5. **Windows Films** ~~Window Films~~ were originally developed in the early 1950's, and are mostly made of polyester substrate that is durable, tough and highly flexible. It absorbs little moisture and has both high aridity and low temperature resistances. Polyester film offers high ~~crystal~~ clarity and can be pre-treated to accept different types of coatings for energy control and long term performance. Window films are made with a special scratch resistant coating on one side and with a mounting adhesive layer on the other side. The adhesive is normally applied to the interior surface (room side) of the glass, unless it is a film specifically designed for the exterior window surface.

~~5.~~

~~B. GLAZED DOORS~~

~~Glazed door is an exterior door having a glazed area of 50 percent or more of the area of the door. These doors are typically installed in exterior walls that separate conditioned space from exterior ambient or unconditioned space. When the door is less than 50 percent it will no longer be considered a glazed door, it will be just but is a door. The glass area will still have to be counted towards the overall glass area of the conditioned space.~~

~~C. SKYLIGHTS/Tubular Daylight Devises~~

~~Skylights and Tubular Daylight Devises (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 room light and reduce dependence upon electrical lighting. On the other hand, 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 window designer optimizes the whole envelope glazing arrangement for good daylight and thermal control, significant heating and cooling energy savings can be realized, especially when skylights and TDDs with the same technology as efficient vertical windows are used.~~

3.5.2 *Relevant Sections in the Energy Standards for Fenestration*

A. §10-111 (Administrative Standards) establishes the rules for rating and labeling fenestration products and establishes the NFRC as the supervising authority.

B. §110.6(a)1 sets air leakage requirements for all manufactured windows, doors and skylights whether they are used in residential or nonresidential buildings.

C. §110.6(a)2 through 4 requires that the U-factor, S~~s~~olar H~~h~~eat G~~g~~ain C~~c~~oefficient (SHGC), and visible transmittance (VT) for manufactured fenestration products be determined using NFRC procedures or use default values.

D. §110.6(a)5 requires that manufactured fenestration products have both a temporary and permanent label. The temporary label shall show the U-factor, SHGC and the VT and verify that the window complies with the air leakage requirements.

E. §110.6(b) field-fabricated fenestration that do not have an NFRC rating shall use the CEC default U-factors, SHGC and optional VT values.

F. §110.7 requires that openings around windows, skylights and doors be caulked, gasketed, weatherstripped or otherwise sealed to limit air leakage.

G. §150.0(q) requires a mandatory U-factor of 0.58 or a maximum weighted average U-factor of 0.58 for windows and skylights separating conditioned space from unconditioned space or the outdoors. An exception allows the greater of 10 ft^2 or 0.5% of the conditioned floor area to exceed 0.58 U-factor.

H. §150.1(c)3 and 4 ~~meet~~ the prescriptive requirements for fenestration and shading in low-rise residential buildings. These include requirements for maximum glazing area, maximum U-factor, and for some climate zones, a maximum SHGC requirement.

I. §150.1(c)3A, in addition to ~~be~~ the basic fenestration allowance of 20% of conditioned floor area (CFA), Exception 1 allows each dwelling unit to have up to 3 ft^2 of glazing installed in doors and up to 3 ft^2 of tubular daylighting device with dual-pane diffusers to have an assumed U-factor and SHGC equivalent to the Package requirements.

J. §150.1(c)3A, in addition to ~~be~~ basic fenestration allowance of 20% of CFA, Exception 2 allows up to 16 ft^2 of the skylights to have up to 0.55 U-factor and up to 0.30 SHGC in each dwelling.

K. §150.1(c)3A Exception 3 allows automatically controlled chromogenic glazing (a type of dynamic glazing) to assume the lowest U-factor and SHGC when connected to automatic~~ally~~ controls that modulate the amount of heat flow into space in multiple steps in response to solar intensity~~, c~~hromogenic glazing shall be considered separately from other fenestration, and must be not be weight averaged with other fenestration.

L. §150.1(c)3A Exception 4 specifies that if a residential dwelling unit contains a combination of manufactured and site-built fenestration; only the site-built fenestration can be determined by using ~~Nonresidential Reference Appendix~~ NA6; however, all fenestration and including site-built can also default to §~~TABLES~~ Tables 110.6-A or B.

M. §150.1(c)3B establishes ~~a prescriptive limit~~ that the prescriptive maximum total fenestration area shall not exceed the percentage of ~~conditioned floor area (~~CFA~~)~~ indicated in §~~TABLE~~ Table 150.1-A. Total fenestration includes skylights and west-facing glazing.

N. §150.1(c)3C states that when west-facing glazing is limited by Package A, west-facing includes skylights tilted in any direction when the pitch is less than 1:12.

O. §150.2(a) sets the prescriptive fenestration area requirements for residential additions as well as other prescriptive requirements for new ~~windows~~. Performance compliance options (existing plus addition) are also available.

P. §150.2(b) establishes the prescriptive requirements for replacement ~~windows~~ in existing residences. Performance compliance options (existing plus alteration) are also available.

3.5.3 *Mandatory Measures, Features and Devices*

~~Applicable Sections :~~ §110.6(a)1; §110.7

3.5.3.1 **Air Leakage**~~.~~

~~A.~~ Manufactured fenestration products, including exterior doors, must be tested and certified to leak no more than 0.3 cubic feet per minute (cfm) per ft² of the ~~window~~ area.

This mandatory measure applies to all manufactured ~~windows~~ that are ~~newly~~ installed in newly-constructed residential~~,~~ (including high-rise)~~residential~~, or newly-installed in existing buildings. To determine leakage, the standard test procedure requires manufacturers to use ~~is~~ either NFRC 400 or ASTM E283 at a pressure differential of 75 Pascal (or 1.57 pounds/ft^2).

~~B.~~A. **Site-built Products**. There are no specific air leakage requirements for site-built fenestration products but the Energy Standards require limiting air leakage ~~through~~ by means of weatherstripping and caulking.

"Note: In the case when unrated NFRC site-built fenestration is used in a residential application, there is an alternative procedure to calculate the default thermal efficiencies U-factor and SHGC values of such products. Using this alternative may not result in meeting the prescriptive values as listed in §Table 150.1-A. However, it may be used in the Performance Approach. The alternative calculation can be found in ~~the Reference Nonresidential Appendices~~ NA6."

B. **Field-fabricated Products.** No air leakage testing is required for field-fabricated fenestration products; however, the Energy Standards still require limiting air leakage ~~through~~ by means of weatherstripping and caulking.

~~C.~~

~~D.~~C. **Exterior Doors.** Exterior doors must meet the following requirements:

1. Manufactured exterior doors must be certified as meeting an air leakage rate of 0.3 cfm/ft² of door area at a pressure differential of 75 Pascal, which is the same as windows.
2. Field-fabricated e~~E~~xterior doors must comply with the requirements of §110.7, as described by~~in~~ "~~Joints and~~ Other Openings;~~,~~" e.g., they must be caulked and weatherstripped~~ if field-fabricated~~.
3. Any door whose surface area has greater than 50%~~ percent~~ glass is considered as a glazed door and must comply with the ~~Mandatory~~ mandatory and applicable Prescriptive and Performance requirements of §150.0, §150.1, and §150.2.
4. Any door whose surface area has ~~Alternatively, if~~ less than or equal to 50% ~~percent of~~ glass, the area may be exempt in accordance with one of the exceptions of §150.0, §150.1, and §150.2.

~~5.~~3.5.3.2 U-factor and SHGC Rating Mandatory Requirements

~~Applicable Sections:~~ §110.6(a)2 and §110.6(a)3; ~~TABLE~~ Table 110.6-A and ~~TABLE~~ Table 110.6-B

Requiring that U-factor and SHGC be calculated using ~~a~~ standardize procedure ensures that the thermal performance or efficiency data for fenestration products, is ~~are~~ accurate, and that the data provided by different manufacturers within each fenestration type (windows, doors, skylights, TDDs) can be easily compared to others within that type and can be independently verified.

For manufactured fenestration products, the mandatory requirements are that the U-factor and Solar Heat Gain Coefficient (SHGC) be rated by NFRC and be listed in NFRC's Certified Product Directory (CPD). The test procedure for U-factor is NFRC 100, and for SHGC is NFRC 200~~ and~~ ~~NFRC-200,~~ NRC-202 ~~or ASTM E972~~ for translucent panels, ~~and~~ NFRC-203 for tubular daylighting device~~s~~ skylights (TDDs)~~, and for certain type of~~ other ~~skylights~~.

At the time of field inspection, the field inspector verifies the fenestration U-factor and SHGC values meets the energy compliance values by checking the NFRC label ~~sticker~~ on the ~~window~~.

W~~Alternatively, w~~hen 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. See Figure 3-2, Sample Default Label~~ Figure 3-2~~.

Note: If no labels are available on site for verification, the field inspector should not allow~~cease~~ any further installation of fenestration until proof of efficiency (label) is produced ~~on site or filed in the field office~~. In cases when proof is not met,~~ then~~ the field inspector ~~can cease~~should not allow construction until the ~~architect/ specifier~~designer or builder can produce such labels.

The Energy Commission~~s~~ default U-factors are listed in ~~TABLE~~ Table 110.6-A of the Energy Standards, and the default SHGC values are listed in ~~TABLE~~ Table 110.6-B of the Energy Standards (also in Appendix B of this compliance manual).

Note: While there is no minimum VT value requirement for residential compliance, the value may be shown on the temporary label for information only. A listing of NFRC certified ratings is available at ~~http://www.NFRC.org~~http://www.nfrc.org/.

Energy Commission ~~(CEC)~~ default values in §~~TABLE~~ Table 110.6-A and §~~TABLE~~ Table 110.6-B in the Energy Standards lists the worst ~~possible~~ performing values that can be assumed when fenestration is not rated by NFRC. For example, a single-pane, operable, metal-framed fenestration product has a U-factor of 1.28. To get credit for high performance window features such as low-e (low-emissivity) coatings and thermal break frames, the window manufacturer must have the window tested, labeled, and certified according to NFRC procedures.

A. **Site-built Fenestration Products**. For special cases in low-rise residential construction in which~~,~~ site-built products are installed, the site-built products shall be treated the same as manufactured products: proof of U-factor and SHGC values must come from NFRC ratings or from ~~Standards~~the default ~~TABLE~~ Table 110.6-A and ~~TABLE~~ Table 110.6-B of the Energy Standards, or alternatively use of ~~Reference Nonresidential Appendix~~ NA-6 if the area of the site-built is less than 250 ft^2~~.~~.

   Note: When ~~only~~ unrated site-built fenestration is used in a residential application, there is an alternative procedure to calculate the default U-factor and SHGC values. ~~Though~~ When ~~u~~using area-weighted averaging, ~~this~~ the alternative may not result in meeting the prescriptive values as required by §Table 150.1-A. The alternative calculation can be found in ~~the Reference Nonresidential Appendices~~ NA6, or it may ~~require the~~the~~o~~be necessary to use ~~of~~ the performance approach to meet energy compliance.

B. **Field-fabricated Products §110.6(b).** Field-fabricated fenestration must always use the Energy Commission default U-factors from ~~Standards TABLE~~ Table 110.6-A and SHGC values from T~~ABLE~~able 110.6-B of the Energy Standards. There is no minimum requirement for VT, ~~but only~~as it is used for informational purposes.

~~For a~~Acceptable methods of determining U-factor and SHGC are shown in Table 3-1A and Table 3-1B respectively.

Table 3-1A – ~~Acceptable~~ Methods for Determining U-factor

Fenestration Category					
U-factor Determination Method	Manufactured Windows	Manufactured Skylights	Site-Built Fenestration (Vertical& Skylight)	Field-Fabricated Fenestration	Glass Block
NFRC's Component Modeling Approach (CMA)[1]	✓	✓	✓	N/A	N/A
NFRC-100	✓	✓	✓	N/A	N/A
Standards Default Table 110.6-A	✓	✓	✓	✓	✓
NA6[2]	N/A	N/A	✓	N/A	N/A

1. *The NFRC Residential CMA method is an option that may be ~~available during the 2013 cycle of~~in the Energy Standards.*
2. *The Alternative Default U-factors from Nonresidential Reference Nonresidential Appendix NA6 may only be used for site-built vertical and skylights having less than 1,000ft^2.*

Table 3-1B – Methods for Determining Solar Heat Gain Coefficients

Fenestration Category					
SHGC Determination Method	Manufactured Windows	Manufactured Skylights	Site-Built Fenestration (Vertical& Skylight)	Field-Fabricated Fenestration	Glass Block
NFRC's Component Modeling Approach (CMA)[1]	✓	✓	✓	N/A	N/A
NFRC-200	✓	✓	✓	N/A	N/A
Standards Default Table 110.6-B	✓	✓	✓	✓	✓
NA6[2]	N/A	N/A	✓	N/A	N/A
The NFRC Residential CMA method is an option that may be available ~~during the 2013 cycle of~~in the Energy Standards. *The Alternative Default U-factors from Nonresidential Reference Nonresidential Appendix NA6 may only be used for site-built vertical and skylights having less than 1,000ft².*					

Table 3-1A – Acceptable Methods for Determining U-fac~~tor~~

~~Fenestration Category~~					
~~U-factor Determination Method~~	~~Manufactured Windows~~	~~Manufactured Skylights~~	~~Site-Built Fenestration (Vertical& Skylight)~~	~~Field-Fabricated Fenestration~~	~~Glass Block~~
~~NFRC's Component Modeling Approach (CMA)~~[1]	~~✓~~	~~✓~~	~~✓~~	~~N/A~~	~~N/A~~
~~NFRC-100~~	~~✓~~	~~✓~~	~~✓~~	~~N/A~~	~~N/A~~
~~Standards Default Table 110.6-A~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~
~~NA6~~[2]	~~N/A~~	~~N/A~~	~~✓~~	~~N/A~~	~~N/A~~

3. ~~*The NFRC Residential CMA method is an option that may be available during the 2013 cycle of the Energy Standards.*~~
4. ~~*The Alternative Default U-factors from Nonresidential Reference Nonresidential Appendix NA6 may only be used for site-built vertical and skylights having less than 1,000ft²*~~.

Table 3-1B – Methods for Determining Solar Heat Gain Coefficien~~t~~s

~~Fenestration Category~~					
~~SHGC Determination Method~~	~~Manufactured Windows~~	~~Manufactured Skylights~~	~~Site-Built Fenestration (Vertical & Skylight)~~	~~Field-Fabricated Fenestration~~	~~Glass Block~~
~~NFRC's Component Modeling Approach (CMA)~~[1]	~~✓~~	~~✓~~	~~✓~~	~~N/A~~	~~N/A~~
~~NFRC-200~~	~~✓~~	~~✓~~	~~✓~~	~~N/A~~	~~N/A~~
~~Standards Default Table 110.6-B~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~	~~✓~~
~~NA6~~[2]	~~N/A~~	~~N/A~~	~~✓~~	~~N/A~~	~~N/A~~

~~3. The NFRC Residential CMA method is an option that may be available during the 2013 cycle of the Energy Standards.~~

~~4. The Alternative Default U-factors from Nonresidential Reference Nonresidential Appendix NA6 may only be used for site-built vertical and skylights having less than 1,000ft².~~

3.5.3.3 Labeling Mandatory Requirements

~~Applicable Sections:~~ §10-111(a); §110.6(a)5

A. Default Temporary Label

The manufacturer can ~~also~~ choose to use Energy Commission ~~(CEC)~~ default values from ~~TABLE~~ Table 110.6-A for U-factors and ~~-TABLE~~ Table 110.6-B for SHGC of the Energy Standards. If default values are used, the manufacturer must attach a temporary label meeting the following specific requirements (permanent etching labels are not required). The p~~P~~roduct shall meet the air infiltration requirements of §110.6(a)1, ~~,~~ U-factor criteria of §110.6(a)2, and SHGC criteria of §110.6(a)3 in the *Building Energy Efficiency Standards for Residential and Nonresidential Buildings.*

Although there is no exact format for the default temporary label, it must be clearly visible and large enough for the enforcement agency field inspectors to read easily; ~~and~~ it must include all information required by the ~~standards~~Energy Standards. The minimum suggested label size is 4 in. x 4 in. and the label must have the following words at the bottom of the label as noted in Figure 3-2;

"Product meets the air infiltration requirements of §110.6(a)1, U-factor criteria of §110.6(a)2, SHGC criteria of §110.6(a)3 and VT criteria of §110.6(a)4 of the 2016~~3~~ California Building Energy Efficiency Standards for Residential and Nonresidential Buildings."

The manufacturer ensures the U-factor and SHGC default values should be labeled large enough to be readable~~visible~~ from ~~4~~ four (4) feet away. The manufacturer ensures the appropriate checkboxes are checked and indicated on default label.

201~~3~~6 California Energy Commission Default Label **XYZ Manufacturing Co.**		
Key Features:	☐ Doors	☐ Double-Pane
	☐ Skylight	☐ Glass Block
Frame Type	**Product Type:**	**Product Glazing Type:**
☐ Metal	☐ Operable	☐ Clear
☐ Non-Metal	☐ Fixed	☐ Tinted
☐ Metal, Thermal Break	☐ Greenhouse/Garden Window	☐ Single-Pane
☐ Air space 7/16 in. or greater ☐ With built-in curb ☐ Meets Thermal-Break Default Criteria	----------	To calculate VT see NA6
California Energy Commission Default U-factor =	**California Energy Commission** Default SHGC =	**California Energy Commission** Calculated VT =
Product meets the air infiltration requirements of §110.6(a)1, U-factor criteria of §110.6(a)2, SHGC criteria of §110.6(a)3 and VT criteria of §110.6(a)4 of the 2016~~3~~ Building Energy Efficiency Standards for Residential and Nonresidential Buildings.		

~~**2013 California Energy Commission Default Label**~~

~~**XYZ Manufacturing Co.**~~

~~Key Features:~~	~~☐ Doors~~	~~☐ Double-Pane~~
	~~☐ Skylight~~	~~☐ Glass Block~~
~~**Frame Type**~~	~~**Product Type:**~~	~~**Product Glazing Type:**~~
~~☐ Metal~~	~~☐ Operable~~	~~☐ Clear~~
~~☐ Non-Metal~~	~~☐ Fixed~~	~~☐ Tinted~~
~~☐ Metal, Thermal Break~~	~~☐ Greenhouse/Garden Window~~	~~☐ Single-Pane~~
~~☐ Air space 7/16 in. or greater~~ ~~☐ With built-in curb~~ ~~☐ Meets Thermal-Break Default Criteria~~	~~----------~~	~~To calculate VT see NA6~~
~~**California Energy Commission**~~ ~~Default U-factor =~~	~~**California Energy Commission**~~ ~~Default SHGC =~~	~~**California Energy Commission**~~ ~~Calculated VT =~~
~~Product meets the air infiltration requirements of §110.6(a)1, U-factor criteria of §110.6(a)2, SHGC criteria of §110.6(a)3 and VT criteria of §110.6(a)4 of the 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings.~~		

Figure~~e~~ 3-2 – Sample of Default Temporary Label
Source: California Energy Commission

B. Certified Temporary and Permanent Labels

~~Applicable Section:~~ §10-111

~~A.~~1. Certified Manufactured Fenestration Products

The Energy Standards require that manufactured fenestration have both temporary and permanent labels. The temporary label shows the U-factor and SHGC~~, on~~ for each rated

~~window~~ unit. The label must also show that the ~~window~~ meets the air infiltration criteria. The temporary label must not be removed before inspection by the enforcement agency.

The **permanent label** must, at a minimum, identify the certifying organization and have an ID number or code to allow tracking back to the original information on file with the certifying organization, NFRC. The permanent label ~~also~~ can also be inscribed on the spacer, etched on the glass, engraved on the frame, or otherwise located so as not to affect aesthetics.

2.

3. **Field-Fabricated Fenestration** A label is not required for field-fabricated fenestration products, but the ~~CEC~~ ~~Energy Commission~~ default values in ~~TABLE~~ Table 110.6-A and ~~TABLE~~ Table 110.6-B of the Energy Standards ~~from the Standards~~ must be used and documented on the Fenestration Certificate NRCC-ENV-05-E ~~(formerly FC-1)~~ form.

~~B.~~

Example 3-4

Question

My new home will have a combination of window types, including fixed, operable, wood, metal, etc., some of which are field-fabricated. What are the options for showing compliance with the Standards?

Answer

First, all windows must meet the mandatory requirements of §110.6 and §110.7 unless exempted.

For field-fabricated windows, you must select U-factors and SHGC values from the default tables (T~~ABLE~~able 110.6-A and T~~ABLE~~able 110.6-B of the Energy Standards ~~from the Standards~~). Windows that are not field-fabricated must be labeled with ~~an~~ NFRC certified or default efficiencies. If the U-factors or SHGC values do not comply with the prescriptive requirements, the performance method must be used. To simplify data entry into the compliance software, you may choose the U-factor from T~~ABLE~~able 110.6-A of the Energy Standards that is the highest of any of the windows planned to be installed, and use this for all windows for compliance purposes. However, you must use the appropriate SHGC from §T~~ABLE~~able 110.6-B for each individual window type being installed.

Answer~~r~~

First, all windows must meet the mandatory requirements of §110.6 and §110.7 unless exempted~~.~~

For field-fabricated windows, you must select U-factors and SHGC values from the default tables (TABLE 110.6-A and TABLE 110.6-B from the Standards). Windows that are not field-fabricated must be labeled with an NFRC certified or default efficiencies. If the U-factors or SHGC values do not comply with the prescriptive requirements, the performance method must be used. To simplify data entry into the compliance software, you may choose the U-factor from TABLE 110.6-A that is the highest of any of the windows planned to be installed, and use this for all windows for compliance purposes. However, you must use the appropriate SHGC from TABLE 110.6-B for each individual window type being installe~~d.~~

Example 3-5

Question

When windows are labeled with a default value, are there any special requirements that apply to the label?

Answer

~~First, all~~All windows must meet the mandatory requirements by §110.6 and §110.7 unless exempted.

There are two criteria that apply to fenestration products labeled with default values.

First, the Administrative Regulations (§10-111) require that the words “CEC Default U-factor” and “CEC Default SHGC” appear on the temporary label in front of or before the U-factor or SHGC (i.e., not in a footnote).

Second, the U-factor and SHGC for the specific product must be listed. If multiple values are listed on the label, the manufacturer must identify, in a permanent manner, the appropriate value for the labeled product. Marking the correct value may be done in the following ways only:

1. Circle the correct U-factor and SHGC (permanent ink);

2. Black out all values except the correct U-factor and SHGC (permanent ink); or

3. Make a hole punch next to the appropriate values.

Example 3-6

Question

What U-factor do I use for an operable metal framed, glass block? What solar heat gain coefficient do I use for clear glass block? Does it need a label?

Can I use the default clear glass SHGC values for tinted glass block?

Answer

For glass block, use the U-factor and SHGC values from ~~Standards TABLE~~ Table 110.6-A~~-~~ and ~~TABLE~~ Table 110.6-B of the Energy Standards for the frame type in which the glass blocks are installed. The worst-case scenario would be metal-framed glass. The U-factor for metal framed glass block is from ~~TABLE~~ Table110.6-A is 0.87. The SHGC depends on whether the glass block has a metal or non-metal frame, and is operable or fixed or clear or tinted. For this example, the glass block is operable and clear, therefore the SHGC is 0.70. Glass block is considered a field-fabricated product and therefore does not need a label.

Yes, the default tables for glass block do not include tinted glass.

Example 3-7

Question

Is there a default U-factor for the glass in sunrooms?

Answer

Yes. For the horizontal or sloped portions of the sunroom glazing, use the U-factor for skylights. For the vertical portions, use the U-factors for fixed windows, operable windows, or doors, as appropriate. As a simple~~ifying~~ alternative, the manufacturer may label the entire sunroom with the highest U-factor of any of the individual fenestration types within the assembly.

Example 3-8

Question

How are various door types treated in compliance documentation for U-factor and SHGC? How can I determine a U-factor and SHGC for doors when less than~~e~~ 50% of the door area is glass?

Answer

All doors with glass area greater than 50% of the door area, which includes French doors, are defined as fenestration products and are covered by the NFRC Rating and Certification Program. The U-factor SHGC for doors with glass area greater than 50% may be determined in one of two ways:

1. Use the NFRC rated and labeled values.

2. Refer to ~~Standards TABLE~~ Table 110.6-B of the Energy Standards, the values are based upon glazing and framing type.

3. In special cases where site-built fenestration is being installed in a residential application, the site-built windows can use an alternative method to calculate the U-factor and the SHGC by using the manufacturer's center-of-glass values (COG). The COG values are calculated in accordance with ~~Nonresidential Reference Appendix~~ NA6. Note the maximum allowed of site-built fenestration is less than 1,000 ft^2.

Doors with less than 50% glass areas are treated as a door with fenestration installed within the door. The glass area is calculated as the sum of the glass areas plus two inches on all sides (to account for framing). For prescriptive or performance approaches, use one of the following options for U-factor and SHGC of the glass:

- The NFRC label if one is available, or
- The default values from ~~Standards~~ T~~ABLE~~Sables 110.6-A and 110.6-B of the Energy Standards

The opaque part of the door is ignored in the prescriptive approach. If the performance approach is used a default SHGC value of 0.50 must be assumed for the opaque portion of the door. Alternatively, if NFRC values for U-factor and SHGC for the entire door are available, the door may be considered a fenestration product.

Example 3-9

Question

As a manufacturer of fenestration products, I place a temporary label with the air infiltration rates on my products. Can you clarify which products must be tested and certified?

Answer

Each product line must be tested and certified for air infiltration rates. Features such as weather seal, frame design, operator type, and direction of operation all affect air leakage. Every product must have a temporary label certifying that the air infiltration requirements are met. This temporary label may be combined with the temporary U- factor, SHGC and VT label.

Example 3-10

Question

Is a custom window “field-fabricated” for purposes of meeting air infiltration requirements?

Answer

No. Most custom windows are manufactured and delivered to the site either completely assembled or “knocked down,” which means they are a manufactured product. A window is considered field-fabricated when the windows are assembled at the building site from the various elements that are not sold together as a fenestration product (i.e., glazing, framing and weatherstripping). 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).

Example 3-11

Question

What constitutes a “double-pane” window?

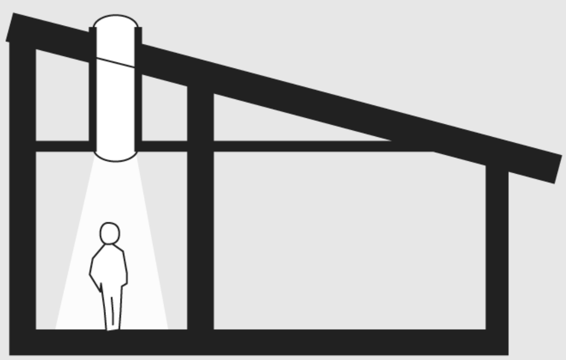
Answer

Double-pane (or dual-pane) glazing is made of two panes of glass (or other glazing material) separated by space (generally 1/4" [6 mm] to 3/4" [18 mm]) filled with air or other gas. Two panes of glazing laminated together do not constitute double-pane glazing.

Example 3-12

Question

To get daylight into a room in my new house, I plan on installing a tubular ~~skylight~~ and will be using the performance approach for compliance purposes. The skylight has a clear plastic dome exterior to the roof, a single pane ¼-inch (6 mm)-thick acrylic diffuser mounted at the ceiling, and a metal tube connecting the two. How do I determine the U-factor and SHGC that I will need to determine if I can comply with the Energy Standards, if U_c is 1.20 and $SHGC_c$ is 0.85?



Answer

Tubular daylighting device (TDD) skylights are an effective means for bringing natural light into interior spaces, as are traditional skylights.

There are three methods available for determining the thermal efficiencies for TDDs:

The first is to use the default U-factor from ~~Standards TABLE~~ Table 110.6-A of the Energy Standards. This tubular ~~skylight~~ would be considered a metal frame, fixed, single-pane skylight resulting in a U-factor of 1.19, which must appear on a label preceded by the words "CEC Default U-factor." (A tubular daylighting device ~~skylight~~ would have to have two panes of glazing with an air space of less than 2 inches (50 mm) between them at the plane of the ceiling insulation for it to be considered double-pane.);

The second method is to determine the U-factor from ~~the Reference Nonresidential Appendix~~ NA6, Equation NA6-1. The U-factor for this tubular daylighting device ~~skylight~~ would be based on metal with no curb (Table NA6-5). The U-factor for this ~~skylight~~, using Equation NA6-1, is 1.25, where U_t = (0.195 + (0.882 x 1.20)). This must appear on a label stated as "CEC Default U-factor 1.25.";

The third and best method, applicable if the ~~skylight~~ has been tested and certified pursuant to NFRC procedures, requires a label that states: "Manufacturer stipulates that this rating was determined in accordance with applicable NFRC procedures NFRC 100,"~~;~~ followed by the U-factor.

There also are three methods available for determining SHGC. The first is to use the default table SHGC in ~~Standards~~ T~~ABLE~~able 110.6-B of the Energy Standards. This tubular ~~skylight~~ would be considered a metal frame, fixed, clear, single-pane skylight resulting in an SHGC of 0.83, which must appear on a label stated as "CEC Default SHGC 0.83."

The second method also determines the SHGC from ~~the Reference Nonresidential Appendix~~ NA6, Equation NA6-2. The SHGC for this skylight using Equation NA6-2 is 0.81, where

$SHGC_t$ =~~(~~= (0.08 + (0.86 x 0.85)). This must appear on a label stated as "CEC Default SHGC 0.81."

The third method, applicable if the ~~skylight~~ has been tested and certified pursuant to NFRC procedures, requires a label that states, "Manufacturer stipulates that this rating was determined in accordance with applicable NFRC procedures."

Example 3-13

Question

How would the U-factor and the SHGC be determined if the tubular daylighting device in the example above has a dual pane diffuser (instead of single pane) mounted at the ceiling?

Answer

The procedure would be exactly the same as the example above, except that the double pane U-factor and SHGC values from ~~Standards~~ T~~ABLE~~ables 110.6-A and §~~TABLE~~ 110.6-B of the Energy Standards would be used instead of single pane values. Note that up to 3 ft^2 of tubular daylighting device is assumed to have the U-factor and SHGC required by Package A for prescriptive performance compliance (Exception 1 to §150.1(c)3A).

Fenestration U-factor

3.5.3.4

~~Applicable Section:~~ §150.0(q)

For fenestration products, ~~With the 2013~~ 2016 ~~update, the mandatory maximum U-factor is set by §150.0(q)~~ states that t~~t~~he mandatory maximum U-factor is 0.58. This is based on the worst case scenario for a double-pane, vinyl framed fenestration product including skylights.~~for fenestration including skylights to be at maximum U-factor of 0.58. While there is an allowance for are~~Area-weighted averaging~~,~~ can be used to allow flexibility for the placement of a fenestration product with a U-factor greater than 0.58. ~~this will limit the use of single pane products.~~ Up to 10 ft^2 or 0.5% of conditioned floor area (whichever is greater) is exempt from the maximum U-factor requirement.

Table 3-~~3~~ 2 – Maximum U-factors, SHGC and Fenestration Area by Climate Zone in Package~~s~~ A

Climate Zone	1, 3, 5	2,4,6-16
Maximum U-factor	0.32	0.32
Maximum SHGC	NR	0.25
Maximum Fenestration Area	20%	20%
Maximum West-Facing Fenestration	NR	5%

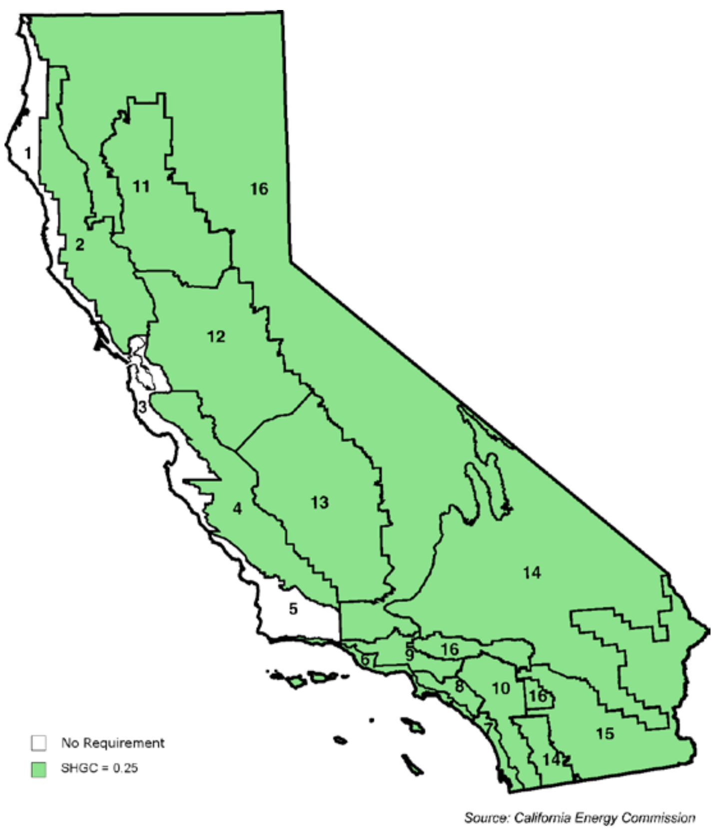


Figure 3-~~4~~ 3 – Package A, ~~-~~SHGC Criteria by Climate Zone

3.5.4 *Prescriptive Requirements*

~~Applicable Section:~~ §150.1(c)3

Prescriptive requirements described in this chapter typically refer to Package A or §Table 150.1-A ~~of the Standards.~~ The maximum U-factor required by prescriptive Package A for all climate zones is 0.32 and the maximum Solar Heat Gain Coefficient (SHGC) is 0.25~~,~~ ~~and isor lower~~ for dwellings in climate zones 2, 4, and 6-16. Homes constructed in climate zones 1, 3, and 5 have no ~~maximum~~ SHGC requirements. 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 SHGC of windows, glazed doors and skylights can be area-weight averaged together to meet the prescriptive requirement using the WS-2R form in Appendix A of this manual.

3.5.5 *Fenestration Prescriptive Exceptions*

~~Applicable Section:~~ §150.1(c)3A through §150.1(c)3C

A. **Doors and Tubular Daylighting Device**

In each dwelling unit, up to 3 ft^2 of the glazing area installed in doors and up to 3 ft^2 of tubular daylighting devices area with dual-pane diffusers at the ceiling are exempt from the prescriptive U-factor and SHGC requirements, where area is included in the maximum of 20% ~~percent~~ fenestration area. However, the U-factor shall not exceed a maximum is 0.58. See §150.0(q) and Exception 1 of §150.1(c)3A.

~~A.~~

B. **Skylights**

Each new dwelling unit may have up to 16 ft^2 of skylight area; the ~~area~~ is included in the maximum of 20% ~~percent~~ fenestration area ~~and meets a maximum 0.55 U-factor and a maximum SHGC of 0.30~~. See Exception 2 of §150.1(c)3A.

Aside from the specific exceptions to the Fenestration Prescriptive requirements, U-factors and SHGCs for skylights can be significantly higher than they are for windows so long as their area weight-averaged U-factor and SHGC do not exceed the ~~0.55 U-factor and is not greater than the 0.30 SHGC~~ ~~when large amounts of individual~~ skylights are used for prescriptive compliance. Alternatively, the performance approach should be used for meeting energy compliance.

C. **Dynamic Glazing**

If a dwelling unit includes a type of dynamic glazing that is electric-chromatic, chromogenic type or integrated shading device, and the glazing is automatically controlled, use the lowest U-factor and lowest SHGC to determine compliance with prescriptive Package A fenestration requirements. Since this type of product has compliance ratings which~~that~~ varies, it cannot be weight averaged with ~~other~~ non-chromogenic products as per Exception 3 of §150.1(c)3A.

~~C.~~

D. **Site-Built Fenestration**

When residential dwelling unit contains combination of manufactured and site-built fenestration; only the site-built fenestration values can be determined by using ~~Nonresidential Reference Appendix~~ NA6; however, all fenestration and including site-built can default to §~~TABLES~~ Tables 110.6-A or B.

~~D.~~

E. **~~Window~~ Maximum Area**

The prescriptive requirements limit total glass area to a maximum of 20% ~~percent~~ of the conditioned floor area in all climate zones;~~,~~ however, there are exceptions to the prescriptive requirements for alterations in §150.2(b)1A which allow additional glass area beyond the 20% ~~percent~~ limitation, including west-facing glass.

F. **Greenhouse Windows/Garden Windows**

Compared to other fenestration products, the NFRC-rated U-factor for greenhouse windows are comparatively high. §150.0(q) includes an exception from the U-factor requirement for dual-glazed greenhouse or garden windows that total up to 30 ft^2 of fenestration area.

~~E.~~

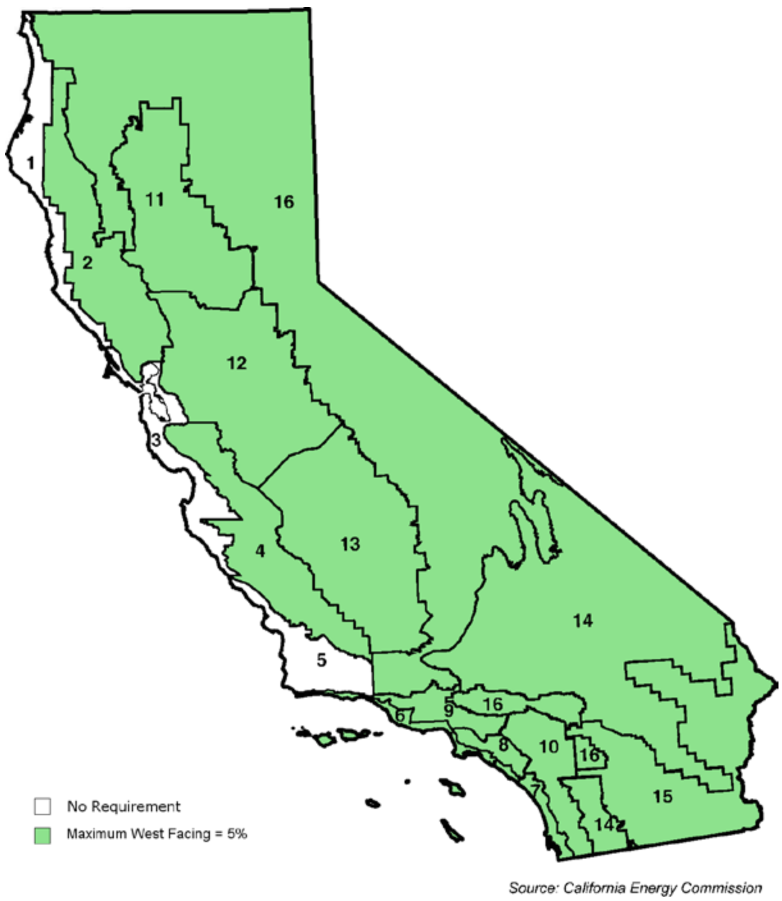


Figure 3-~~5~~ 4 – Package A, Prescriptive West-Facing Window Area Limits by Climate Zone

3.5.6 *Fenestration Shading Types*

~~F.~~**A. Shading**

While a low emissivity (low-e) coating on the glass is one of the most common ways to reduce solar gain in combination with insulated window frame, there are other options to help increase shading:

1. Use of permanent installed exterior shade screens;
2. Louvers on the outside of the window are typically used on windows facing south. See Table 3-4 for different types of Exterior Shades and Solar Heat Gain Coefficients;
3. ~~3.~~ Properly sized overhang - ~~See **Fixed Permanent Shading Devices** d~~Discussed later in Section 3.5.8.4.~~this chapter below.~~

3.

~~G.~~**B. Dynamic Glazing:**

Dynamic Glazing products are either Integrated Shading Systems or Electro-Chromatic type devices and are considered a fenestration product. Integrated shading systems include blinds positioned between glass panes that can be opened and closed manually or using automatic controls. The labels for ~~internal~~ shading systems will reflect the endpoints of the product's performance for U-factor and SHGC. See Figure 3-~~6~~76.

Figure 3-~~6~~ 5– Example of Dynamic Glazing Type - Integrated Shading System
Source: NFRC Dynamic Glazing Products Fact Sheet

Its unique rating "Variable Arrow" identifier helps consumers~~/specifiers~~ understand the "dynamics" of the product and allows comparison with other similar dynamic fenestration products. The following is a label reference:~~s are;~~

1. The Variable Arrow – If the fenestration product can operate at intermediate states, a dual directional arrow, (↔), with the word "Variable" will appear on the label. Some dynamic glazing~~s~~ is~~are~~ able to adjust to intermediate states allowing for a performance level between the endpoints. The low value rating is displayed to the left (in the c~~C~~losed or darker position) and the high value rating is displayed to the right (in the o~~O~~pen or lighter position). This lets the consumer know at a glance the best and worst case performance of the product and ~~what~~ the default or de-energized performance level.

Figure 3-~~7~~ 6 – Dynamic Glazing NFRC Label Stickers
Source: NFRC Dynamic Glazing Products Fact Sheet

~~H.~~C. Chromatic Glazing

One type of dynamic glazing product uses a c~~C~~hromatic type of glass that has the ability to change its performance properties, allowing the occupant to control ~~manually or automatically~~ their environment manually or automatically by tinting or darkening ~~a window~~ with the flip of a switch. Some ~~windows and doors~~ can change their performance automatically ~~in response to~~ with the use of an automatic control or environmental signals. These high-performance ~~windows~~ provide a variety of benefits; including reduced energy costs due to controlled daylighting and unwanted heat gain or heat loss. While still a relatively new technology, they are expected to grow substantially in the coming years. A view of c~~C~~hromatic glazing in the open (off) and closed (on) position is shown in Figure 3-~~8~~ 7 below.

Figure 3-~~8~~ 7– Chromatic Glazing
Source: Sage Electrochromics

~~3.5.1~~3.5.7 *Dynamic Glazing Device*~~*YANMIC GLAZING COMPLIANCE*~~

A. Integral Shading Device

To use the high performance values the following must be met:

1. Must have ~~a~~ an NFRC Certified Label ~~sticker~~; or
2. When no NFRC is available, then the default values from §Tables 110.6-A and 110.6-B must be used.

B. Chromogenic Glazing

1. Must have ~~a~~ an NFRC Certified Label sticker; and
2. Automatic controls must be installed to receive best rated performance value.
3. If there is no NFRC label but with automatic controls, then default to §Table 150.1-A maximum U-factor of 0.32 and m~~M~~aximum SHGC of 0.25; or
4. If there is ~~with~~ a~~n~~ NFRC label, but no automatic controls, then default to §Table 150.1-A maximum U-factor of 0.32 and m~~M~~aximum SHGC of 0.25; or
5. If there is no NFRC and no automatic controls, then the default values from Tables 110.6-A and 110.6-B of the Energy Standards must be used.

C. Window Films

Window films are p~~P~~olyester film that offer ~~crystal~~ high-clarity and can be pre-treated to accept different types of coatings. There are three basic categories of window films:

1. Clear (Non-Reflective)~~;~~ films are used as safety or security film to reduce ultraviolet (UV) light which contributes greatly to fading; however, they are not normally used for solar control or energy savings.
2. Tinted or Dyed (Non-Reflective)~~; and~~ films reduce both heat and light transmission, mostly through increased absorb~~pt~~ance, and can be used in applications where the desired primary benefit is glare control with energy savings secondary.
3. Metalized (Reflective) film, which can be metalized through vacuum coating, sputtering, or reactive deposition or reactive deposition and may be clear or colored. These are the preferred film in most energy savings applications, since they reduce transmission primarily through reflectance and are manufactured to selectively reflect heat more than visible light through various combinations of metals.
4. Performance Window Film Compliance:

To receive window film credit, the following must be met:

- The Performance Approach must be used to meet energy compliance;
- NFRC Window Film Energy Performance Label is required for each different film applied; otherwise the default Tables 110.6-A and 110.6-B of the Energy Standards values must be used;
- Window films must have at least a ten-year warranty.

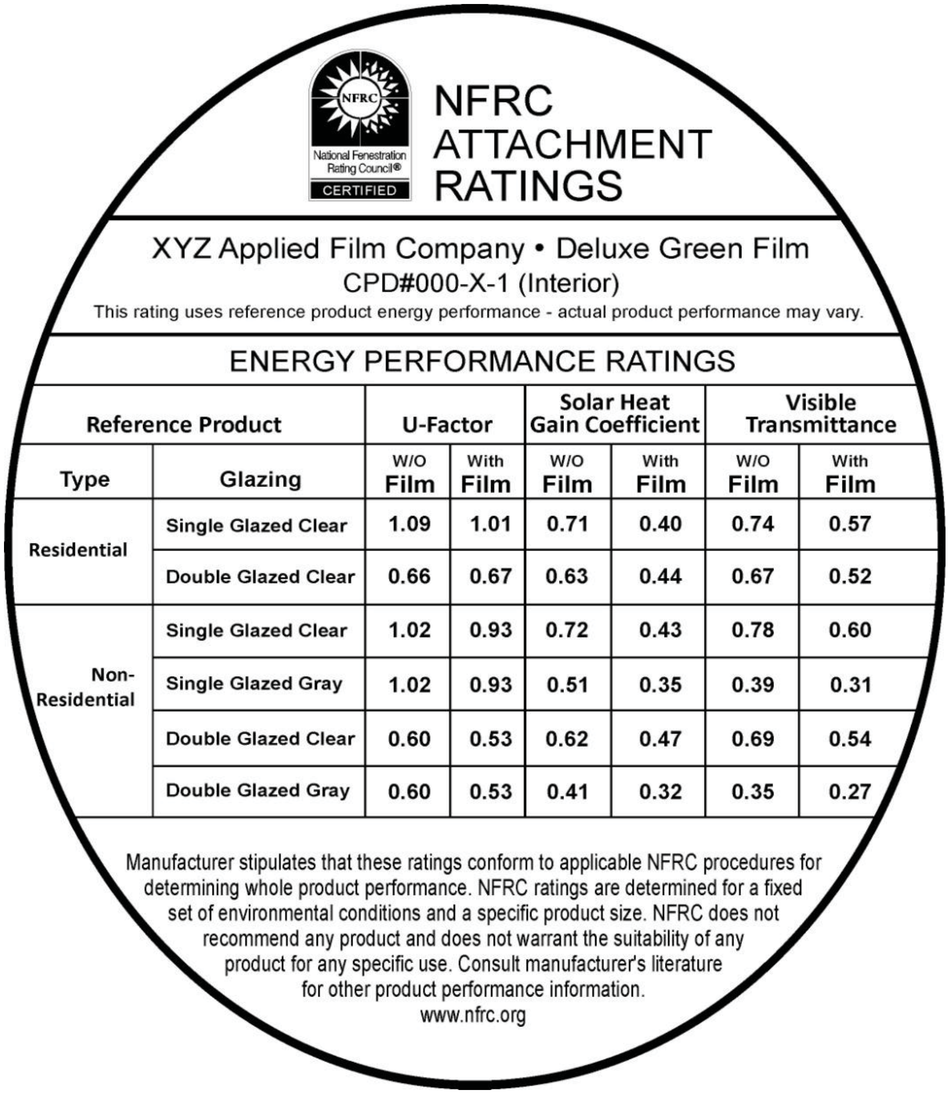
~~3.~~

4. ~~Clear films are used as safety or security films and to reduce ultraviolet (UV) light which contributes greatly to fading; however, they are not normally used for solar control or energy savings.~~

5. ~~Tinted or dyed films reduce both heat and light transmission, mostly through increased absorptance, and can be used in applications where the~~ desired ~~primary benefit desired is glare control with energy savings secondary.~~

~~6. Metalized (reflective) films are the preferred film in most energy savings applications, since they reduce transmission primarily through reflectance, and are manufactured to selectively reflect heat more than visible light through various combinations of metals.~~

See Figure 3-~~9~~ 8 below. NFRC Attachment Ratings Label which helps to identify the energy performance of Window Films.



NFRC ATTACHMENT RATINGS

National Fenestration Rating Council® CERTIFIED

XYZ Applied Film Company • Deluxe Green Film
CPD#000-X-1 (Interior)
This rating uses reference product energy performance - actual product performance may vary.

ENERGY PERFORMANCE RATINGS

Reference Product		U-Factor		Solar Heat Gain Coefficient		Visible Transmittance	
Type	Glazing	W/O Film	With Film	W/O Film	With Film	W/O Film	With Film
Residential	Single Glazed Clear	1.09	1.01	0.71	0.40	0.74	0.57
	Double Glazed Clear	0.66	0.67	0.63	0.44	0.67	0.52
Non-Residential	Single Glazed Clear	1.02	0.93	0.72	0.43	0.78	0.60
	Single Glazed Gray	1.02	0.93	0.51	0.35	0.39	0.31
	Double Glazed Clear	0.60	0.53	0.62	0.47	0.69	0.54
	Double Glazed Gray	0.60	0.53	0.41	0.32	0.35	0.27

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information.
www.nfrc.org

Figure 3-~~9~~ 8 – Window Film Energy Performance Label

Source: NFRC Applied Film Products Fact Sheet

~~D. Performance Window Film Compliance~~

~~To receive window film credit, the following must be met:~~

1. ~~The Performance Approach must be used to meet energy compliance;~~
2. ~~NFRC Window Film Energy Performance Label is required for each different film applied; otherwise use the default §TABLES Tables 110.6-A and 110.6-B values must be used;~~
3. ~~Windows films must have at least a 10 ten- year warranty.~~

~~E.~~D. Glazed Doors

§110.6

~~The following rules apply to doors with glass:~~

Any door that is more than one-half glass is considered a glazed door and must comply with the mandatory measures and other requirements applicable to a fenestration product. Up to 3 ft^2 of glass in a door is exempt from the U-factor and SHGC requirements (or can be considered equivalent to the Package A values). The U-factor and SHGC shall be based on either the NFRC values for the entire door including glass area, or use default values in §Table 110.6-A for the U-factor and §Table 110.6-B for the SGHC. If the door is made up of less than 50% ~~percent~~, the opaque part of the door is ignored in the prescriptive approach, but in the performance method it is assumed a default U-factor of 0.50. The glass area of the door is calculated as the sum of all glass surfaces plus 2 inches on all sides of the glass to account for a frame.

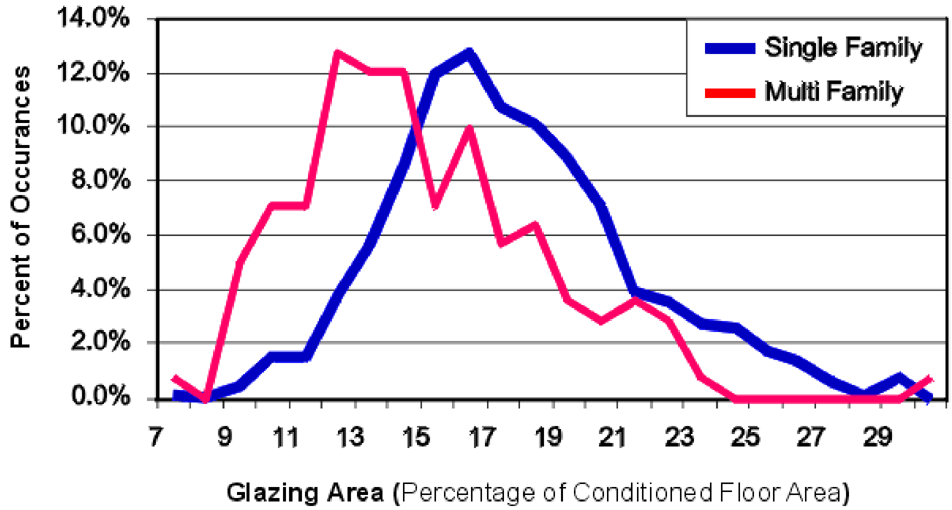
~~3.5.2~~3.5.8 *Compliance Alternatives*

While the prescriptive requirements and mandatory measures establish a minimum level of building energy performance, ~~the~~ opportunities to exceed the requirements of the ~~standards~~ Energy Standards are considerable. Some of these *compliance options* are discussed in this section while others are included in the Performance Compliance section (Chapter 8). Options that are recognized for credit through the performance method are called *compliance options*. Most require using the performance approach, but a few exterior shading devices and south facing overhangs may be used to comply when using~~with~~ the prescriptive ~~requirements~~approach.

~~A.~~3.5.8.1 Fenestration Area

Beginning with the 2005 update to the Standards, no credit is offered through the performance approach for reducing fenestration area below the maximum allowed 20% ~~percent~~ of the conditioned floor area (CFA).

Data shows that the average window area in single family homes is about 17.3% ~~percent~~ of the CFA. In multifamily buildings, the average window area is about 14.5% ~~percent~~ of the CFA~~conditioned floor area~~. ~~While these are averages, the variations are considerable as shown in Figure 3-10.~~



~~*Figure 3-10 – Glass Area in Single Family and Multifamily Residence*~~
~~*(Source: Residential New Construction Database)*~~

The Energy Commission made fenestration area less than or equal to 20%~~ percent~~ a neutral variable in the *performance approach* with the 2005 update, and there is no change in this regard in the 2016~~3~~ update. The Energy Commission recognizes that area and orientation can have a big impact on energy use, but because these are so variable in buildings, the Energy Commission does not want the energy efficiency of other building components to be eroded in buildings that have relatively small fenestration areas. While there is no credit for fenestration area less than 20%~~ percent~~ of CFA, there is a penalty for buildings that have a window area that exceeds 20%~~ percent~~ of CFA. Such buildings are permitted only with the performance approach, where the standard design has a fenestration area equal to the proposed design, up to 20%~~ percent~~ of CFA~~the conditioned floor area~~, and the glass area in the standard design is uniformly distributed among cardinal orientations. The proposed design has the exact proposed glass area and orientation.

~~B.~~3.5.8.2 Orientation

Window and skylight orientation has a huge impact on both energy use and peak electric demand. Orientation is a compliance option that is recognized in the performance approach, since the standard design has windows uniformly distributed on the north, south, east, and west sides of the building.

~~C.~~3.5.8.3 Improved Fenestration Performance

With the 2016~~3~~ update, the weighted average U-factor remains at ~~has been reduced to~~ 0.32 in all climate zones as indicated in Package A. This means there is only a minor~~less~~ credit available for installing high performance fenestration that could be traded off or be used to avoid other measures, such as duct sealing and verification. However, choosing high performance fenestration ~~which~~ that performs better than the prescriptive requirements level can still earn significant~~some~~ credit through the performance method. In air conditioning climates, choosing a window with an SHGC lower than 0.25 will reduce the cooling loads compared to the standard design.

The magnitude of the impact will vary by climate zone; in mild coastal climates the benefit from reducing fenestration U-factor will be smaller than in cold, mountain climates. Several factors affect window performance. For fenestration with NFRC ratings, the following performance features are accounted for in the U-factor and SHGC ratings:

1. Frame materials, design, and configuration (including cross-sectional characteristics). Fenestration is usually framed in wood, aluminum, vinyl, or composites of these. Frame materials such as wood and vinyl are better insulators than metal. Some aluminum-framed units have thermal breaks that reduce the conductive heat transfer through the framing element as compared with similar units having~~that have~~ no such conductive thermal barriers.
2. Number of panes of glazing, coatings, and fill gases. Double-glazing with coatings or~~,~~ dynamic glazing with controls~~,~~ offer~~s~~ opportunities for improving performance beyond the dimension of the air space between panes. For example, special materials that reduce emissivity of the surfaces facing the air space, including low-e or other coatings and chromogenic glazing, improve the thermal performance of fenestration products. Fill gases other than dry air such as, carbon dioxide, argon, or krypton and chromogenic glazing— also improve thermal performance.

~~D.~~3.5.8.4 **Fixed ~~permanent~~ Permanent Shading Devices**

Shading of windows is also an important compliance option. Overhangs or sidefins that are attached to the building or shading from the building itself, are compliance options for which credit is offered through the performance approach. However, no credit is offered for shading from trees, adjacent buildings, or terrain.

Windows that face south can be effectively shaded by overhangs positioned above the window. The ideal overhang is one that provides shade during the months when the building is likely to be in an air conditioning mode and allows direct solar gains in the heating months. This can be achieved because during the summer the sun is high as it passes over the south side, while in the winter it is low, enabling solar radiation to pass beneath the overhang. Due to the potential effectiveness of south-facing overhangs, a prescriptive compliance option is offered. See ~~the following s~~Section ~~F~~ 3.5.8.6 for details.

Shading is much more difficult on the east and west sides of the house. When the sun strikes these façades it is fairly low in the sky, making overhangs ineffective. Vertical fins can be effective, but they degrade the quality of the view from the window and limit the natural light that can enter. In cooling climates, the best approach is to minimize windows that face east and west. Landscaping features can be considered to increase comfort but cannot be used for compliance credit.

~~E.~~3.5.8.5 **Reserved**

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~~F.~~3.5.8.6 **Exterior Shading Devices**

The prescriptive requirements~~Standards~~ require fenestration products with an SHGC of 0.25 or lower in climate zones 2, 4 and 6 through 16. However, a fenestration product with an SHGC greater than 0.25 may be used with the prescriptive requirements if a qualifying exterior shading device is used. Exterior shading devices and their SHGC values are shown in Table 3-~~4~~3. These include woven sunscreens as well as perforated metal sunscreens. As shown in the table, these devices transmit between 13% ~~percent~~ and 30% ~~percent~~ of the sun that strikes them.

When exterior overhangs are used, the SHGC requirements of prescriptive Package- A may be met if the calculated combination of the overhang and fenestration SHGC efficiency is equal or lower than 0.25.

For compliance credit, exterior shading devices must be permanently attached as opposed to clips, hooks, latches, snaps, or ties. Exterior shading devices on windows or skylights that are prohibited by life-safety codes from being permanently attached for emergency egress reasons are exempt from this requirement. Compliance ~~with WS-03R~~CF1R-ENV-03~~ ~~ form is used to calculate the combined SHGC of windows and exterior shading devices. When exterior shades are required for compliance, they must also be listed on the CF1R form and documented on the plans.

The SHGC of the window in combination with an exterior device is given by the following:

Equation 3-1:

$$SHGC_{combined} = (0.2875 \text{ x } SHGC_{max} + 0.75) \text{ x } SHGC_{min}$$

All operable windows and skylights are assumed to have an insect screen and this is the default condition against which other window/exterior shading device combinations are compared. The standard case is a window with an SHGC of 0.25 and an insect screen with an SHGC of 0.76. For this default case, the SHGC of the window is the $SHGC_{min}$, and the SHGC of the exterior sunscreen is $SHGC_{max}$. Working through the math on the ~~WS-03R~~CF1R-ENV-03 form, $SHGC_{combined}$ is 0.25. This means that any combination of window SHGC and exterior SHGC that results in a $SHGC_{combined}$ of 0.25 or less complies with the prescriptive requirements.

Most of the shading devices (other than the default insect screen) have an SHGC of 0.30 or lower. Combining this with the SHGC of any ~~window~~ may result in a combined SHGC which is equal to or lower than the prescriptive criterion of 0.25. This method of combining the SHGC of the ~~window~~ with the SHGC of the exterior shading device is also used with the whole building performance approach.

Compliance CF1R-ENV-03 ~~WS-03R~~ form is used to calculate the combined SHGC of ~~windows~~ and exterior sunscreen type shading devices. When exterior shades are required for compliance, they must be listed on the CF1R form and be documented on the plans.

Table 3-~~4~~ 3 – Exterior Shades and Solar Heat Gain Coefficients

[1] The equation can be found in the 201~~3~~6 Residential Compliance Manual and it is included in WS-3R in Appendix A.

Exterior Shading Device	**SHGC***
Standard Bug (insect) Screen (default for windows)	0.76
Exterior Sunscreens with Weave 53 x 16/inch	0.30
Louvered Sunscreens w/Louvers as wide as Window Openings	0.27
Low Sun Angle Louvered Sunscreen	0.13
Vertical Roller Shades or retractable/Drop Arm/ Combination/Marquisolette and Operable Awnings	0.13
Roll Down Blinds or Slats	0.13
None (for skylights only)	1.00
* Reference glass values assume single pane clear glass and metal framing 1/8th inch double strength (DSS) glass. Use WS-3R Worksheet for calculation.	

~~G.~~3.5.8.7 –Interior Shading

There is no credit for interior aftermarket shading devices, although they can be effective in reducing solar gains and should be considered by homeowners. The Energy Commission considers these added interior shades in the category of home furnishings and not a feature of the house that is provided by the builder or fenestration manufacturer. Draperies, interior blinds, interior shades, and other interior devices are not credited toward energy compliance; however, a default standard shade is still considered in performance calculations so that estimates of energy use are more realistic, and tradeoffs against other measures are more equitable.

~~H.~~3.5.8.8 –Bay Windows

Bay windows are a special compliance case. Bay windows may either have a unit NFRC rating (i.e., the rating covers both the window and all opaque areas of the bay window), an NFRC rating for the window only, or no NRFC rating. Non-rated bay windows may or may not have factory-installed insulation.

For bay windows that come with an NFRC rating for the entire unit, compliance is determined based on the rough opening area of the entire unit, applying the NFRC U-factor and SHGC. If the unit U-factor and SHGC do not meet the package requirements or area-weighted average, the project must show compliance using the performance approach.

Bay windows with no rating for the entire unit (where there are multiple windows that make up the bay) and with factory-installed or field-installed insulation must comply accounting for the performance characteristics of each component separately. Opaque portions of bay windows including roofs and floors must be insulated to meet the wall insulation requirements of Package A for prescriptive compliance. The opaque portion must either meet the minimum insulation requirements of Package A for the applicable climate zone or be included in a weighted average U-factor calculation of an overall opaque assembly that does meet the Package A requirements. For the windows, the U-factor and SHGC values may be determined either from an NFRC rating or by using default values in ~~§~~Tables 110.6-A and 110.6-B of the Energy Standards. If the window U-factor and SHGC meet the package requirements, the bay window complies prescriptively (if overall building fenestration area meets prescriptive compliance requirements). If the bay window does not meet package requirements, the project must show compliance under the performance approach.

~~I.~~3.5.8.9 **Natural Ventilation through Fenestration**

Operable ~~windows~~ can be a source of ventilation air useful for improving indoor air quality by dilution of indoor air contaminants and moisture and “free” cooling. During periods when the outdoor temperature is lower than the desired indoor temperature and the indoor temperature is uncomfortably warm from solar gains through ~~windows~~ or from heat generated inside the house, ~~windows~~ may be opened for some or all of the cooling. Natural ventilation can reduce the need to run the air conditioner. Not only does natural ventilation save energy, but it can also provide better air quality inside the home.

When building envelopes are sealed to reduce infiltration, air exchange with the outside air is reduced which increases the need for a mechanical means of bringing in outside air.

Energy Commission sponsored research in California homes has shown that a significant number of home occupants do not regularly open their windows for

ventilation. ~~When building envelopes are sealed to reduce infiltration, air exchange with the outside air is reduced, which increases the need for a mechanical means of bringing in outside air.~~

Starting with the 2008 update, it is mandatory to meet the requirements of ASHRAE Standard 62.2 which include mechanical ventilation and minimum open-able window area requirements. This mandatory measure is discussed in greater detail in Section 3.6.1.17 and 3.6.1.18.

~~J.~~3.5.8.10 **Construction Practice/Compliance and Enforcement**

The compliance and enforcement process~~,~~ should ensure that the fenestration efficiency values, areas, orientation, etc. be indicated on the CF1R form and are also specified on the building plans. In addition, the ~~same~~ efficiency values of the actual installed fenestration products meet or exceed the efficiency values on the CF1R form. For more information, see Compliance and Enforcement on fenestration in ~~c~~Chapter 2 of this manual.

3.6 Envelope Features

This section of the building envelope chapter addresses the requirements for the building shell, excluding fenestration. Components of the building shell include walls, floors, and roofs and/or ceilings. Fenestration, ~~and~~ windows and doors are addressed in Section 3.5~~ Fenestration~~.

3.6.1 *Mandatory Requirements*

§110.7, §110.8, §150.0

~~Joints and Other Openings~~

~~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. The following openings in the building envelope shall be caulked, gasketed, weatherstripped or otherwise sealed:~~

~~A. Exterior joints around window and door frames, including doors between the house and garage, between interior HVAC closets and conditioned space, between attic access and conditioned space, between wall sole plates and the floor, exterior panels and all siding materials;~~

~~B. Openings for plumbing, electricity, and gas lines in exterior walls, ceilings and floors;~~

~~C. Openings in the attic floor (such as where ceiling panels meet interior and exterior walls and masonry fireplaces);~~

~~D. Openings around exhaust ducts such as those for clothes dryers;~~

~~E. Weatherstripping is required for all field-fabricated operable windows and doors (other windows and doors must meet infiltration requirements and be laboratory tested). This includes doors between the garage and the house, between interior HVAC closets and conditioned space, and between the attic access and conditioned space (§110.6(b)); and~~

~~F. All other such openings in the building envelope.~~

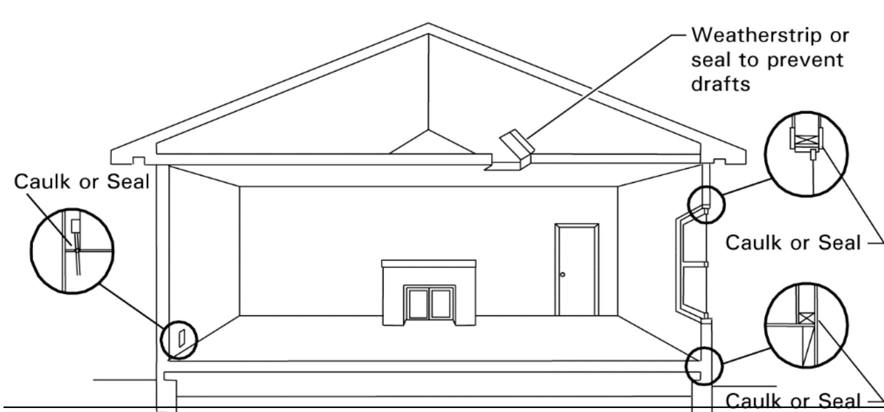
~~Alternative techniques may be used to meet the mandatory caulking and sealing requirements for exterior walls. These include, but are not limited to:~~

~~1. Stucco~~

~~2. Caulking and taping all joints between wall components (e.g., between slats in wood slat walls~~

~~3. Building wraps~~

~~4. Rigid wall insulation installed continuously on the exterior of the building~~



~~*Figure 3-13 – Caulking and Weatherstripping*~~
~~*Source: California Energy Commission*~~

~~These mandatory requirements are necessary to support the long-term goal of zero net energy buildings by not allowing building envelope components to be traded away under the performance modeling compliance method. Building efficiency is an important and strong foundation that helps attain long-term energy goals without changing the design of the building.~~

~~A.~~3.6.1.1 **Joints and Other Openings**

§110.7

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. The following openings in the building envelope shall be caulked, gasketed, weatherstripped or otherwise sealed:

~~G.~~1. Exterior joints around window and door frames, including doors between the house and garage, between interior HVAC closets and conditioned space, between attic access and conditioned space, between wall sole plates and the floor, exterior panels and all siding materials;
~~H.~~2. Openings for plumbing, electricity, and gas lines in exterior walls, ceilings and floors;
~~I.~~3. Openings in the attic floor (such as where ceiling panels meet interior walls, ~~and~~ exterior walls, and masonry fireplaces);
~~J.~~4. Openings around exhaust ducts such as those for clothes dryers;
~~K.~~5. Weatherstripping is required for all field-fabricated operable windows and doors (other windows and doors must meet infiltration requirements and be laboratory tested). This includes doors between the garage and the house, between interior HVAC closets and conditioned space, and between the attic access and conditioned space (§110.6(b)); and
~~L.~~6. All other such openings in the building envelope.

Alternative techniques may be used to meet the mandatory caulking and sealing requirements for exterior walls. These include, but are not limited to:

~~5.~~1. Stucco
~~6.~~2. Caulking and taping all joints between wall components (e.g., between slats in wood slat walls
~~7.~~3. Building wraps
~~8.~~4. Rigid wall insulation installed continuously on the exterior of the building

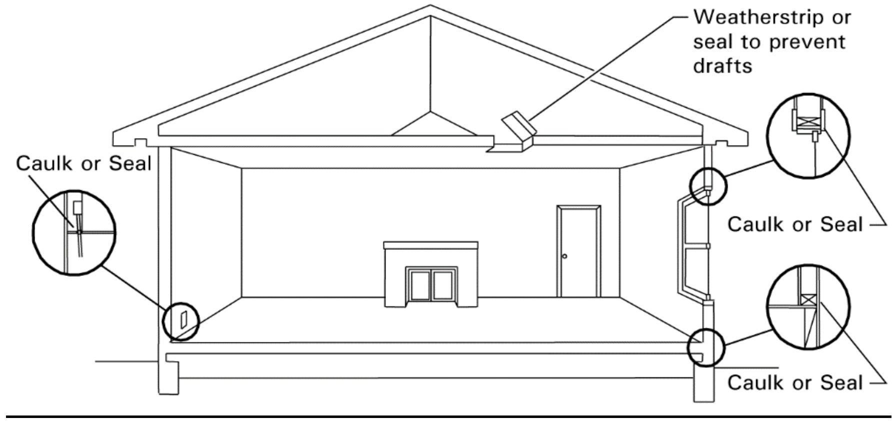


Figure 3-~~13~~9 – Caulking and Weatherstripping
Source: California Energy Commission

Construction Practice/Compliance and Enforcement

~~3.7~~

~~3.8~~

The compliance and enforcement process should ensure that all potential sources of infiltration and exfiltration in the building envelope, joints and openings are caulked, gasketed, or otherwise sealed. For more information on Compliance and Enforcement for~~on~~ joints and openings, see Chapter 2.

~~A.~~3.6.1.2 **Certification of Insulation Materials**

§110.8(a)

Manufacturers must ~~first~~ certify that insulating materials comply with *California Quality Standards for Insulating Materials* (CCR, Title 24, Part 12, Chapters 12-13), which ensure that insulation sold or installed in the S~~s~~tate performs according to stated R-values and meets minimum quality, health, and safety standards. Builders and enforcement agencies shall use the Department of Consumer Affairs *Directory of Certified Insulation Material* to verify the certification of the insulating material. If an insulating product is not listed in the current ~~most recent~~ edition of the directory, contact the Department of Consumer Affairs, Bureau of Home Furnishing and Thermal Insulation Program, at (916) 999-2041 or by E-mail: HomeProducts@dca.ca.gov.

~~B.~~3.6.1.3 **Urea Formaldehyde Foam Insulation**

§110.8(b)

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

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

~~C.~~3.6.1.4 Flame Spread Rating of Insulation

§110.8(c)

The *California Quality Standards for Insulating Materials* requires that exposed facings on insulation material be fire resistant and be tested and certified not to exceed a flame spread of 25 and a smoke development rating of 450. Insulation facings must be in contact with the finished assembly surface or they are considered exposed applications and cannot be installed.

Flame spread ratings and smoke density ratings are shown on the insulation or packaging material or may be obtained from the manufacturer.

~~D. Insulation Placement on Roof/Ceilings~~

~~**§110.8(e)**~~

~~**Insulation installed on the top of suspended (T-bar) ceilings with removable ceiling panels may not be used to comply with the Standards unless the installation meets the criteria described in the *Exception* to §110.8(e)3 below. Insulation may be installed in this location for other purposes such as for sound control, but it will have no value in terms of meeting roof/ceiling insulation requirements of the Standards.**~~

~~**Acceptable insulation installations include placing the insulation in direct contact with a continuous roof or ceiling that is sealed to limit infiltration and exfiltration as specified in §110.7; including but not limited to placing insulation either above or below the roof deck or on top of a drywall ceiling.**~~

~~E.~~3.6.1.5 Insulation Requirements for Heated Slab Floors

§110.8(g)

Heated slab-on-grade floors must be insulated according to the requirements in §Table 110.8-A and Table 3.4 below. ~~of the Sstandards.~~ The top of the insulation must be protected with a rigid material~~plate~~ to prevent intrusion of insects into the building foundation.

A common location for the slab insulation is on the perimeter of the foundation (See Figure 3-10).~~.~~ 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.

Another option is to install the insulation between the heated slab and foundation wall. In this case, insulation must extend downwards to the top of the footing and then extend horizontally inwards a distance of 4 ft towards~~s~~ 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.

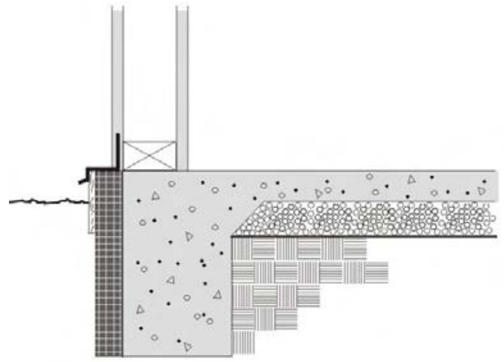


Figure 3-~~14~~ 10 – Perimeter slab insulation
Source: California Energy Commission

Table 3-~~5~~ 4 – Slab Insulation Requirements for Heated Slab Floors

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	5
			16	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	5
			16	10 vertical and 7 horizontal

~~F.~~3.6.1.6 Wet Insulation Systems

§110.8(h)

Wet insulation systems are roofing systems where the insulation is installed above the roof's waterproof membrane. Water can penetrate this insulation material and have an effect on 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 roof's waterproof membrane must be multiplied by 0.8 and using the result value in~~before~~ choosing the table column in Reference 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 Joint Appendix JA4.

~~G.~~3.6.1.7 Roofing Products Solar Reflectance & Thermal Emittance

§110.8(i)

Roofing products shall be ~~tested and labeled~~rated by the Cool Roof Rating Council (CRRC) and labeled appropriately by the roofing manufacturer for both solar reflectance and thermal emittance. The CRRC certification includes solar reflectance and thermal emittance. There are ~~two~~ three kinds of solar reflectance:

1. Initial solar reflectance
2. 3-year aged solar reflectance
3. Accelerated aged solar reflectance

All requirements of the Energy Standards are based on the 3-year aged reflectance. However, 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~~ aged value equation (using the initial value for solar reflectance) or an accelerated process. Until the appropriate aged rated value for the reflectance is posted in the directory, t~~T~~he equation below ~~can be~~can be used to calculate~~d~~ the ~~aged rated~~aged rated solar reflectance~~, until the appropriate aged rated value for the reflectance is posted in the directory.~~ or a new method of testing is used to find the accelerated solar reflectance.

Equation 3-2: Aged $Reflectance_{calculated}=(0.2+ \beta[\rho_{initial} – 0.2])$

Where:

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

β = soiling resistance which is listed in Table 3-~~6~~5

Table 3-~~6~~ 5– Values Of Soiling Resistance β By Product Type

PRODUCT TYPE	β
Field-applied coating	0.65
Other	0.70

The Energy Standards do not distinguish between initial and aged thermal emittance, meaning that either value can be used to demonstrate compliance with the Energy Standards. If a manufacturer fails to obtain CRRC certificate for their roofing products, the following default aged solar reflectance and thermal emittance values must be used for compliance:

1. For asphalt shingles, 0.08/0.75
2. For all other roofing products, 0.10/0.75

~~2.~~

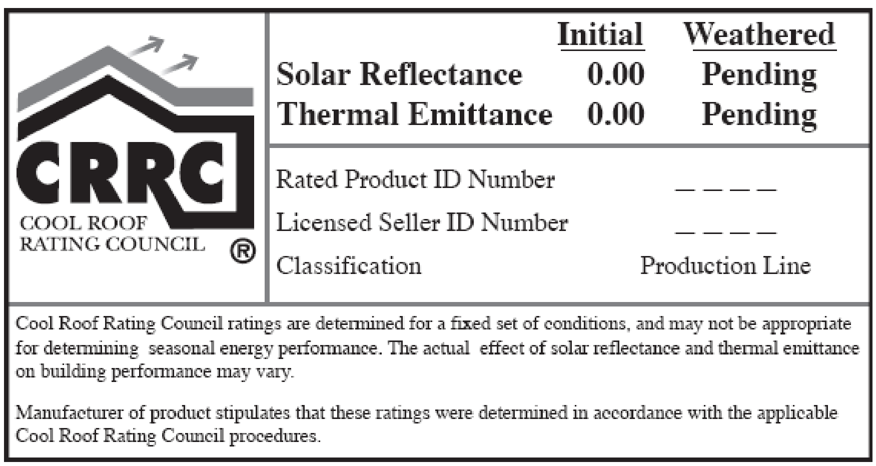


Figure 3-~~15~~ 11 – Sample CRRC Product label and information
Source: Cool Roof Rating Council

A. Field Applied Liquid Coatings

There are a number of liquid products, including elastomeric coatings and white acrylic coatings that qualify for Field Applied Liquid Coatings. The Energy Standards specify minimum performance and durability requirements for field-applied liquid coatings. Please note that 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. The requirements depend on the type of coating and are described in greater detail below. Liquid roof coatings applied to low-sloped roofs in the field as the top surface of a roof covering shall comply with the following mandatory requirements and descriptions.

a. 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 top surface of the coating while it is setting, providing a shiny and reflective surface. Because of the shiny surface and the physical properties of aluminum, these coatings have a thermal emittance below 0.75, which is the minimum rating for prescriptive compliance.

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 to. Also, the aluminum-pigmented asphalt roof coatings shall be manufactured in accordance with ASTM D2824[2]. Standard s~~S~~pecification is also required for Aluminum-Pigmented Asphalt Roof Coatings, Nonfibered, Asbestos Fibered, and Fibered without Asbestos that are suitable for application 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~~; and installed in accordance with ASTM D3805, *Standard Guide for Application of Aluminum-Pigmented Asphalt Roof Coatings.*

b. Cement-Based Roof Coatings

This class of coatings consists of a layer of cement and has been used for a number of years in the central valley of California and in 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% Portland c~~C~~ement and meet the requirements of ASTM D822, ASTM C1583 and ASTM D5870.

c. 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 surface 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 a number of performance and durability requirements as specified in §Table 110.8-C ~~of the Standards~~ or the minimum performance requirements of ASTM C836, D3468~~, D6083~~, or D6694, whichever are appropriate to the coating material.

~~3.9 Field Applied Liquid Coatings~~

~~3.10~~

~~**There are a number of liquid products, including elastomeric coatings and white**~~

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

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

~~C. The following precautionary caveat pertains only to the test method portion, Section 8, of this specification: This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.~~

~~**acrylic coatings that qualify for Field Applied Liquid Coatings. The Standards specify minimum performance and durability requirements for field-applied liquid coatings. Please note that 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. The requirements depend on the type of coating and are described in greater detail below. Liquid roof coatings applied to low-sloped roofs in the field as the top surface of a roof covering shall comply with the following mandatory requirements and descriptions.**~~

~~**A.** 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 top surface of the coating while it is setting, providing a shiny and reflective surface. Because of the shiny surface and the physical properties of aluminum, these coatings have a thermal emittance below 0.75, which is the minimum rating for prescriptive compliance.**~~

~~**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 to. Also, the aluminum-pigmented asphalt roof coatings shall be manufactured in accordance with ASTM D2824[3]. Standard Specification is also required for Aluminum-Pigmented Asphalt Roof Coatings, Nonfibered, Asbestos Fibered, and Fibered without Asbestos that are suitable for application 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.**~~

~~**B.** Cement-Based Roof Coatings~~

~~**This class of coatings consists of a layer of cement and has been used for a number of years in the central valley of California and in 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,**~~

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

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

C. The following precautionary caveat pertains only to the test method portion, Section 8, of this specification: This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

~~**cement-based coatings shall be manufactured to contain no less than 20% Portland Cement and meet the requirements of ASTM D822, ASTM C1583 and ASTM D5870.**~~

~~**C.** 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 surface 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 a number of performance and durability requirements as specified in Table 110.8-C of the Standards or the minimum performance requirements of ASTM C836, D3468, D6083, or D6694, whichever are appropriate to the coating material.**~~

~~D.~~3.6.1.8 **Radiant Barriers**

§110.8(j)

The radiant barrier is a reflective material that reduces radiant heat transfer caused by solar heat gain in the roof. Radiant barriers are installed below the roof deck in the attic and reduce radiant heat to air distribution ducts and insulation located below the radiant barrier. To qualify, a radiant barrier must have an emittance of 0.05 or less. The product must be tested according to ASTM C-1371-~~98~~ 10 or ASTM E408-~~71~~13(20~~13~~~~02~~) and must be certified by the California Bureau of Electronic and Appliance Repair, Home Furnishings and Thermal Insulation and listed in their Consumer Guide and Directory of Certified Insulation material, at ~~http://www.bhfti.ca.gov/industry/tinsulation.shtml.~~ http://www.bhfti.ca.gov/industry/tinsulation.shtml.

~~**E. Ceiling and Rafter Roof Insulation**~~

~~*2 §110.8(d), §110.8(e), §150.0(a), §150.0(b) These sections are also shown in Appendix B of this document.*~~

~~3 Wood framed roof/ceiling construction assemblies must have at least R-30 22 insulation or a maximum U-factor of 0.031 043 based on 24 inch on center wood framed rafter roofs, as determined from the Reference Joint Appendix JA4. Some areas of the roof/ceiling can be less than the mandatory minimum U-factor as long as other areas exceed the requirement and the weighted average U-factor for the overall ceiling/roof is 0.031 043 or less.~~

~~4 Metal-framed and roof/ceiling constructions other than wood framed must have a U-factor of 0.031 043 or less in order to comply with the mandatory measures. If the insulation is not penetrated by framing, such as rigid insulation laid over a structural deck, then the rigid insulation can actually have a rated R-value of less than R-30 22 so long as the total roof/ceiling assembly U-factor is not greater than U-0.031043.~~

~~**F.** Loose Fill Insulation~~

~~*5 §150.0(b) Loose Fill Insulation*~~

~~6 Loose fill insulation must be blown in evenly, and insulation levels must be documented on the Certificate of Installation (CF2R). 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 must also meet the manufacturer's specified minimum weight per ft² for the corresponding R-value. When installing loose fill insulation, the following guidelines should be followed:~~

7 ~~For wood trusses that provide a flat ceiling and a sloped roof, the slope of the roof should be at about 4:12 or greater in order to provide adequate access for installing the insulation. Insulation thickness near the edge of the attic will be reduced with all standard trusses, but this is acceptable as long as the average thickness is adequate to meet the minimum insulation requirement.~~

8 ~~If the ceiling is sloped (for instance, with scissor trusses), loose fill insulation can be used as long as the slope of the ceiling is no more than 4:12. If the ceiling slope is greater than 4:12, loose fill should be used only if the insulation manufacturer will certify the installation for the slope of the ceiling.~~

9 ~~At the apex of the truss, a clearance of at least 30 inch should be provided to facilitate installation and inspection.~~

~~G. Wall Insulation~~

10 *~~§150.0(c) Wall Insulation~~*

11 ~~The mandatory measures have two requirements depending on frame size:~~

12 ~~2x4 inch wood-framed walls above grade shall have at least R-13 insulation installed in the cavities between framing members, or a U-factor that cannot exceed U-0.102. Insulation may be of greater insulating value in certain areas of the wall and of lesser insulating value in other areas of the wall provided that the area-weighted U- factor does not exceed 0.102 to show equivalence to an R-13 wall.~~

13 ~~2x6 inch or greater wood-framed walls above grade shall have at least R-19 insulation installed in the cavities between framing members or a U-factor not exceeding 0.074. Insulation may be of greater insulating value in certain areas of the wall and of lesser insulating value in other areas of the wall provided that the area-weighted U-factor does not exceed 0.074 to show equivalence to an R-19 wall.~~

14 ~~There are several cases where the mandatory measures for wall insulation do not apply or apply in a special way. These include the following:~~

15 ~~The mandatory measures apply to framed foundation walls of heated basements or heated crawl spaces that are located above grade, but not to the portion that is located below grade.~~

16 ~~For additions to existing buildings, existing wood-framed walls that are already insulated with R-11 insulation need not comply with the mandatory R-13 wall insulation.~~

17

18 ~~Rim joists between floors of a multi-story building are deemed to comply with these mandatory measures if they have R-13 insulation installed on the inside of the rim joist and are properly installed between joist members.~~

19 *~~For demising partitions and knee walls are not required to meet the prescriptive requirements of §150.1(c)1B. Demising partitions and knee walls are required to meet the mandatory minimum~~*

~~*insulation requirement as set in §150.0(c)1 and 2. §150.0(c)1 requires that insulation not less than R-13 be installed between a 2x4 framing, or a U-factor which shall not exceed U-0.102. §150.0(c)2 requires insulation not less than R-19 be installed in framing of 2x6 inch or greater, or a U-factor equal to or less than 0.074.*~~

~~H. Raised-floor Insulation~~

20 ~~*§150.0(d)*~~

21 ~~Wood-framed floors must have at least R-19 insulation installed between framing members, or the construction must have a U-factor of 0.049 or less. The equivalent U-factor is based on R-19 insulation in a wood-framed floor. The R-19 insulation value and U-factor of U-0.049 are for the floor assembly alone and do not assume the effects of a crawlspace or buffer zone beneath the floor. If comparing to a crawlspace assembly, the equivalent U-factor is 0.037, which includes the effect of the crawlspace.~~

22 ~~Other types of raised floors, except for concrete raised floors (concrete raised floors do not have a mandatory requirement, but do have a prescriptive requirement) **need to meet, must also meet the maximum U-factor. In all cases, some areas of the floor can have a U-factor less than the requirement as long as other areas have a U-factor that exceeds the requirement and the area-weighted average U-factor is less than described above.~~

23 ~~Raised slab floors with radiant heat (heated slab floors) must meet special insulation requirements that are described in Chapter 4 of this manual.~~

24 ~~When a controlled ventilated crawlspace or an unvented crawlspace is used, raised-floor insulation is not required.~~

25

~~I. Fireplaces, Decorative Gas Appliances and Gas Logs~~

26 ~~*§150.0(e)*~~

27 ~~The Standards have mandatory requirements to limit infiltration associated with fireplaces, decorative gas appliances, and gas logs. Fireplace efficiency can be greatly improved through proper air control, and reduced infiltration is also a benefit when the fireplace is not operating (the majority of the time for most houses).~~

28 ~~Installation of factory-built or masonry fireplaces (see Figure 3-16) must include the following:~~

29

30 ~~Closable metal or glass doors covering the entire opening of the firebox,~~

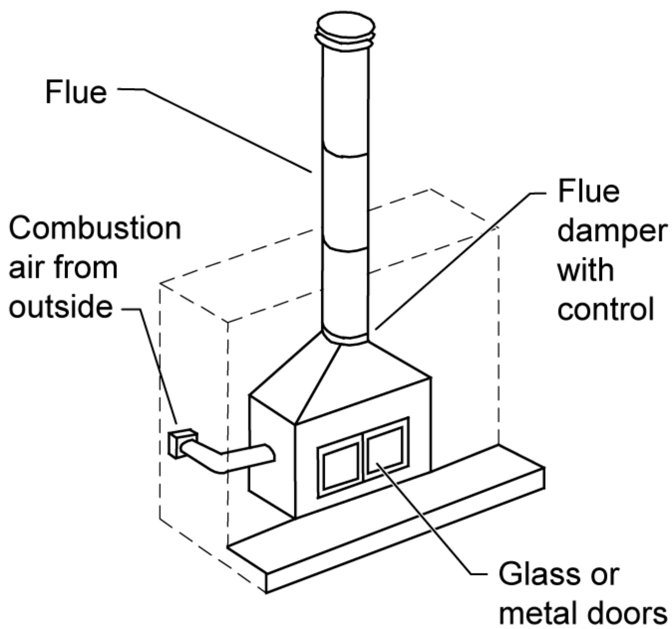
31 ~~Doors covering the entire opening of the firebox that can be closed when the fire is burning,~~

32 ~~A combustion air intake that is at least 6 square inches to draw air from outdoors and equipped with a readily accessible, operable and tight-fitting damper or combustion air control device (*Exception*: An outside combustion air intake is not required if the fireplace is installed over a concrete slab and the fireplace is not located on an exterior wall),~~

33 ~~A flue damper with a readily accessible control. (*Exception:* 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 manufacturer's installation instructions or the California Mechanical Code).~~

34 ~~Continuous burning pilot lights are prohibited for fireplaces as well as for decorative gas appliances and gas logs. In addition, indoor air may not be used for cooling a firebox jacket when that indoor air is vented to the outside of the building.~~

35 ~~When a gas log, log lighter or decorative gas appliance is installed in a fireplace, the flue damper must be blocked open if required by the manufacturer's installation instructions or the California Mechanical Code.~~



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37 ~~Figure 3-16 – Fireplace Installation~~
~~Source: California Energy Commission~~

38 ~~Example 3-14~~

39 ~~**Question**~~

40 ~~Are closable glass or metal doors required for decorative gas appliances?~~

41 ~~**Answer**~~

42 ~~Yes. Decorative gas appliances are required to have closable glass or metal doors covering the entire opening of the firebox.~~

43 ~~Example 3-15~~

44 ~~Question~~

45 ~~If I want to have a gas log or some other device in the fireplace of my home, can I have a standing pilot light? Can I block open the damper?~~

46 ~~Answer~~

47 ~~The Standards disallow standing pilot light. The flue damper may be blocked open if required by either the manufacturer's installation instructions or the California Mechanical Code.~~

48

~~Example 3-16~~

~~Question~~

~~§150.0(e)2 states that no fireplace, decorative gas appliance or gas log can be installed if it has a continuously burning pilot light. The California Mechanical Code requires all gas appliances installed in California to have a manually operated shut-off valve, accessible to the inhabited space. Does this shut-off valve meet the intent of this section?~~

~~Answer~~

~~Not if the pilot light must be manually extinguished when the appliance is off. A unit that meets the intent of this section will have a pilot light that cannot stay on when the unit is off.~~

~~Example 3-17~~

~~Question~~

~~A building plan specifies a freestanding gas heater that is decorative; however, the equipment is vented and is rated as a room heater. Is it acceptable that this appliance have a pilot light?~~

~~Answer~~

~~Yes. Since this equipment is rated as a room heater, it can have a continuous burning pilot light.~~

~~Example 3-18~~

~~Question~~

~~Do decorative gas appliances need glass or metal doors?~~

~~Answer~~

~~Yes, the door requirement applies to masonry or factory-built fireplaces only. If a decorative gas appliance is installed inside a fireplace, the fireplace needs doors. Consult with the manufacturer of the decorative gas appliance regarding combustion air requirements.~~

~~J. Recessed Luminaires in Ceilings~~

~~§150.0(k)8~~

~~Luminaires recessed in insulated ceilings can create thermal bridging through the insulation. Not only does this degrade the performance of the ceiling assembly, but it can also permit condensation on a cold surface of the luminaire if exposed to moist air, as in a bathroom.~~

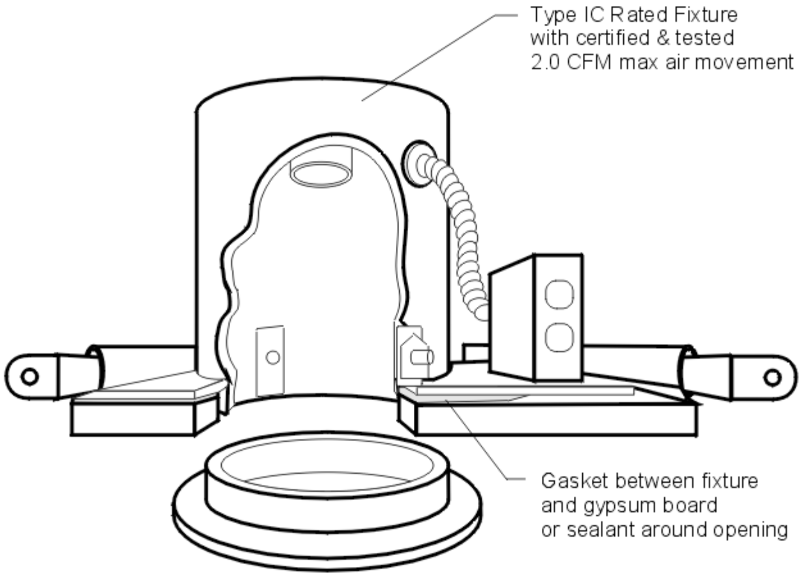
~~For these reasons, luminaires recessed in insulated ceilings must meet three requirements:~~

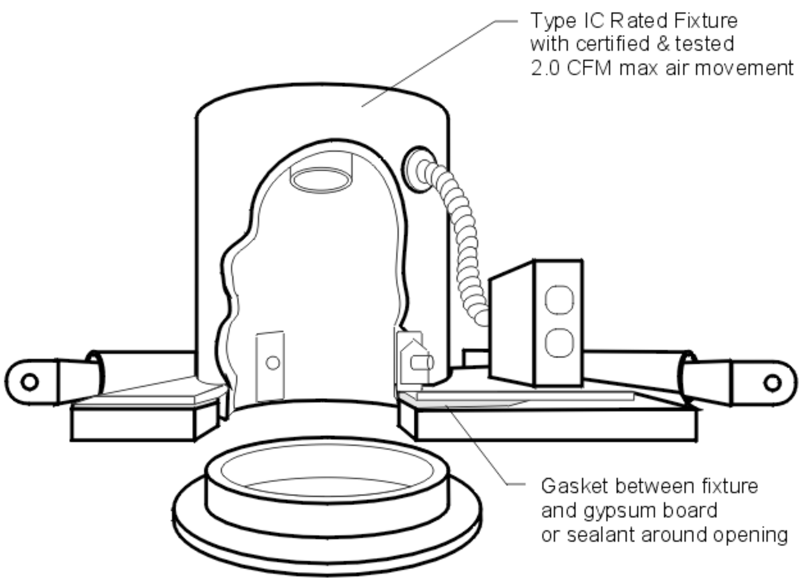
~~They must be listed as defined in the Article 100 of the California Electric Code for zero clearance insulation contact (IC) by Underwriters Laboratories or other testing/rating laboratories recognized by the International Conference of Building Officials. This enables insulation to be in direct contact with the luminaire.~~

~~The luminaire must have a label certified as per §150.0(k)8B for air tight (AT) construction. Air tight construction means that leakage through the luminaire will not exceed 2.0 cfm when exposed to a 75 Pa pressure difference, when tested in accordance with ASTM E283.~~

75 ~~The luminaire must be sealed with a gasket or caulk between the housing and ceiling.~~

~~Refer to the Lighting chapter (Chapter 6) of this compliance manual for more information regarding the applicable requirements for recessed luminaires.~~





76 *~~Figure 3-17 – IC-Rated Luminaire (Light Fixture)~~*
~~Source: California Energy Commission~~

~~K. Slab Insulation~~

77 *~~§150.0(l) §118(g)~~*

78 ~~Mandatory measures require that the insulation material must be suitable for the application, with 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. An example of an insulating material that meets these specifications is smooth-skin extruded polystyrene.~~

79 ~~The insulation must also 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 by other suitable means.~~

~~L. Ventilation for Indoor Air Quality~~

80 ~~*§150.0(o)*~~

81 ~~All buildings shall meet the requirements of ASHRAE Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Low-Residential Buildings. The whole-building ventilation airflow shall be provided to meet the requirements of ASHRAE 62.2. Window operations are not a permissible method of providing whole house ventilation. Use of a continuously operating central fan integrated with a forced-air system air handler cannot be used to meet the whole-building ventilation airflow requirement.~~

~~M. Ventilation Openings~~

82 ~~ASHRAE Standard 62.2 requires ventilation openings in habitable spaces, toilets and utility rooms. Spaces that meet the exhaust requirements are exempted from meeting the whole-building ventilation air flow requirement; there for an exhaust system can be substituted for a ventilation opening (see Section 4.6.6).~~

83 ~~Field Verification and Diagnostic Testing~~

84 ~~Field verification and diagnostic testing is required to confirm proper ventilation airflow following the procedures specified in the Residential Reference Appendices, Appendix RA3.7.~~

85

86 ~~Example 3-19 – Ventilation Opening Louvers~~

87 ~~**Question**~~

88 ~~There are fixed wooden louvers over a window in a bedroom. The louvers have slats that are 1/8 inch thick, and they are spaced 1 inch apart. What is the reduction in square inches of openable area?~~

89 ~~**Answer**~~

90 ~~Assuming a window of 4 x 5 feet with 1 inch spacing between 1 inch louvers. Each louver has a space of 1 inch measured perpendicular to the slats (the correct way). The reduction is the slat thickness divided by the spacing, or 1/8 inch. The opening area is the original opening area (2880in^2) x ((1in – 1/8in)/1in) = 2520in^2.~~

91

~~N. Vapor Retarder~~

~~*§150.0(g) and Reference Residential Appendix RA4.5.2*~~

~~Vapor retarder class is a measure of the ability of a material or assembly to limit the amount of moisture the passes through the material or assembly. Vapor retarder classes are defined in Section 202 of the 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~~

~~In climate zones 14 and 16, a continuous 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 floors of vented attics, on the roof decks of vented attics with above or below deck air-permeable insulation, and in unvented attics with air-permeable insulation.~~

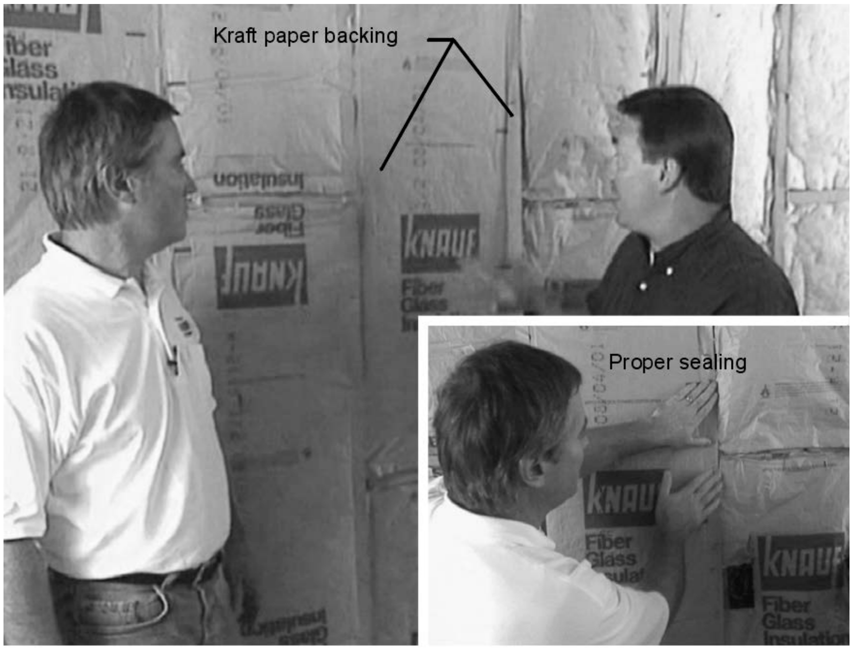
~~Buildings with unvented crawl spaces in Climates zones 1-16 must have a Class I or Class II vapor retarder covering the earth floor to protect against moisture condensation.~~

~~If a building has a controlled ventilation crawl space a Class I or Class II vapor retarder must be placed over the earth floor of the crawl space to reduce moisture entry and protect insulation from condensation in accordance with Reference Residential Appendix RA4.5.2.~~

~~There are many product types having tested vapor retarder performance. Some common examples are:~~

1. ~~Foil and other facings on gypboard can provide moisture resistance and product literature should always be checked to ensure conformance to ASTM E96.~~
2. ~~The kraft paper used as facing on thermal batt insulation material is typically a Class II vapor retarder. Faced-batts may or may not 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 their installation integrity through friction-fitting within the cavity of framed assemblies. In all cases, the insulation must be installed properly.~~
3. ~~Many interior painted surfaces may also qualify for meeting the vapor retarder requirement if the paint product has been tested to show its compliance as a vapor retarder. The effectiveness of vapor retarder paint is dependent on the installed thickness, in mils. These products often require more than one layer to achieve their tested perm rating and care must be shown by the installer of the paint and for inspection by the building official.~~

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



Source: California Energy Commission

~~Figure 3-18 – Typical Kraft Faced Vapor Retarder Facing~~

3.6.1.9 Ceiling and Attic~~Rafter~~ Roof Insulation

§110.8(d), ~~§110.8(e),~~ §150.0(a), ~~§150.0(b) These sections are also shown in Appendix B of this document.~~

Wood framed roof/ceiling construction assemblies must have at least R-22 insulation or a maximum U-factor of 0.043 based on ~~24~~16 inch on center wood framed rafter roofs, as determined from ~~the Reference Joint Appendix~~ JA4. Some areas of the roof/ceiling can be less than the mandatory minimum U-factor as long as other areas exceed the requirement and the weighted average U-factor for the overall ceiling/roof is 0.043 or less.

Metal-framed and roof/ceiling constructions other than wood framed must have a U-factor of 0.043 or less in order to comply with the mandatory measures. If the insulation is not penetrated by framing, such as rigid insulation laid over a structural deck, then the rigid insulation can actually 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.

~~A.~~3.6.1.10 Loose Fill Insulation

§150.0(b) ~~Loose Fill Insulation~~

Best Practice:

~~For wood trusses that provide a flat ceiling and a sloped roof, the slope of the roof should be 4:12 or greater in order to provide adequate access for installing the insulation. Insulation thickness near the edge of the attic will be reduced with all standard trusses, but this is acceptable as long as the average thickness is adequate to meet the minimum insulation requirement.~~

~~If the ceiling is sloped (for instance, with scissor trusses), loose fill insulation can be used as long as the slope of the ceiling is no more than 4:12. If the ceiling slope is greater than 4:12, loose fill should be used only if the insulation manufacturer will certify the installation for the slope of the ceiling.~~

~~At the apex of the truss, a clearance of at least 30 inch should be provided to facilitate installation and inspection.~~

l insulation must be blown in evenly, and insulation levels must be documented on the Certificate of Installation (CF2R). 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 must also meet the manufacturer's specified minimum weight per ft² for the corresponding R-value. When installing loose fill insulation, the following guidelines should be followed:

1. For wood trusses that provide a flat ceiling and a sloped roof, the slope of the roof should be 4:12 or greater in order to provide adequate access for installing the insulation. Insulation thickness near the edge of the attic will be reduced with all standard trusses, but this is acceptable as long as the average thickness is adequate to meet the minimum insulation requirement.
2. If the ceiling is sloped (for instance, with scissor trusses), loose fill insulation can be used as long as the slope of the ceiling is no more than 4:12. If the ceiling slope is greater than 4:12, loose fill should be used only if the insulation manufacturer will certify the installation for the slope of the ceiling.
3. At the apex of the truss, a clearance of at least 30 inch should be provided to facilitate installation and inspection.

Wall Insulation~~For wood trusses that provide a flat ceiling and a sloped roof, the slope of the roof should be at about 4:12 or greater in order to provide adequate access for installing the insulation. Insulation thickness near the edge of the attic will be reduced with all standard trusses, but this is acceptable as long as the average thickness is adequate to meet the minimum insulation requirement.~~

~~If the ceiling is sloped (for instance, with scissor trusses), loose fill insulation can be used as long as the slope of the ceiling is no more than 4:12. If the ceiling slope is greater than 4:12, loose fill should be used only if the insulation manufacturer will certify the installation for the slope of the ceiling.~~

~~At the apex of the truss, a clearance of at least 30 inch should be provided to facilitate installation and inspection.~~

~~**B.**~~3.6.1.11

§150.0(c) ~~Wall Insulation~~

The mandatory measures have two requirements depending on frame size:

1. 2x4 inch wood-framed walls above grade shall have at least R-13 insulation installed in the cavities between framing members, or a U-factor that cannot exceed U-0.102. Insulation may be of greater insulating value in certain areas of the wall and of lesser insulating value in other areas of the wall provided that the area-weighted U-factor does not exceed 0.102 to show equivalence to an R-13 wall.

2. 2x6 inch or greater wood-framed walls above grade shall have at least R-19 insulation installed in the cavities between framing members or a U-factor not exceeding 0.074. Insulation may be of greater insulating value in certain areas of the wall and of lesser insulating value in other areas of the wall provided that the area-weighted U-factor does not exceed 0.074 to show equivalence to an R-19 wall.

There are several cases where the mandatory measures for wall insulation do not apply or apply in a special way. ~~These include the following~~For best practice, the following should be implemented~~followed~~:

1. The mandatory measures apply to framed foundation walls of heated basements or heated crawl spaces that are located above grade, but not to the portion that is located below grade.
2. ~~2.~~ For additions to existing buildings, existing wood-framed walls that are already insulated with R-11 insulation need not comply with the mandatory R-13 wall insulation.

2.

3. Rim joists between floors of a multi-story building are deemed to comply with these mandatory measures if they have R-13 insulation installed on the inside of the rim joist and are properly installed between intersecting joist members.

Demising partitions and knee walls are not required to meet the prescriptive requirements of §150.1(c)1B. Demising partitions and knee walls are required to meet the mandatory minimum insulation requirement as set in §150.0(c)1 and §150.0(c)1, requiringe~~es~~ that insulation not less than R-13 be installed between ~~a~~ 2x4 framing, or a U-factor which shall not exceed U-0.102. §150.0(c)2 requires insulation not less than R-19 be installed in framing of 2x6 inch or greater, or a U-factor equal to or less than 0.074.

~~C.~~3.6.1.12 Raised-floor Insulation

§150.0(d)

Wood-framed floors must have at least R-19 insulation installed between framing members, or the construction must have a U-factor of 0.049 or less. The equivalent U-factor is based on R-19 insulation in a 2x6, ~~i~~16 inch on center wood-framed floor without a crawl space. The R-19 insulation value and U-factor of U-0.049 are for the floor assembly alone and do not assume the effects of a crawlspace or buffer zone beneath the floor. If comparing to a crawlspace assembly, the equivalent U-factor is 0.037, which includes the effect of the crawlspace.

Other types of raised floors, except for concrete raised floors (concrete raised floors do not have a mandatory requirement, but do have a prescriptive requirement) must also meet the maximum U-factor. In all cases, some areas of the floor can have a U-factor less than the requirement as long as other areas have a U-factor that exceeds the requirement and the area-weighted average U-factor is less than that described above.

Raised slab floors with radiant heat (heated slab floors) must meet special insulation requirements that are described in Chapter 4 of this manual.

When a controlled ventilated crawlspace or an unvented crawlspace is used, raised-floor insulation is not required.

~~D.~~3.6.1.13 Fireplaces, Decorative Gas Appliances and Gas Logs

§150.0(e)

The Energy Standards have mandatory requirements to limit infiltration associated with fireplaces, decorative gas appliances, and gas logs. Fireplace efficiency can be greatly improved through proper air control.~~,~~ Reduced infiltration is also a benefit when the fireplace is not operating (the majority of the time for most homes).

Installation of factory-built or masonry fireplaces (see Figure 3-1~~6~~2) must include the following:

~~1. Closable metal or glass doors covering the entire opening of the firebox,~~

~~2.~~1. Closable metal or glass d~~D~~oors covering the entire opening of the firebox that can be closed when the fire is burning,

~~3.~~2. A combustion air intake that is at least 6 square inches to draw air from outdoors and equipped with a readily accessible, operable and tight-fitting damper or combustion air control device (*Exception*: An outside combustion air intake is not required if the fireplace is installed over a concrete slab and the fireplace is not located on an exterior wall),

~~4.~~3. A flue damper with a readily accessible control. (*Exception:* 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 manufacturer's installation instructions or the California Mechanical Code).

Continuous burning pilot lights are prohibited for fireplaces as well as for decorative gas appliances and gas logs. In addition, indoor air may not be used for cooling a firebox jacket when that indoor air is vented to the outside of the building.

When a gas log, log lighter or decorative gas appliance is installed in a fireplace, the flue damper must be blocked open if required by the manufacturer's installation instructions or the California Mechanical Code.

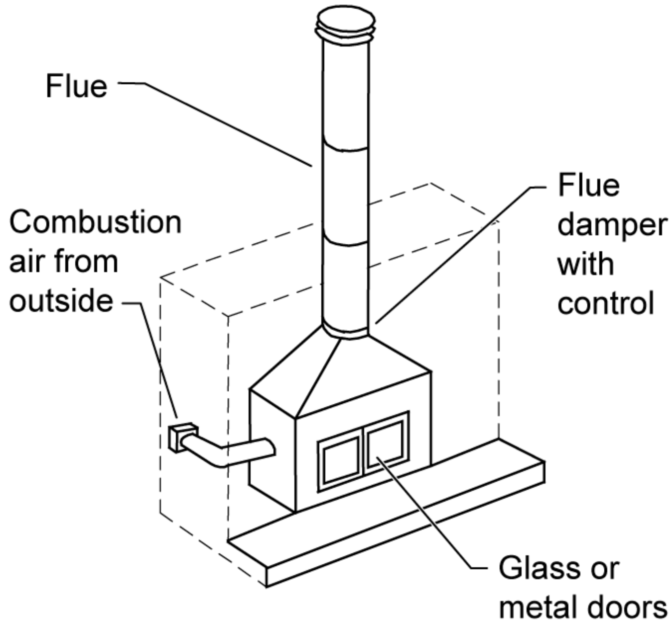


Figure 3-1~~6~~2 – Fireplace Installation
Source: California Energy Commission

Example 3-14

Question

Are closable glass or metal doors required for decorative gas appliances?

Answer

Yes. Decorative gas appliances are required to have closable glass or metal doors covering the entire opening of the firebox.

Example 3-15

Question

If I want to have a gas log or some other device in the fireplace of my home, can I have a standing pilot light? Can I block open the damper?

Answer

The Energy Standards disallow standing pilot lights. The flue damper may be blocked open if required by either the manufacturer's installation instructions or the California Mechanical Code.

Example 3-16

Question

§150.0(e)2 states that no fireplace, decorative gas appliance or gas log can be installed if it has a

continuously burning pilot light. The California Mechanical Code requires all gas appliances installed in California to have a manually operated shut-off valve, accessible to the inhabited space. Does this shut-off valve meet the intent of this section?

Answer

Not if the pilot light must be manually extinguished when the appliance is off. A unit that meets the intent of this section will have a pilot light that cannot stay on when the unit is off.

Example 3-17

Question

A building plan specifies a freestanding gas heater that is decorative; however, the equipment is vented and is rated as a room heater. Is it acceptable that this appliance have a pilot light?

Answer

Yes. Since this equipment is rated as a room heater, it can have a continuous burning pilot light.

Example 3-18

Question

Do decorative gas appliances need glass or metal doors?

Answer

Yes, the door requirement applies to masonry or factory-built fireplaces only. If a decorative gas appliance is installed inside a fireplace, the fireplace needs doors. Consult with the manufacturer of the decorative gas appliance regarding combustion air requirements.

~~E.~~3.6.1.14 **Slab Insulation**

§150.0(f~~l~~) §118(g)

Mandatory measures require that the insulation material must be suitable for the application, with a water absorption rate no greater than 0.3%~~-~~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. An example of an insulating material that meets these specifications is smooth-skin extruded polystyrene.

The insulation must also 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 by other suitable means.

~~A.~~3.6.1.15 **Vapor Retarder**

§150.0(g) and ~~Reference Residential Appendix~~ RA4.5.1~~2~~

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

~~4.~~1. Class I: 0.1 perm or less

~~5.~~2. Class II: 0.1 < perm < 1.0 perm

~~6.~~3. Class III: 1.0 < perm < 10 perm

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 floors of vented attics, on the roof decks of vented attics with above or below deck air-permeable insulation, and in unvented attics with air-permeable insulation.

Buildings with unvented crawl spaces in climates zones 1-16 must have a Class I or Class II vapor retarder covering the earth floor to protect against moisture condensation.

If a building has a controlled ventilation crawl space a Class I or Class II vapor retarder must be placed over the earth floor of the crawl space to reduce moisture entry and protect insulation from condensation in accordance with RA4.5.1~~2~~.

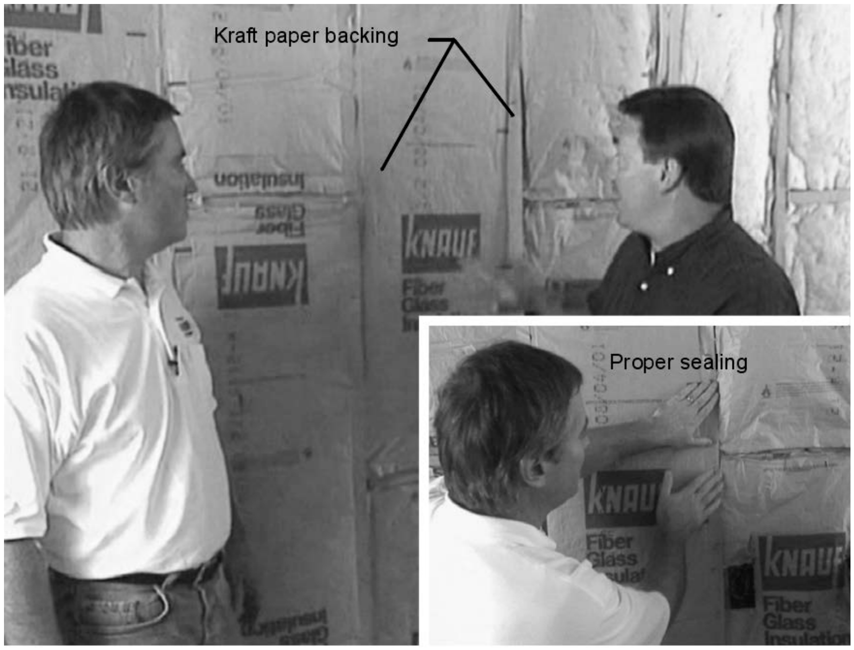
There are many product types having tested vapor retarder performance. Some common examples are:

~~4.~~1. Foil and other facings on gypsum board can provide moisture resistance and product literature should always be checked to ensure conformance to ASTM E96.

~~5.~~2. The kraft paper used as facing on thermal batt insulation material is typically a Class II vapor retarder. Faced-batts may or may not 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 their installation integrity through friction-fitting within the cavity of framed assemblies. In all cases, the insulation must be installed properly.

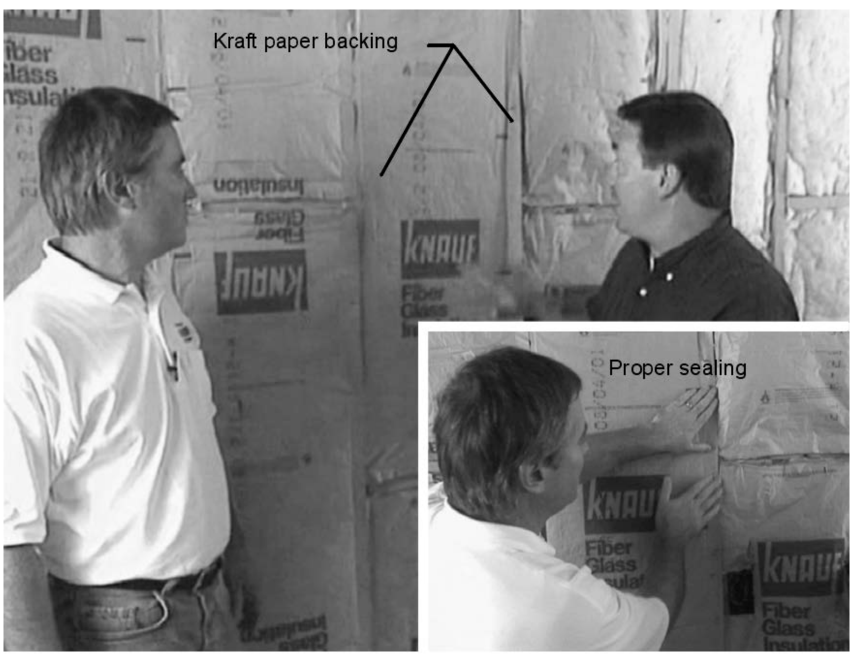
~~6.~~3. Many interior painted surfaces may also qualify for meeting the vapor retarder requirement if the paint product has been tested to show its compliance as a vapor retarder. The effectiveness of vapor retarder paint is dependent on the installed thickness, in mils. These products often require more than one layer to achieve their tested perm rating and care must be shown by the installer of the paint and for inspection by the building official.

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



Source: California Energy Commission

Figure 3-13 – Typical Kraft Faced Vapor Retarder Facing



Source: California Energy Commission

~~Figure 3-187 – Typical Kraft Faced Vapor Retarder Facing~~

3.6.1.16 **Recessed Luminaires in Ceilings**

§150.0(k)~~8~~1C

Luminaires recessed in insulated ceilings can create thermal bridging through the insulation. Not only does this degrade the performance of the ceiling assembly, but it can also permit condensation on a cold surface of the luminaire if exposed to moist air, as in a bathroom.

For these reasons, luminaires recessed in insulated ceilings must meet three requirements:

1. They must be listed as defined in the Article 100 of the California Electric Code for zero clearance insulation contact (IC) by Underwriters Laboratories or other testing/rating laboratories recognized by the International Conference of Building Officials. This enables insulation to be in direct contact with the luminaire.
2. The luminaire must have a label certified as per §150.0(k)1Cii~~8B~~ for air tight (AT) construction. Air tight construction means that leakage through the luminaire will not exceed 2.0 cfm when exposed to a 75 Pa pressure difference, when tested in accordance with ASTM E283.
3. The luminaire must be sealed with a gasket or caulk between the housing and ceiling.

Refer to the Lighting chapter (Chapter 6) of this compliance manual for more information regarding the applicable requirements for recessed luminaires.

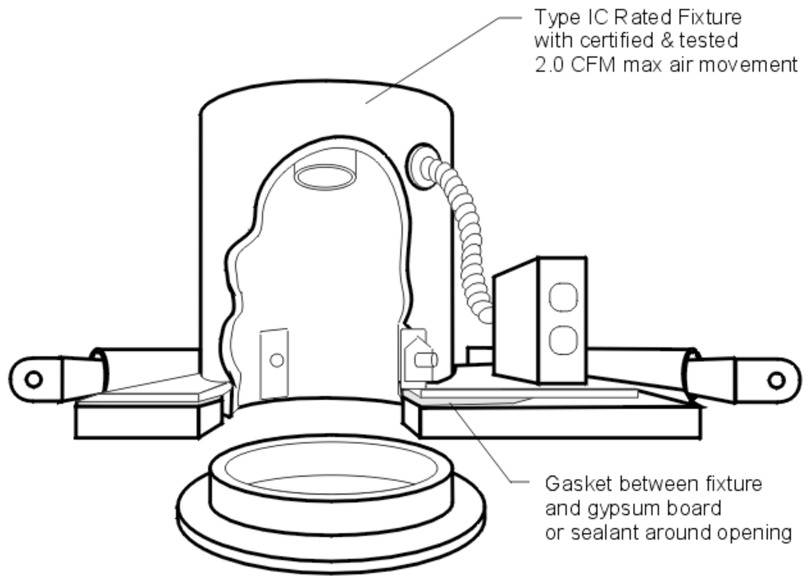


Figure 3-14~~3-13-13-15-15-13-11~~78 – IC-Rated Luminaire (Light Fixture)
Source: California Energy Commission

~~A.~~3.6.1.17 **Ventilation for Indoor Air Quality**

§150.0(o)

All buildings shall meet the requirements of ASHRAE Standard 62.2, *Ventilation and Acceptable Indoor Air Quality in Low-Residential Buildings*. The whole-building ventilation airflow shall be provided to meet the requirements of ASHRAE 62.2. ~~Window operations are not a permissible method offor providing whole house ventilation.~~ Use of a continuously operating central fan integrated with a forced-air system air handler cannot be used to meet the whole-building ventilation airflow requirement.

~~B.~~3.6.1.18 **Ventilation Openings**

ASHRAE Standard 62.2 requires ventilation openings in habitable spaces, toilets and utility rooms. Spaces that meet the exhaust requirements are exempted from meeting the whole-building ventilation air flow requirement; there-fore, an exhaust system can be substituted for a ventilation opening (see Section 4.6.6.6).

Field verification and diagnostic testing is required to confirm proper ventilation airflow following the procedures specified in the RA3.7.

Example 3-19 – Ventilation Opening Louvers

Question

There are fixed wooden louvers over a window in a bedroom. The louvers have slats that are 1/8 inch thick, and they are spaced 1 inch apart. What is the reduction in square inches of openable area?

Answer

Assuming a window of 4 x 5 feet with 1 inch spacing between 1 inch louvers. Each louver has a space of 1 inch measured perpendicular to the slats (the correct way). The reduction is the slat thickness divided by the spacing, or 1/8 inch. The opening area is the original opening area (2880in^2) x ((1in – 1/8in)/1in) = 2520in^2.

3.6.2 *Prescriptive ~~Requirements~~Approach*

3.6.2.1 Roof/Attic

The 2016 Standards are designed to offer flexibility to the builders and designers of residential new construction in terms of achieving the intended energy efficiency targets. As such, the 2016 Standards offer several options for achieving one of two design objectives related to improving energy performance of homes built with ventilated attics in climate zones 4, 8-16 as shown in:

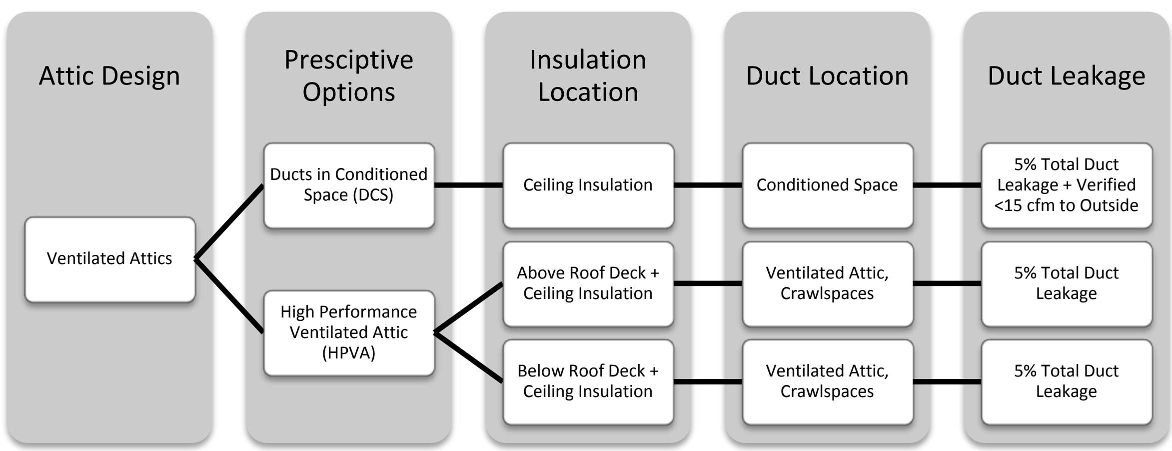


Figure 3-~~3-19~~15 – Ventilated Attic Prescriptive Compliance Choices

High Performance Ventilated Attic (HPVA) implements measures that minimize temperature difference between the attic space and the conditioned air being transported through ductwork in the attic. The package consists of insulation either below the roof deck or insulation above the roof deck in addition to insulation at the ceiling, R-8 ducts, and 5% total duct leakage of the nominal air handler airflow.

Ducts in Conditioned Space (DCS), locates ducts and air handlers in the building's thermal and air barrier envelope. The Ducts in Conditioned Space option requires field verification in order to meet the prescriptive requirement.

Note: A~~that a~~ll the prescriptive requirements for HPVA or DCS are based on the assumption that the home is built with the following construction practices:

1. The attic is ventilated with appropriate free vent area~~a as d~~ as described in Section 3.6.2.1(E)~~escribed in section **3.6.2.1A Reference source not found.**3.9~~
2. The roof is constructed with standard wood rafters and trusses
3. The outermost layer of the roof construction is either tiles or shingles
4. The air handler and ducts are in the ventilated attic for HPVA and are in conditioned space for DCS
5. The air barrier is located at the ceiling (excludes~~not a~~ "cathedral" ~~attic~~roof/ceiling systems)~~)~~

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

Example 3-20

Question

If 5% of a roof will be a cathedral ceiling, can it still comply under the prescriptive requirements?

Answer

No. The entire attic must be a ventilated space with the building air barrier located at the ceiling with standard wood rafter trusses to comply with the prescriptive requirements. This project must comply through the performance approach.

Example 3-21

Question

Does a sealed (unventilated) attic with insulation at the roof deck comply under the prescriptive requirements?

Answer

No. The entire attic must be a ventilated space with the building air barrier located at the ceiling with standard wood rafter trusses to comply with the prescriptive requirements. This project must comply through the performance approach.

A. Roof/Ceiling Insulation

In this section we describe the requirements and approaches necessary to meet the requirements for the High Performance Ventilated Attic (HPVA) as they relate to roof/ceiling insulation. HVAC aspects of the HPVA including duct insulation and duct leakage are described in Section 4. Requirements and approaches to meet the Ducts in Conditioned Space (DCS) are also described in Section 4 of this manual.

§150.1(c).1 requires different values of roof/ceiling insulation depending on whether the HPVA (option A or B) or DCS (option C) is chosen as described in Figure 3-16 Prescriptive Requirements for Roof/ Ceiling Insulation (§150.1(c).1)

~~16~~ and Figure 3~~-Figure 3-317:~~. Note that the standard design in the performance approach is based on Option B, as detailed in [1] of Figure 3-17, installed with a tile roof.

Strategy		How to Comply
High Performance Ventilated Attics		
Option A	Vented attic with continuous insulation applied above the roof deck. (Figure 3-18). Ceiling insulation required separately above finished attic ceiling.	§Table 150.1-A Roof Assembly Option A
Option B	Vented attic with ~~unfaced~~ batt or spray in cellulose/fiberglass secured with netting. (Figure 3-18~~xx~~). Ceiling insulation required separately above finished attic ceiling.	§Table 150.1-A Roof Assembly Option B
Ducts in Conditioned Space		
Option C	Vented attic with no insulation at roof deck. Ceiling insulation required separately above finished attic ceiling. Ducts and air handler equipment in conditioned space that is NOT a sealed attic.	§Table 150.1-A Roof Assembly Option C Form: CF2R-MCH-20b

Figure 3-~~216~~3-~~2~~3-~~2~~ Prescriptive Requirements for Roof/ Ceiling Insulation (§150.1(c).1)

Option A (CZ 4, 8-16)	Option B[1] (CZ 4, 8-16)	Option C (CZ 4, 8-16)
☐ Vented attic ☐ R6 (air space) or R8 (no air space) continuous above deck rigid foam board insulation ☐ R38 ceiling insulation ☐ Radiant Barrier ☐ R8 duct insulation ☐ 5% total duct leakage	☐ Vented attic ☐ R13 (air space) or R15 (no air space) batt or spray in cellulose/fiberglass below roof deck secured with netting ☐ R38 ceiling insulation ☐ R8 duct insulation ☐ 5% total duct leakage	☐ Vented attic ☐ R30 or R38 ceiling insulation (climate zone specific) ☐ R6 or R8 ducts (climate zone specific) ☐ Radiant Barrier ☐ Verified ducts in conditioned space

[1] Standard Design used to set the energy budget for the Performance Approach.

Figure 3-~~317~~3-~~33~~-~~35~~-~~3.~~ Checklists for Prescriptive Requirements for HPVA/DCS

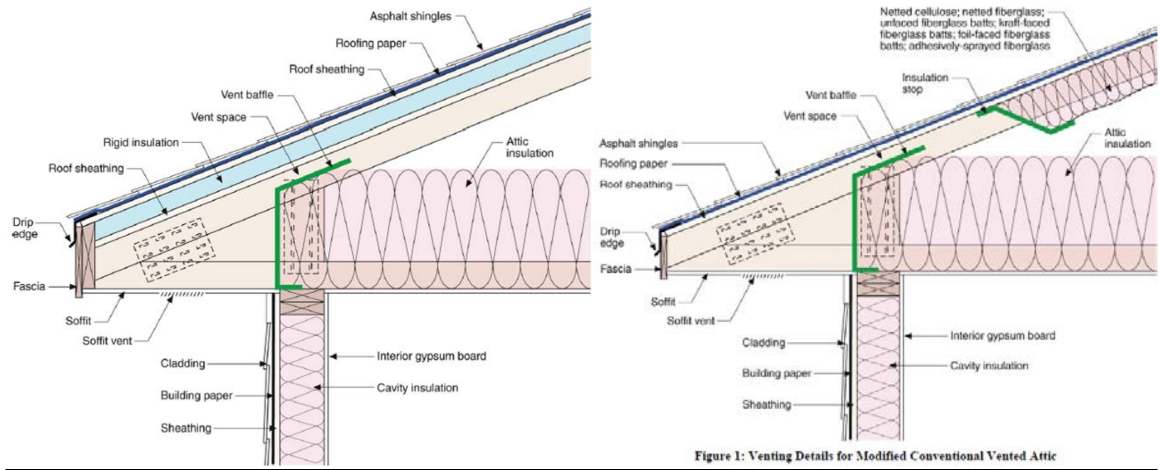


Figure 3-4183-43-85-45-33-33. Option A (left) and Option B (right)

Source: Building Science Corporation

Both Options A and B require insulation above the roof rafters or below the roof deck between the roof rafters at different values depending on whether or not there is an air gap present between the roofing materials and the roof deck. For roof constructions with an air gap present, which is standard for concrete or clay tile, R6 insulation is required above the roof rafters or R13 below the roof deck placed between the rafters. If there is no air gap present between the roofing and roof deck, R8 insulation is required above the roof rafter or R18 below the roof deck placed between the rafters.

The R--values for insulation installed above the roof rafters are lower than the R-values for insulation installed below the roof deck due to the added benefit of reduced thermal bridging when continuous insulation is applied to the roof deck. Further, when an air space is present between the roofing and the roof deck, the impact of insulation is greater than when there is no air space.

Standard residential -roof construction practices in California for concrete/clay tiles is to have an air gap between the tiles and roof deck, and for asphalt shingles is to place the roofing material directly on top of the roof deck without an air gap. It is however possible for builders to construct different construction assemblies than these standard assemblies such as providing air gaps between the asphalt shingles and roof deck (through construction techniques explained later in this document).

The prescriptive requirement for roof deck insulation can also be met by placing ducts in conditioned space and getting HERS verification (Option C). The requirements to comply with Option C are explained in Chapter 4 of this manual.

Is this strategy new for you?

Design Considerations and Best Practices:

- Commit to a compliance strategy early in the building design process
- Have a kick-off meeting with builder, subcontractor, designer, energy consultant, and HERS rater to set expectations and express the value of the design.
- Communicate strategy and schedule to subcontractors and other team members early.
- May require coordinating an additional building inspection for above deck insulation prior to installation of final roofing materials.
- Include insulation specifications according to the CF1R on the building plans.
- Roofer will install above roof deck insulation, whereas insulation contractor will install insulation below roof deck (ideally at the same time as ceiling insulation)~~.~~
- All relevant subcontractors must be aware of where air barrier is located and be conscious of where they make penetrations, especially if designing for verified ducts in conditioned space.

Construction Practice/Compliance and Enforcement

1. Above Roof ~~Deck~~Rafter Insulation (Option A):

In a vented attic, rigid board insulation can be installed above the roof rafters to add value to the thermal integrity of the roof system. As described above, the prescriptive insulation value depends on whether an air gap is present above the rigid insulation or not. Above rafter insulation can be implemented with either asphalt shingles or clay/concrete tiles. Check manufacturer’s specifications for proper nail schedules (fastening patterns); this will change depending on the roof pitch, truss spacing, and roofing material. When above rafter insulation is installed, a radiant barrier must also be installed in the required climate zones.

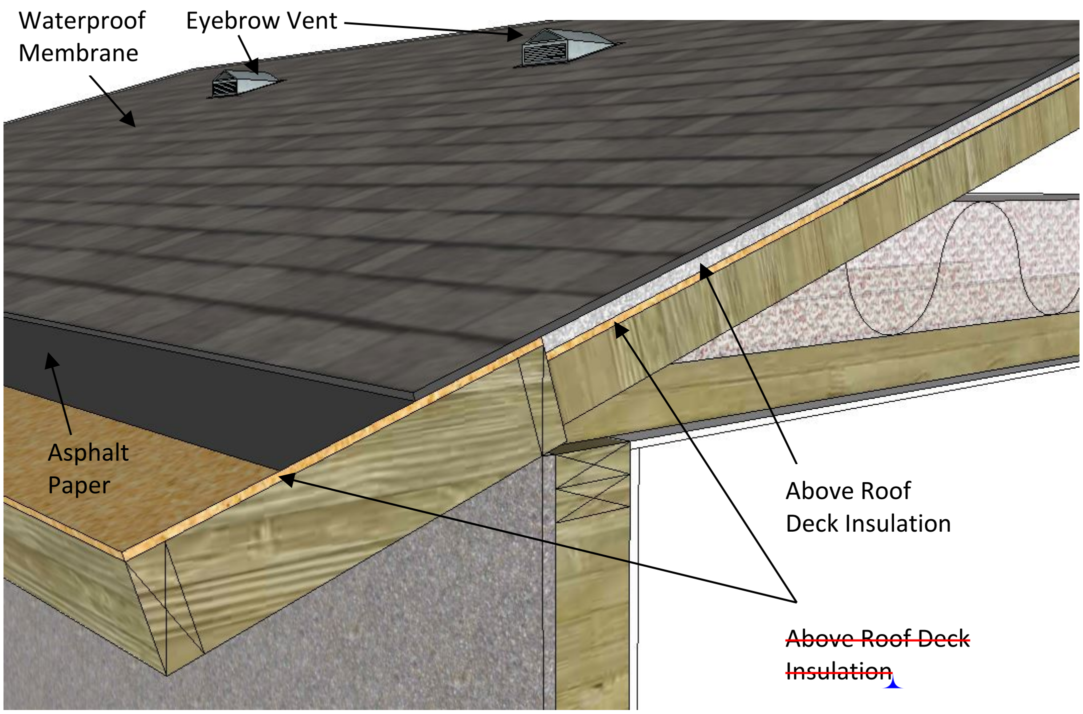


Figure 3-~~30~~19 – Above Roof Deck Insulation
Source: California Energy Commission

Roofing with Asphalt Shingles, - Best Practices:

When installing asphalt shingles with roof deck insulation, it is best practice to implement a ventilation method between the roofing product and the top sheathing or insulation, as shown in Figure 3-~~X~~19 and Figure 3-~~X~~20, to prevent the roofing material from experiencing high temperatures and reducing effective product life. Spacers can be inserted either above or below a second roof sheathing to provide both roof deck ventilation and a nailable base for asphalt shingles, as seen in Figure 3-~~Figure 3~~21. Manufacturers offer prefabricated insulation products with spacers and top sheathing. Check manufacturers' and trade association websites for a list of products available that provide an air space and nailable base.

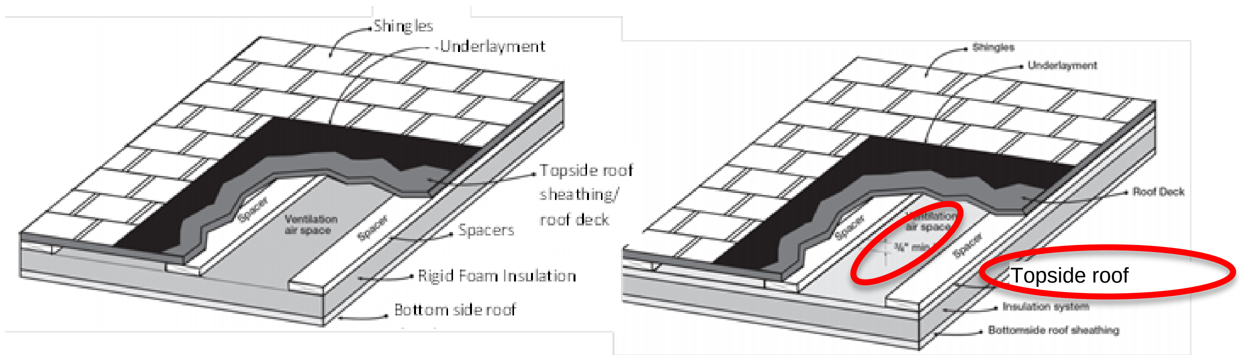


Figure 3-~~53-53-95-55-43-443.~~20 Above deck insulation with spacers installed with and without top sheathing Source:~~(~~ARMA technical bulletin No. 211-RR-94~~)~~

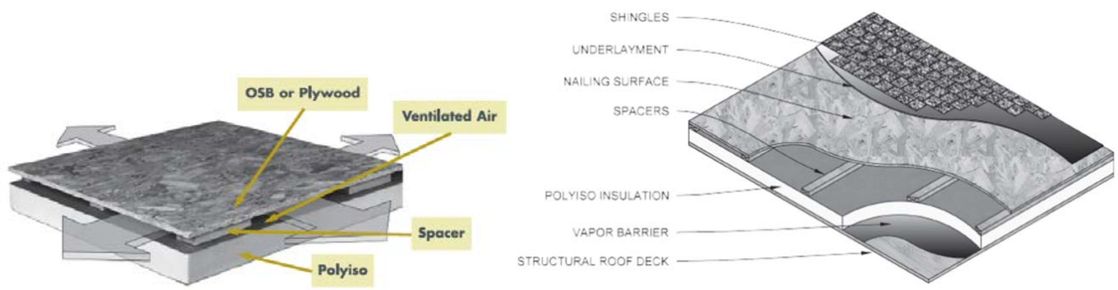


Figure 3-~~6~~21~~3-63-105-65-53-553~~24. Asphalt shingles and spacers installed with above deck insulation

~~(~~Source: PIMA Tech Bulletin #106~~)~~

Roofing with Concrete/Clay Tiles, - Best Practices:

With tile roofs, there is traditionally an air gap between the tile and the roof deck due to the shape of the tiles and the way tiles are installed over purlins. When adding insulation above roof deck, there are two options to addressing the air gap. If the air gap is desired, one option is to install rigid insulation over the roof deck and a second roof sheating layer added above the rigid insulation along with a vapor retarder above that to host the purlins above with the tiles rest. This is shown in Figure 3-22.

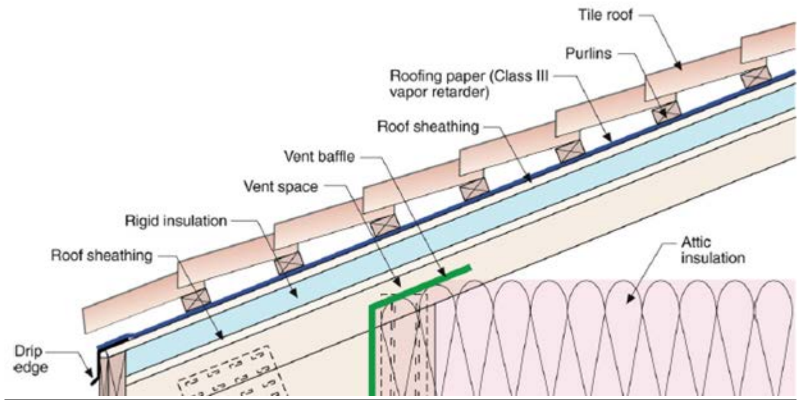


Figure 3-~~72~~2~~3-7~~3-~~11~~5-~~7~~5-~~6~~3-~~664~~35 Battens (~~P~~purlins) installed with above deck insulation ~~(~~

Source: Building Science Corporation~~)~~

If the air gap is not desired, there are insulation products available that can fit directly ~~take~~under ~~a~~concrete/clay tile without the need for purlins, as shown in the figure below.

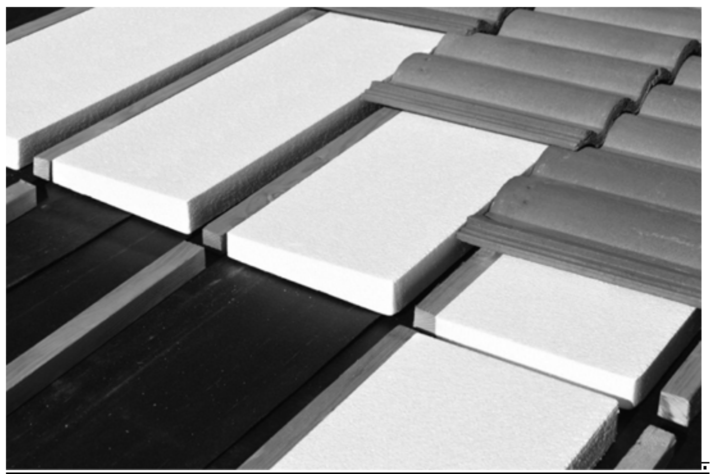


Fig. 1a

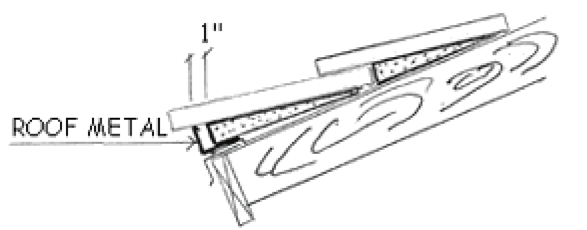


Figure 3-~~82~~3~~3-8~~3-~~12~~5-~~8~~5-~~7~~3-~~77~~5. ~~Wedge-It~~Wedged insulation formed to be placed directly below tile without an air gap

~~(~~Source: Wedge-It~~)~~

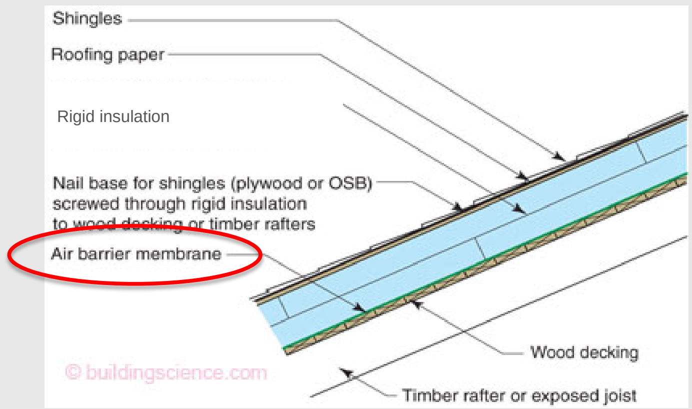
Example 3-22

Question

A project plans to install R8 rigid foam insulation above the roof deck using two R4 foam boards. Can this method be used to meet the prescriptive requirements? If so, are there best practices for installing the two layers of insulation?

Answer

Yes, installing two R4 rigid foam board layers meets the R8 prescriptive requirement (remember that R8 is required when there is no air gap between insulation and roofing materials, but R6 is required if there is air gap). To prevent water infiltration, it is best practice to stagger the horizontal and vertical joints of the two layers and take care to properly seal each joint. ~~See Ffigure below3-X.~~



Source: Building Science Corporation

Example 3-23

Question

A project plans to install R6 rigid foam insulation above the roof deck with roofing material placed *directly* over the insulation, does this meet the prescriptive requirements? Are there best practices for installing the insulation?

Answer

No, this construction does not comply with the prescriptive requirements. R6 insulation can only be used above the roof deck when there is an air gap between the insulation and the finishing roofing material. Using spacers or battens (purlins) are two strategies to create this air gap. Products exist that combine insulation, spacers, and an additional sheathing for nailing asphalt shingles, check with insulation manufacturers for available products. Refer to the Best Practices above in the Above Roof Deck Insulation section. Alternatively, R8 insulation can be installed if no air gap is desired.

Addressing Attic Ventilation with Above Deck Insulation

Proper attic ventilation occurs at two points at the roof: the soffit (or eave) vents and the ridge vents. Ridge venting must be maintained when installing above deck insulation as shown in Figure 3-~~.3-30~~x29?.

Addressing Fire Performance of Roof Assemblies with Above Deck Insulation

Example 3-24~~20~~

Question

Does a roof assembly using above deck insulation meet Class A/B/C fire rating specifications, as determined by California Building Code, Chapter 15?

Answer

Application of above deck insulation affects the fire rating classification of roof covering products. Roof covering products are currently rated to class A/B/C based on the ASTM E108 [NFPA 256, UL790] test. Class A/B/C ratings are done with specific roof assemblies, and ratings are only valid when the installation is the same as the assembly as rated. Under current building code requirement, tile roof products installed directly over the roof deck or over purlins are automatically rated Class A. Chapter 15 in the California Building Code (and International Building Code section 1505 for Fire Classification) specify that certain roofing materials are Class A without having to test to ASTEM E108. These materials include slate, clay, concrete roof tile, an exposed concrete roof deck, and ferrous and copper shingles; however, asphalt shingles are not covered under this category.

Insulation products on the other hand are subject to a different fire test from roof covering products. California Building Code (and International Building Code section 2603 for Foam Plastic Insulation) require foam plastic insulation to be tested to demonstrate a flame spread~~s~~ index of not more than 75 and a smoke-developed index of not more than 450 according to ASTM E84 [UL723]. The requirements are applicable to roof insulation products, including XPS/ polyiso/ polyurethane above-deck insulation and SPF below-deck insulation products.

In order to ensure that roof assemblies with insulation meet the proper fire rating classification, roof product manufacturers and insulation manufacturers must test and develop assemblies that meet the CBC testing specifications.

2. Below Deck Insulation (Option B):

In a vented attic, air-permeable or air-impermeable insulation (i.e. batt, spray foam, loose fill cellulose or fiberglass) ~~can~~should be placed **directly** below the roof deck between the truss members and secured in place to provide a thermal barrier for the attic space. This is especially useful when ducts and equipment are present. Insulation must be ~~flush~~in direct contact with the roof deck and a plastic membrane or netting can be used to secure insulation.

Proper attic ventilation must always be maintained to prevent the potential for moisture to condense. In climate zones 14 and 16, a Class I or Class I~~I~~I vapor retarder must also be used to manage moisture[4], as stated in California Residential Code Section R806.2. See Figure 3-~~Figure 9Figure 8~~4 – Figure 3-27 for depictions of insulation options and maintaining proper ventilation. More information on best practices to maintain proper attic ventilation is discussed below.

Best Practice:

Attic vapor retarders are not necessary in most climates when using blown-in insulation or unfaced batts if sufficient attic ventilation is maintained[~~1~~4]. Although not required, the use of vapor retarders can provide additional security against moisture and humidity levels

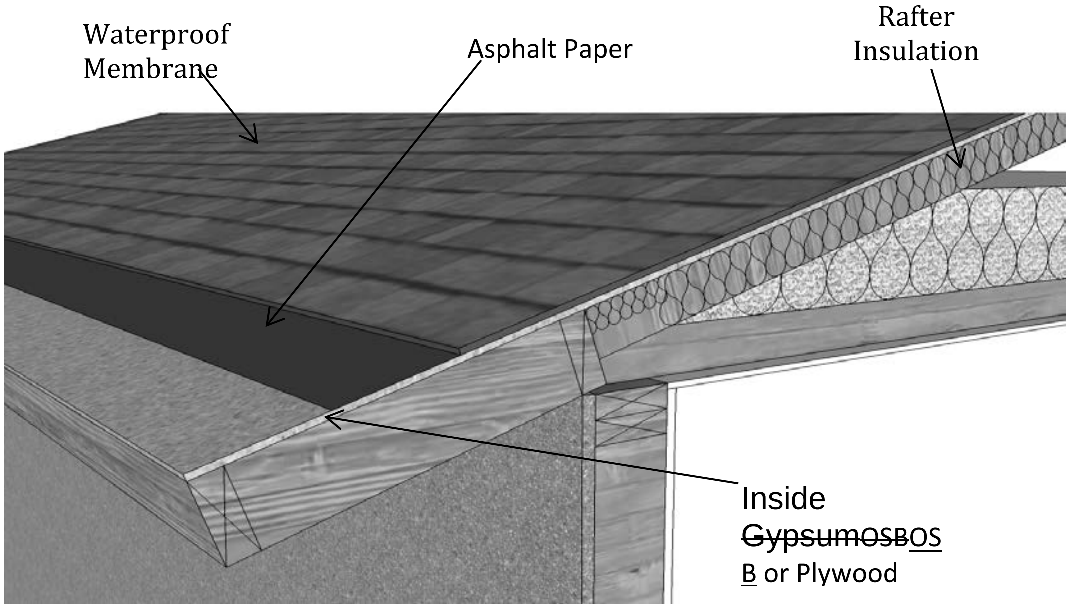


Figure 3-2~~9~~4 – Below Roof Deck Insulation
Source: California Energy Commission

[4] Insulation Contractors Association of America. (2004). Technical Bulletin No. 6 Use of Vapor Retarders.

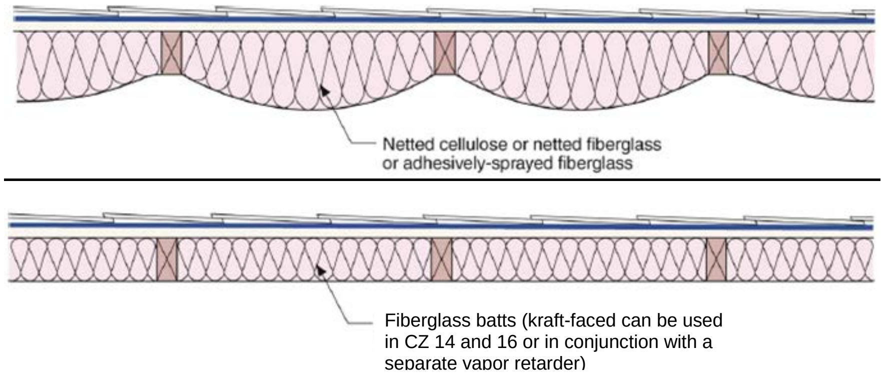


Figure 3-~~93-113-145-105-93-998.~~25 - Placement of insulation below the roof deck.

(Source: Building Science Corporation)

When insulation is installed below the roof deck, a radiant barrier is not required. ~~because it is not technically feasible to install these two products in combination.~~

Addressing Attic Ventilation with Below Deck Insulation

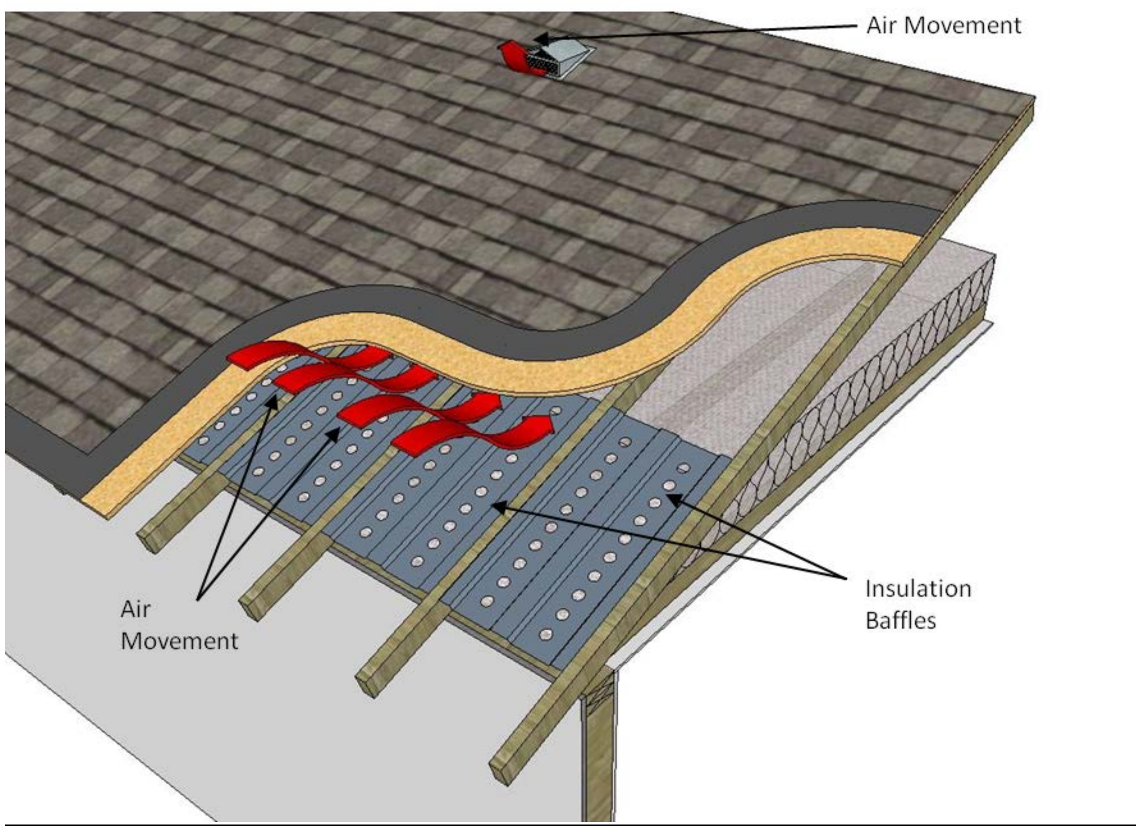


Figure ~~????~~3-26 Insulation Air Baffles

When installing insulation below the roof deck, vent baffles and insulation stoppers can be used to maintain proper ventilation space, as shown in Figure 3-27~~Figure 6~~27. Proper flow of air through the space helps remove moisture and prevents any associated issues.

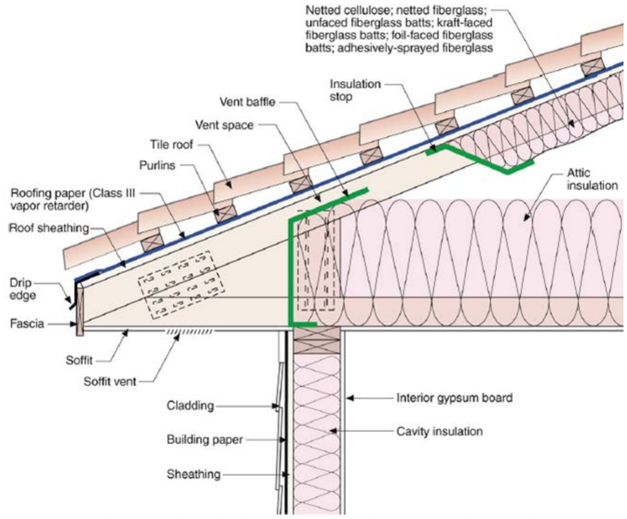


Figure 31: Vented Attic – Tile Roof – Air Permeable Insulation On Underside of Roof Deck - Can be

Figure 3-~~10~~27~~3-123-155-115-103-10106.~~ Vented attic - below deck insulation with insulation stopper

~~(~~Source: Building Science Corporation

Best Practice:

Maintaining attic ventilation and moisture management using:

- Vent baffles and insulation stoppers. See Figure 3-X
- Vapor retarder below the roof deck to further assist in moisture management. (Although this is only required in Climate Zones 14 and 16).

~~)~~

Example 3-25~~21~~

Question

A new construction project in climate zone 12 was designed to meet the prescriptive requirements for roof deck and ceiling insulation, but due to miscommunication amongst the team, was built without the roof deck insulation. R-49 ceiling insulation was installed instead. Does this project still comply?

Answer

This project no longer meets the prescriptive requirements, and must follow the Performance Approach. For future projects, clearly communicating the project expectations to all team members early in the construction process is key to succeeding at this design strategy. Having a project initiation meeting with all subcontractors and team members is a best practice, at least for the first few projects until the entire team is aware of the design needs.

How to comply with residential envelope requirements using Option C: Verified Ducts in Conditioned Space.

Option C allows a project to place and verify that ducts are located in condition space instead of installing insulation at the roof deck. This ~~is true for~~prescriptively applies to climate zones 4, 8-16. If complying with this path, ceiling and duct insulation must be installed at the values specified in Table 150.1-A for Option C, and a radiant barrier is also required in some climate zones. Simply locating ducts in conditioned space does not qualify for this requirement; a HERS rater must test and verify the system.

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 key is that the ducts and equipment are placed within the building's air barrier. See Section 4.4.2 for detailed information on DCS strategies.

Design strategies that cannot be used to prescriptively comply with Option C include~~are~~ placing ducts and equipment in sealed (unvented) attics or in conditioned crawlspace. However, these methods are effective under the Performance Approach. See Section 3.6.3 for more information on advanced assemblies.

3. Duct and Air Handlers Located in Conditioned Space (Option C):

Option C allows a project to place and verify that ducts are located in conditioned space instead of installing insulation at the roof deck. This prescriptively applies to climate zones 4, 8-16. If complying with this path, ceiling and duct insulation must be installed at the values specified in §Table 150.1-A for Option C, and a radiant barrier is also required in some climate zones. Simply locating ducts in conditioned space does not qualify for this requirement; a HERS rater must test and verify the system

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 key is that the ducts and equipment are placed within the building's air barrier. See Section 4.4.2 for detailed information on DCS strategies.

Design strategies that cannot be used to prescriptively comply with Option C are placing ducts and equipment in sealed (unvented) attics or in conditioned crawlspace. However, these methods are effective under the Performance Approach. See Section 3.6.3 for more information on advanced assemblies.

B. Ceiling Insulation~~:~~

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 ~~.~~(See Figure ~~x~~3-28?~~-~~). This can cause structural damage and reduce the insulation's effectiveness.

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 is not required but may be desirable. See ~~the Advanced Assembly section.~~Section 3.6.3.1(C) for details.

~~A.~~C. Radiant Barriers

§150.1(c)2

The prescriptive requirements call for a radiant barrier in climate zones 2 through 15, except when below deck insulation is installed. The radiant barrier is a reflective material that reduces radiant heat transfer caused by solar heat gain in the roof. Radiant barriers reduce the radiant gain to air distribution ducts and insulation located below the radiant barrier, typically within the attic space. In the performance approach, radiant barriers are modeled as separate adjustments to the heating U-factor and the cooling U-factor. The duct efficiency is also affected by the presence of a radiant barrier when using the performance approach.

Radiant Barrier Construction Practice

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 them 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 Residential Reference Appendices 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 as described above to the roof sheathing between framing members. This construction type is described in the Residential Reference Appendices RA4.2.1.1. See below for drawings of radiant barrier installation methods.

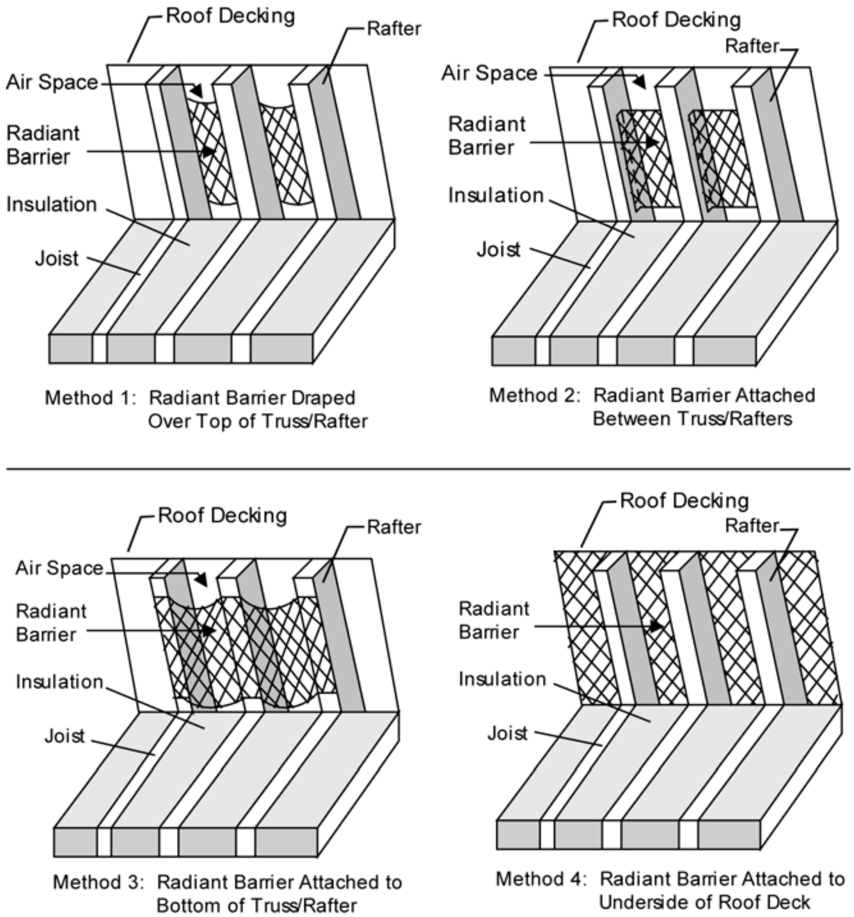


Figure 3-~~19~~ 28 – Methods of Installation for Radiant Barriers
Source: California Energy Commission

~~B.~~D. Roofing Products (Cool Roof)

§150.1(c)11

Cool roofs of steep and low-sloped roofs are required in some climate zones. A low-slope roof is defined as a surface with a pitch less than or equal to 2:12 (9.5 degrees from the horizontal or less) while a steep-slope roof is a surface with a pitch greater than 2:12 (more than 9.5 degrees from the horizontal). The prescriptive requirement is based on an aged solar reflectance and thermal emittance tested value from the Cool Roof Rating Council (CRRC).

An alternative to the aged solar reflectance and thermal emittance is to use the Solar Reflectance Index (SRI) to show compliance. A calculator has been produced to calculate the SRI by designating the s~~S~~olar r~~R~~eflectance and ~~T~~thermal emittance of the desired roofing material. The calculator can be found at ~~http://www.energy.ca.gov/title24/2013standards~~http://www.energy.ca.gov/title24/2013standards. To calculate the SRI, the 3-year aged value of the roofing product must be used. By using the SRI calculator a cool roof may comply with an emittance lower than 0.85, as long as the aged reflectance is higher and vice versa.

The residential roofing product requirement in the prescriptive package is as follows~~.~~:

1. For steep-sloped applications in climate zones 10-15, the three year aged solar reflectance requirement of 0.20 and a (three year aged or initial) thermal emittance requirement of 0.75, or a minimum solar reflectance index (SRI) of 16.
2. For low-sloped roofing applications, in climate zones 13 and 15, there is a minimum aged solar reflectance of 0.63 and thermal emittance of 0.75, or a minimum SRI of 75.

There are two exceptions to meeting the roofing products requirements in the prescriptive package:

1. The roof area with building integrated photovoltaic panels and building integrated solar thermal panels are exempt from the minimum requirements for aged solar reflectance and thermal emittance or SRI Exception 1 to §150.1(c)11B.
2. Roof constructions that have thermal mass over the roof membrane with a weight of at least 25 lb/ft² are exempt from the minimum requirements for aged solar reflectance and thermal emittance or SRI under Exception 2 to §150.1(c)11B.

Construction Practice/Compliance and Enforcement

The compliance and enforcement process should ensure that the cool roof efficiency values (solar reflectance and thermal emittance values) modeled on the CF1R form are specified on the building plans, and that those same values of the actual installed cool roof product meet or exceed the efficiency values on the CF1R form. For more information on Compliance and Enforcement on cool roof, see C~~c~~hapter 2 of this manual.

Example 3-26~~0~~

Question

A computer method analysis shows that a new house requires R-19 ceiling insulation to comply using the performance approach, but the minimum mandatory insulation level for ceiling insulation is ~~only R-30~~R-22. Which insulation level should be used?

Answer

~~R-30 the higher insulation level must be installed for the building to comply. In some cases such as this, minimum mandatory measures are superseded by stricter compliance measures when using the performance approach.~~The mandatory insulation requirement is an area weighted average. Therefore, some areas can have lower insulation, such as R-19, but other areas will need to have higher levels of insulation so that the area weighted average is at least R-22.

Example 3-27~~1~~

Question

A small addition to an existing house appears to comply using only R-15 ceiling insulation with the performance approach. Does this insulation level comply with the Standards?

Answer

No. R-15 would not be sufficient because the required minimum ceiling insulation level established by the mandatory measures is R-~~30~~22. However, R-15 could be used in limited areas, as follows:

1. 16-inches on center framing with attic with the weighted average U-factor for the entire ceiling/roof less than 0.032.

2. 24-inches on center framing with attic with the weighted average U-factor for the entire ceiling/roof less than 0.031

3. 16-inches on center rafter without attic with the weighted average U-factor for the entire ceiling/roof less than 0.051.
4. 24-inches on center rafter without attic with the weighted average U-factor for the entire ceiling/roof less than 0.049.

~~A.~~E. Attic Ventilation

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-~~31~~29). 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 a number of acceptable methods for maintaining ventilation air, including pre-formed baffles made of either cardboard or plastic. In some cases, plywood baffles are used.

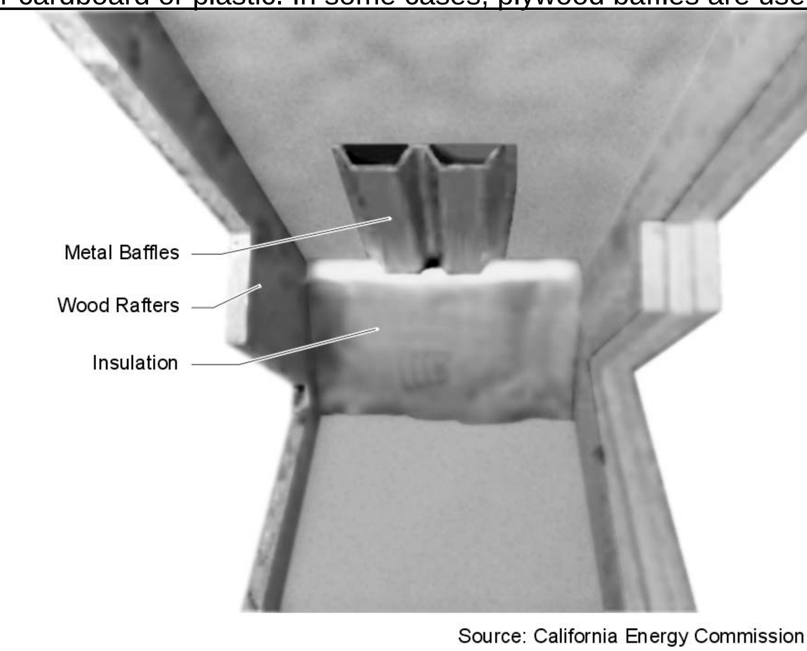


Figure 3-~~31~~29 – Baffles at the Eave in Attics
Source: California Energy Commission

The California Building Code (CBC) requires a minimum vent area to be provided in roofs with attics, including enclosed rafter roofs creating 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 shall not be less than 1/300 of the area of the space ventilated.
2. CBC, Title 24, Part 2, Vol. 2.5, Section R806.2 requires that the net free ventilating area shall 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.

NOTE: In either situation, a minimum of 50% of the vents must be located in the upper portion of the space being ventilated at least 3 feet above eave or cornice vents.

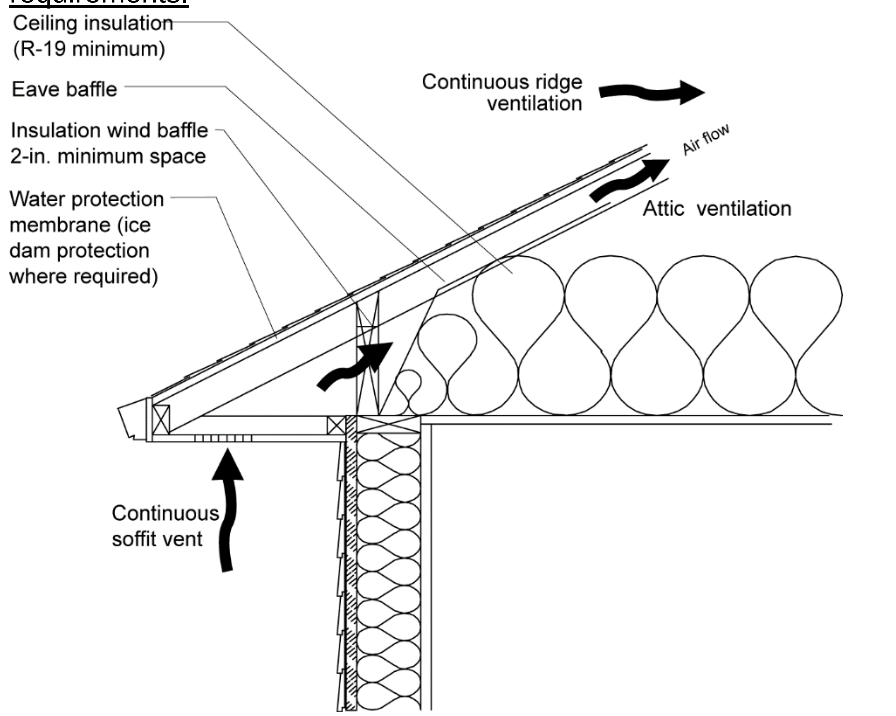
Ventilated openings are covered with corrosion resistant wire cloth screening or similar mesh material. When part of the vent area is blocked by meshes or louvers, the resulting “net free area” of the vent must be considered when meeting ventilation requirements.

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

~~a. *Wood Rafter Constructions*~~

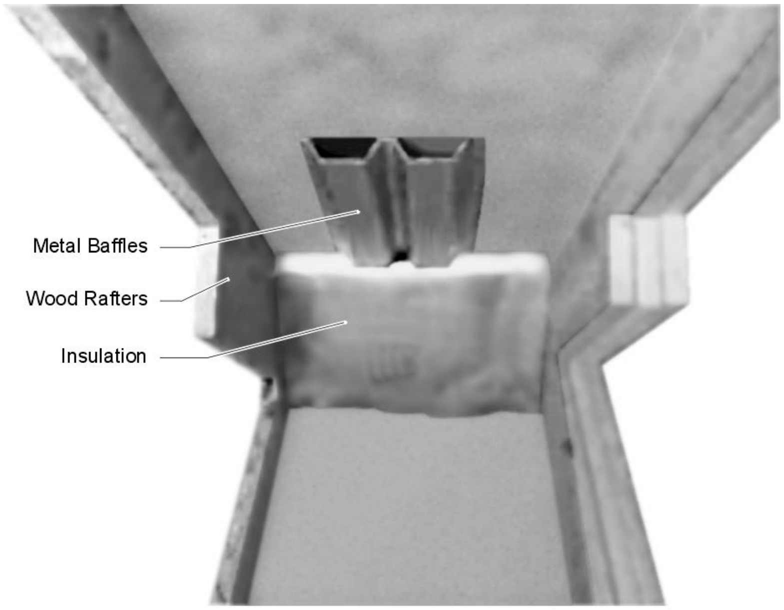
~~Ventilating framed rafter spaces is more difficult than ventilating attics because each framing cavity requires its own vent openings. It is common practice with loose-fill insulation material to completely fill the cavity so that there is no ventilation at all. With batt insulation it is possible to ventilate above the insulation using higher density (cathedral ceiling) batts because this material is specifically manufactured to allow a minimum of 1 inch above the top of the insulation to allow for ventilation. If spray polyurethane foam is used, it is applied to the underside of the roof deck leaving no ventilation space.~~

~~Attic ventilation, particularly in hotter climate zones, can provide an energy benefit. However, no energy credit is allowed for reducing the ventilation area below building code requirements.~~



~~*Figure 3-31 – Ceiling Insulation Construction Detail*~~

~~*Source: California Energy Commission*~~



Source: California Energy Commission

~~*Figure 3-32 – Baffles at the Eave in Attics*~~
~~*Source: California Energy Commission*~~

~~C.~~3.6.2.2 Walls

~~D.~~A. Wall Insulation

1. Framed Walls

§150.1(c)1B

The Package A prescriptive requirements (§~~Standards~~ Table 150.1-A) call for a U-factor of 0.~~065~~ 051 in climate zones 1-5 and 8-15, and a U-factor of 0.065 in climate zones 6 and 7.

~~Wood-framed walls may comply by specifying and installing the minimum R-value indicated. For metal-framed walls, or as an alternative to meeting the installed R-value in wood-framed walls, t~~The designer may choose any wall construction from Reference Joint Appendix JA4 (Tables 4.3.1 and 4.3.4) that has a U-factor equal to or less than 0.051 or 0.065, depending on the climate zone~~)~~. U-factors can also be calculated by building the construction assembly in Commission approved compliance software including the inside finish, sheathing, cavity insulation, and exterior finish. ~~.~~

JA4 Table 4.3.4 shows that a 2x6 wood framed wall at 16" on center can achieve a U-factor of 0.051 with R-19 ~~(low density)~~ batt insulation in the cavity and R-5 exterior insulation.

Some examples of various wood-framed wall assemblies, their construction, and their U-values are provided in Figure 3-~~X~~30.

Stud	Cavity Insulation	Cavity Insulation Type	Exterior Insulation	U-Factor
2x4	R15	High density batt	R4	0.065
2x6	R21	Loose-fill cellulose or high density batt	R4	0.051

2x6	R19	Low density batt	R5	0.051
2x4	R15	High density batt	R8	0.050
2x6	R31	Closed cell spray foam (ccSPF)	R2	0.050
2x6	R23	High density batt or mineral wool	R4	0.049
	~~R31~~	~~Closed cell spray foam (ccSPF)~~	~~R2~~	~~0.050~~

Figure 3-~~X~~30. Wood-Framed Wall Assemblies and U-Factors, Assuming Gypsum Board Interior

Metal-framed assemblies will also require rigid insulation in order to meet the maximum U--factor criteria. U-factors for metal-framed walls are given in Reference Joint Appendix JA4 Table 4.3.4, and can also ~~can~~ be calculated in compliance software.

Demising partitions and knee walls are not required to meet the prescriptive Package A requirements ~~of §150.1(c)1B~~. Demising partitions and knee walls ~~are required~~ shall ~~to~~ meet the mandatory minimum wall insulation requirements ~~as set in~~ from §150.0(c)1 and ~~2.~~ §150.0(c)1 requires ~~that~~ a minimum of R-13 cavity insulation ~~not less than R-13 be installed between~~ in ~~a~~ 2x4 wood framing, or a U-factor ~~which shall not exceed~~ less than or equal to U-0.102. §150.0(c)2 requires ~~insulation not less than~~ a minimum of R-19 cavity insulation for ~~be installed in framing of~~ 2x6 inch or greater wood framing, or a U-factor less than or equal to ~~or less than~~ 0.074.

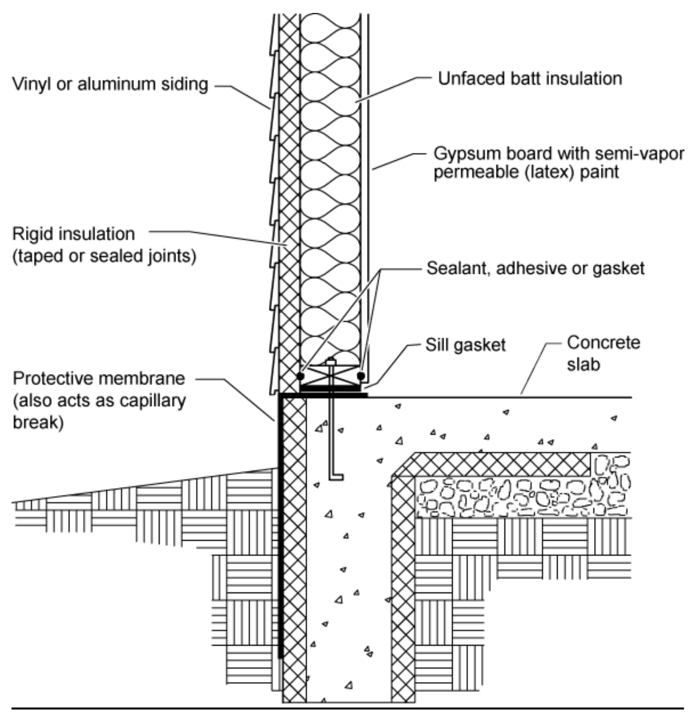


Figure 3-~~23~~31 – Wood-Framed Wall with Stucco Siding ~~Wall ConstructionD~~ Detail

~~Wood-Framed Wall with Vinyl or Aluminum Siding, Mandatory Minimum R-13 Insulation~~
Source: California Energy Commission

2. Mass Walls

§150.1(c) These sections are also shown in Appendix B of this document.

The prescriptive requirements have separate criteria for mass walls with interior insulation and mass walls with exterior insulation. “Interior” denotes that insulation is installed on the interior surface of the mass wall and “exterior” denotes insulation is installed on the exterior surface of the mass wall. Placement of insulation on mass walls does affect the thermal mass properties of a building. The ~~affect~~effect of thermal mass helps temper the fluctuation of heating and cooling loads throughout the year in the building.

~~3.~~**a.** Concrete Mass and Furred Walls

To determine the total R-value of a mass wall, the U-factor from Reference Joint Appendix JA4 Table 4.3.5, 4.3.6 or other masonry tables is added to an insulation layer selected from Reference Joint Appendix JA4 Table 4.3.14. When the prescriptive requirements are used, the insulation must be installed integral with or on the exterior or interior of the mass wall.

Figure 3-~~23~~21 – Masonry~~Brick~~ Wall with Furring Details
Source: California Energy Commission

The walls addressed in the *Properties of Solid Unit Masonry and Solid Concrete Walls* tables in the Reference Joint Appendix JA4 tables are rarely used in residential construction, but are common in some types of nonresidential construction. For residential construction, the Prescriptive CF1R, CF1R-ADD and CF1R-ALT can calculate complex wall systems to include furred ~~strip~~ walls.

A four step process is required to calculate the effective U-factor of a furred wall;

1. Select one of the concrete or masonry walls tables and select a U-factor; and
2. Select the appropriate Effective R-value for Interior or Exterior Insulation Layers in Table 4.3.14; and
3. Fill out the CF1R Insulation Values for Opaque Surface table columns. To achieve the Proposed Assembly U-factor or R-value column, first the *Furring Strips Construction Table for Mass Walls Only* table needs to be filled out; and
   4. Calculate the Final Assembly R-value and carry the value back to the Insulation Values for Opaque Surface Details table. Compare the R-value, it must be equal to or greater than the mass standard R-value from Energy Standards Prescriptive ~~TABLE~~ Table 150.1-A of the Energy Standards.

The U-factor of furred concrete or masonry walls could also be determined by building the construction assembly in Commission approved compliance software.

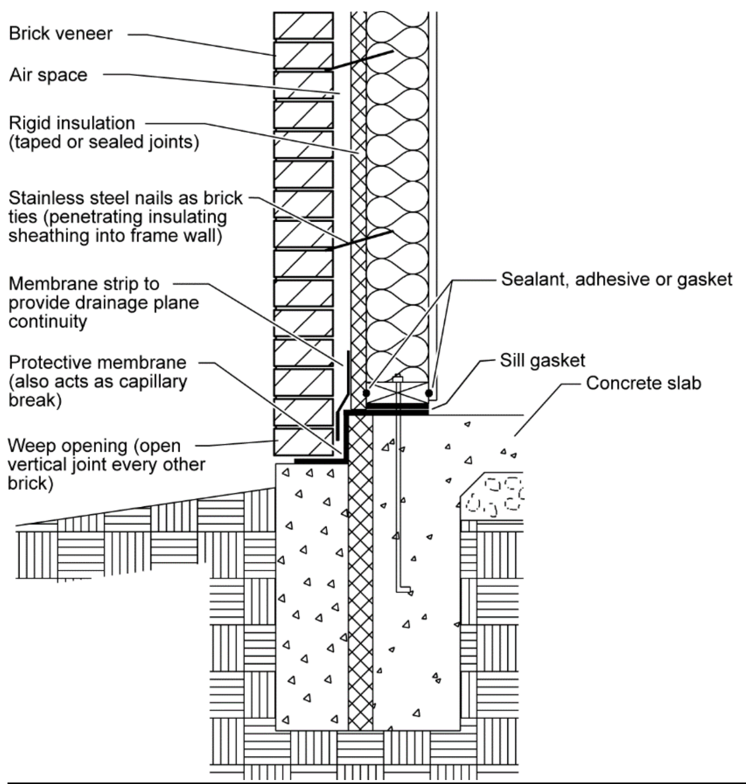


Figure 3-~~22~~ 33– Wood-Framed Wall with Brick Veneer~~Brick Wall Construction Details~~

~~Wood-Framed Wall with Brick Veneer, Mandatory Minimum R-13 Insulation~~
Source: California Energy Commission

Construction Practice/Compliance and Enforcement

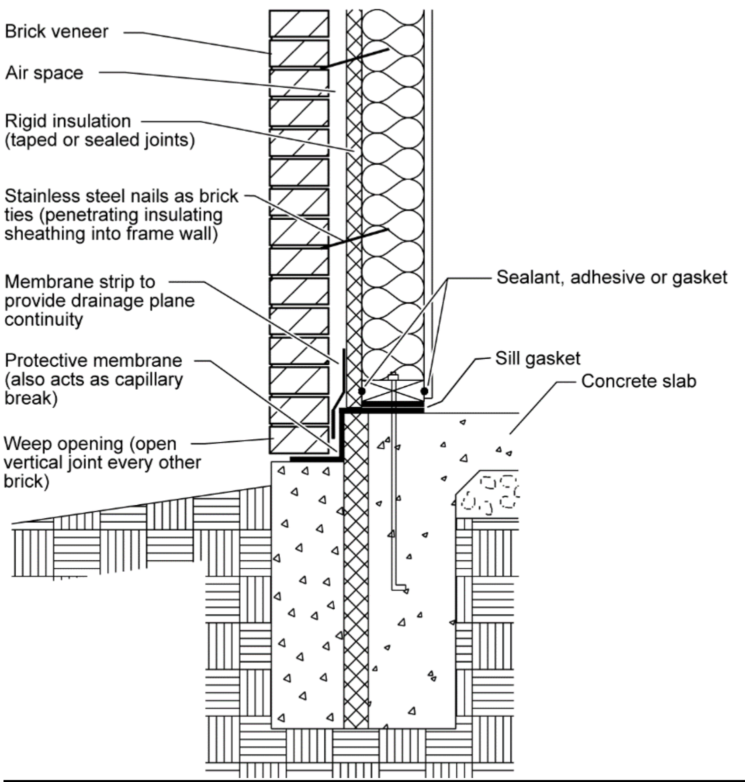
The compliance and enforcement process should ensure that the insulation R-value for walls (cavity and/or continuous) on the CF1R form is specified on the building plans and that the same value for the actual installed wall insulation meets or exceeds the R-value on the CF1R form. For more information on Compliance and Enforcement on *wall insulation*, see Chapter 2 of this manual.

Because it is difficult to inspect wall insulation behind tub/shower enclosures after the enclosures are installed, insulation of these wall sections should be inspected during the framing inspection.

Batt and loose fill insulation should fill the wall cavity evenly. If Kraft or foil-faced insulation is used, it should be installed per manufacturer recommendations to minimize air leakage and avoid sagging of the insulation.

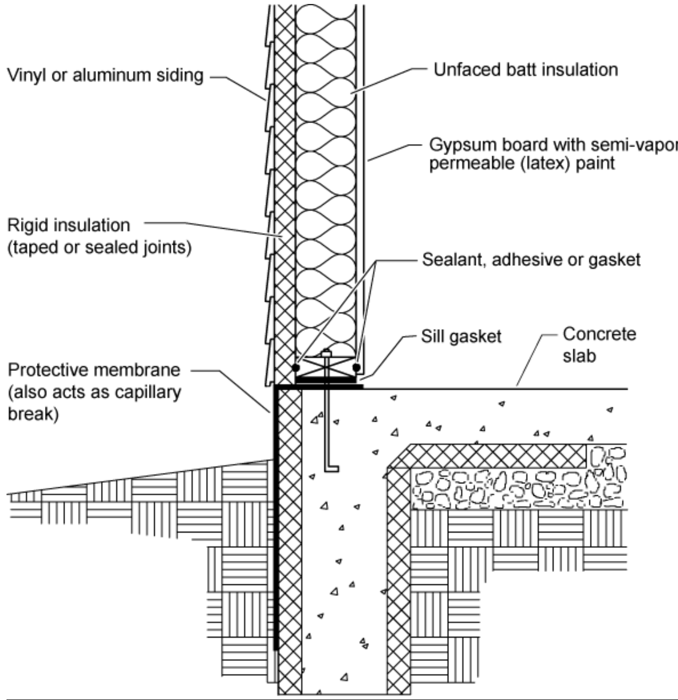
Wall insulation should extend into the perimeter floor joist (rim joist) cavities along the same plane as the wall.

If a vapor retarder is required, it must be installed on the conditioned space side of the framing.



~~*Figure 3-22 – Brick Wall Construction Details*~~

~~*Wood-Framed Wall with Brick Veneer, Mandatory Minimum R-13 Insulation*~~
~~*Source: California Energy Commission*~~



~~Figure 3-23 – Wall Construction Detail~~

~~Wood-Framed Wall with Vinyl or Aluminum Siding, Mandatory Minimum R-13 Insulation~~
~~Source: California Energy Commission~~

Example 3-28~~2~~

Question

Do new residential buildings or additions consisting of block walls (for example, converting a garage into living space) have to comply with the R-13 minimum wall insulation requirement? If not, what insulation R-value do they need?

Answer

2x4 ~~Framed~~ framed walls must meet the R-13 wood framed cavity insulation requirement or the U-factor associated with it. There is no mandatory minimum insulation requirement for mass walls. However, there are minimum insulation requirements in Package A for both framed and mass walls that must be met under Prescriptive compliance.

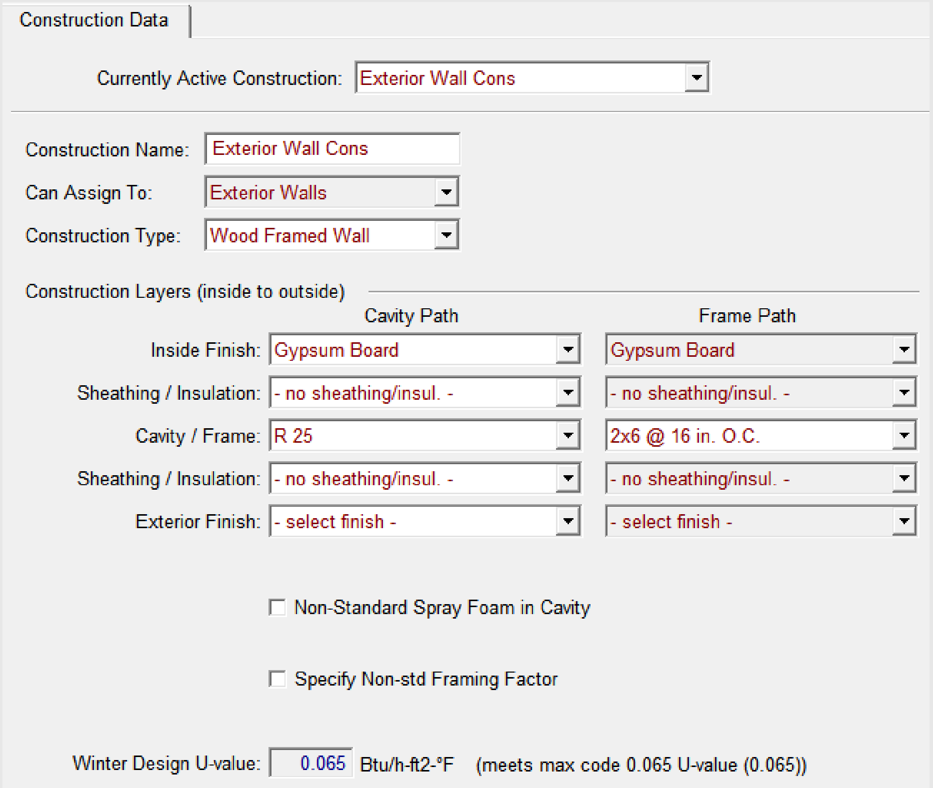
Example 3-29~~3~~

Question

For a new wall, ~~If~~ if 2-inches of medium density closed cell spray polyurethane foam (ccSPF) is used in combination with R-13 batt insulation in the cavity of a 2x6 wood framed wall with 16” on center spacing, without continuous insulation added, what is the total U-factor for the wall assembly? Does this assembly meet prescriptive compliance Package A requirements in climate zones 6 and 7? How about other Climate Zones?

Answer

The assembly does meet Package A requirements in climate zones 6 and 7. Medium density ccSPF is given a default value of R-5.8 per inch, as per JA Table 4.1.7. When 2 inches of ccSPF is added to R-13 batt insulation, the total cavity insulation is rounded to R-25. The assembly U-factor was calculated to be 0.065 using Commission approved compliance software:



~~Figure 3-2x –~~ CBECC-Res Software Wall Assembly Construction showing U-0.065 Assembly

Source: California Energy Commission

~~ADD CAPTION~~

The assembly does meet the minimum mandatory wall insulation U-factor requirement of 0.074, as well as the prescriptive Package A U-factor requirement of 0.065 in climate zones 6 and 7.

However, the assembly does not meet the prescriptive compliance Package A U-factor requirement of 0.051 in climate zones 1-5 and 8-16. To meet the Package A requirement for those climate zones, other wall assemblies may be used, such as those in Figure 3-~~X~~30, and/or Advanced Wall System (AWS) techniques may be used to reduce the framing factor~~, or continuous insulation may be added (see section 3.6.3.2)~~. Alternatively, the project could be shown to comply with Title 24 using the Performance Approach, which allows energy efficiency trade-offs with other building components.

Example 3-30~~24~~

Question

A new single family house will have six-inch of ~~2x6~~ framed walls with R-19 cavity insulation and R-5 continuous rigid insulation on the outside. Can this building comply with Title 24 using either the prescriptive or performance approach?

Answer

If the house has wood framing, the assembly U-factor would be U-0.051 as per JA4 Table 4.3.1. This U-factor prescriptively complies with the Package A U-factor requirements in all climate zones, and the building would not need to use the performance approach. If the house has metal framing, the assembly U-factor would be U-0.084 as per JA4 Table 4.3.4. This U-factor exceeds the maximum U-factor allowed in the prescriptive Package A, and also exceeds the mandatory maximum (U-0.074). Thus, the building would not be able to comply even by using the performance method.

3.6.2.3 Floor/Slab

~~C.~~A. Floor Insulation

1. Raised-floor

§150.1(c)1C

Package A prescriptive requirements call for R-19 or maximum U-factor of 0.037 insulation in raised floors in all climates.

The requirement may be satisfied by installing the specified amount of insulation in a wood-framed floor or by meeting an equivalent U-factor. U-factors for raised-floors are listed in Reference Joint Appendix JA4. Concrete floors separating multifamily habitable space from a parking garage are also considered a raised-floor. For this class of construction, R-4 insulation is required for climate zones 12 and 15, and R-8 is required for climate zones 1, 2, 11, 13, 14, and 16. No insulation is required in other climate zones with a concrete raised floor.

Table 3-~~7~~ 5 – Raised Floor Constructions Used as Basis for Equivalent U-factor Compliance

Insulation R-value	Crawlspace?	Reference Joint Appendix JA4 Construction and Table Cell Entry	Equivalent U-factor
R-19	No	4.4.2 A4	0.049
R-19	Yes	4.4.1 A4	0.037

Construction Practice/Compliance and Enforcement

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 inch or less prior to rolling out the insulation (See Figure 3-34). ~~.~~ Insulation hangers are heavy wires up to 48 inch 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.

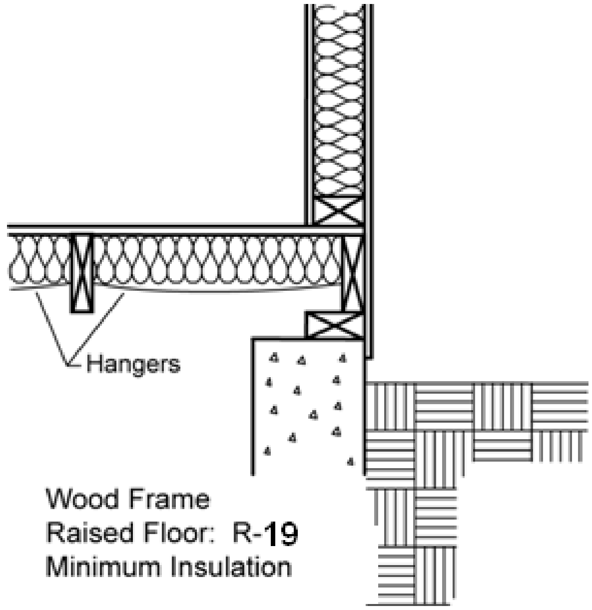


Figure 3-~~24~~ 34 – Raised Floor Insulation
Source: California Energy Commission

~~2.~~B. Slab Insulation

§150.1(c)1D

Prescriptive §Table 150.1-A, Package A, requires slab insulation only in climate zone 16. In this case, a minimum of R-7 must be installed. The insulation must be installed to a minimum depth of 16 in. 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 (see Figure 3-235).

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, covered porch, or covered patio. Neither would it be practical or necessary to insulate concrete steps attached to the outside slab edge.

In situations where the slab is below grade and slab edge insulation is being applied to a basement or retaining wall, the top of the slab edge insulation should be placed as near to ground level as possible and extended down at least 16 inches. In situations where the slab is above grade and slab edge insulation is being applied, the top of the slab edge insulation should be placed at the top of the slab.

Construction Practice/Compliance and Enforcement

Slab-edge insulation should be protected from physical damage and ultraviolet light exposure because deterioration from moisture, pest infestation, ultraviolet light and other factors can significantly reduce the effectiveness of the insulation.

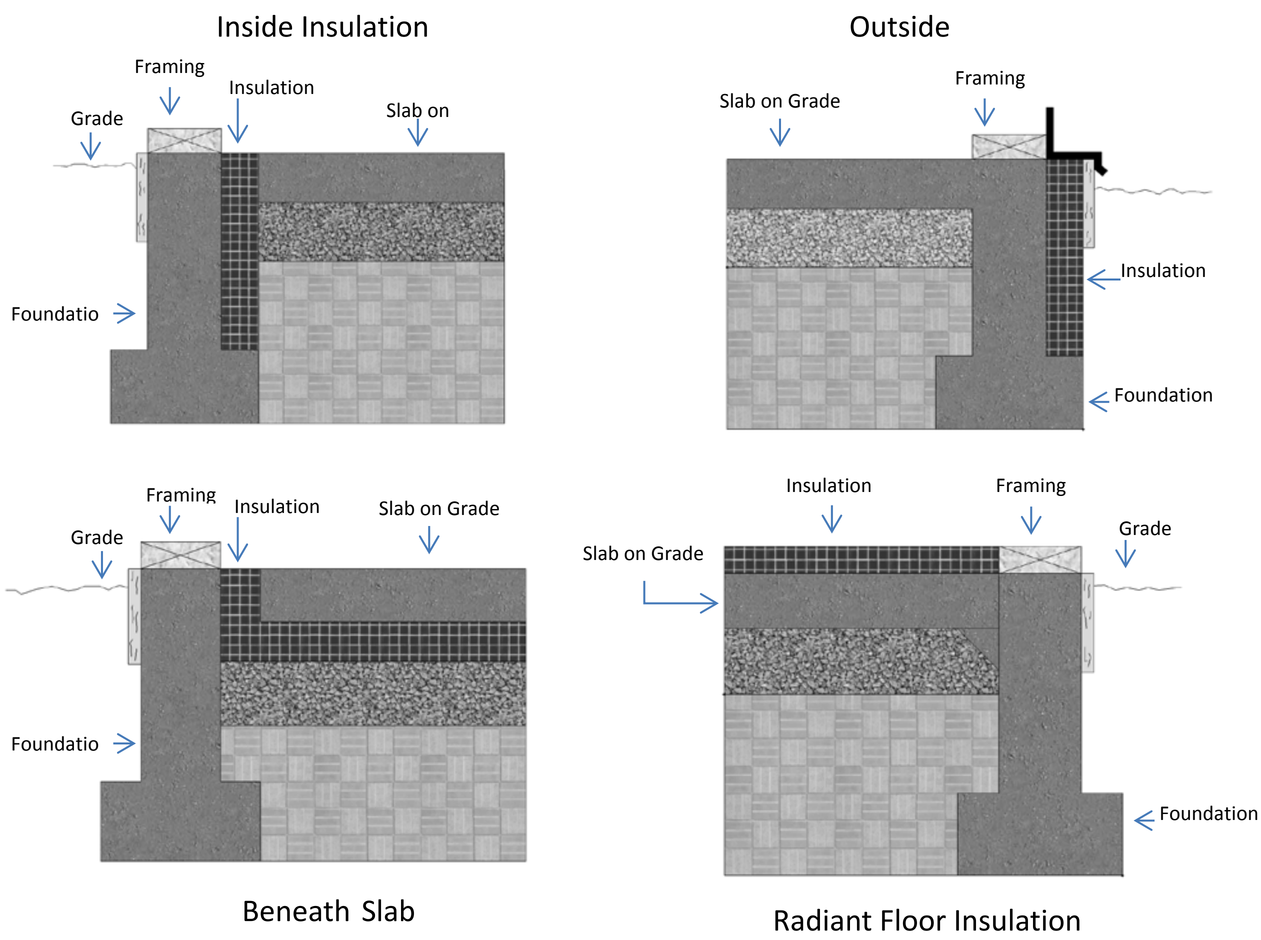


Figure 3-~~25~~ 35 – Allowed Slab Edge Insulation Placement

When slab-edge insulation is required by the prescriptive or performance requirements, then minimum depth is 16 inch or to the top of the footing, whichever is less.
Source: California Energy Commission

Example 3-31~~24~~

Question

What are the slab edge insulation requirements for a hydronic-heating system with the hot water pipes in the slab?

Answer

The requirements for insulation of heated slabs can be found in §110.8(g) of the Standards and are described in Chapter 4 of this manual. The material and installation specifications are as follows:

- Insulation values as shown in Table 110.8-A of the Energy Standards
- Protection from physical damage and ultra-violet light deterioration
- Water absorption rate no greater than 0.3% (ASTM-C272)
- Water vapor permeance no greater than 2.0 perm/inch (ASTM-E96)

3.6.3 *Performance ~~Options~~Approach*

Some residential designs may not wish to use or do not meet the requirements for prescriptive options A, B, and C described above in Section 3.6.2. The performance approach offers increased flexibility as well as compliance credits for certain assemblies, usually requiring HERS verification. The designs described below are examples of residential envelope strategies that can be implemented under the Performance Approach. The proposed design used under the Performance Approach is compared to the standard design, which is determined by the Prescriptive Requirements.

3.6.3.1 **Roof Assembly**

The construction techniques described below are assemblies that can be used in residential construction to help meet or perform better than ~~exceed~~ minimum prescriptive requirements~~, particularly~~ when using the performance compliance approach. This section describes typical constructions for unvented (sealed) attics, attic ventilation, insulated tiles, and raised heel trusses (also called “energy trusses”).

~~Compliance software can model the thermal effects and energy benefits of both above deck and below deck insulation, and the effects of a vented versus unvented attic.~~

~~B.~~A. Unvented (Sealed) Attic Assemblies

Attic ventilation is the traditional way of controlling temperature and moisture in an attic. In an unvented attic (conditioned attic) assembly insulation is applied directly at the roofline of the building, either above or below the structural roof sheathing. The roof system becomes part of the insulated building enclosure. For this case, the thermal boundary of the building results in an unconditioned attic space between the ceiling gypboard and the insulated roof above.

The provisions of CBC, Title 24, Part 2, Vol. 2.5, Section R806.4 describes conditions for insulation placed at the roof of the building as opposed to on top of the horizontal ceiling. Unvented attic assemblies are allowed provided that:

~~A.~~1. **Air-impermeable** insulation is used below and in direct contact with the underside of the roof sheathing, or

~~B.~~2. **Air-permeable** insulation is used below and in direct contact with the underside of the roof sheathing and rigid board or sheet insulation of at least R-4 is used above the roof sheathing, or

~~C.~~3. **Air-impermeable** insulation is used below and in direct contact with the underside of the roof sheathing and an additional layer of air-permeable insulation is installed directly under the air-impermeable insulation.

Check with the local building jurisdiction to determine their specific requirements for unvented attic conditions.

~~A building that employs an unvented attic with above or below roof deck insulation can attain significant energy credits due to the increased thermal benefits of the insulation R-value, plus the reduction of duct conduction and leakage losses (bringing ducts within the conditioned space).~~ Combining this strategy with the additional design improvement of low air leakage for the rest of the building would achieve ~~significant~~ energy savings and compliance energy credit. Additionally, this design eliminates the need to seal or limit penetrations at the ceiling level, such as recessed cans, because the air and thermal boundary is now located at the roof deck.

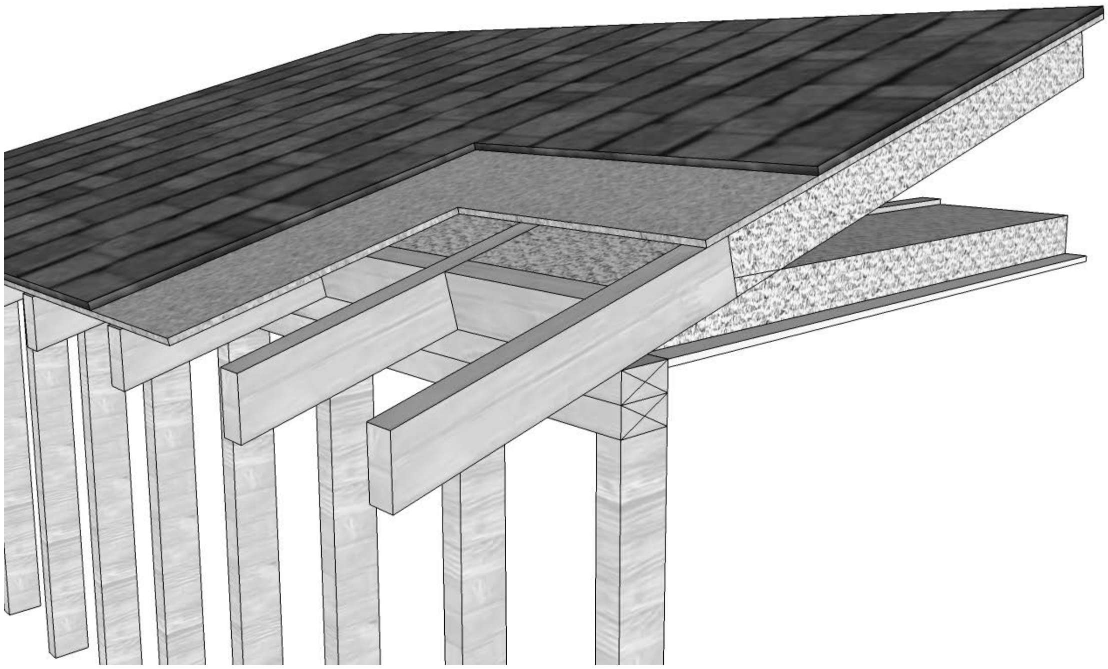


Figure 3-~~33~~ 6– Unvented Attic Assembly
Source: California Energy Commission

~~**C. Attic Ventilation**~~

~~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 3-31). 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 a number of acceptable methods for maintaining ventilation air, including pre-formed baffles made of either cardboard or plastic. In some cases, plywood baffles are used.~~

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

~~3. CBC, Title 24, Part 2, Vol. 1, Section 1203.2 requires that the net free ventilating area shall not be less than 1/300 of the area of the space ventilated.~~

~~4. CBC, Title 24, Part 2, Vol. 2.5, Section R806.2 requires that the net free ventilating area shall 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 either situation, a minimum of 50% of the vents must be located in the upper portion of the space being ventilated at least 3 feet above eave or cornice vents.~~

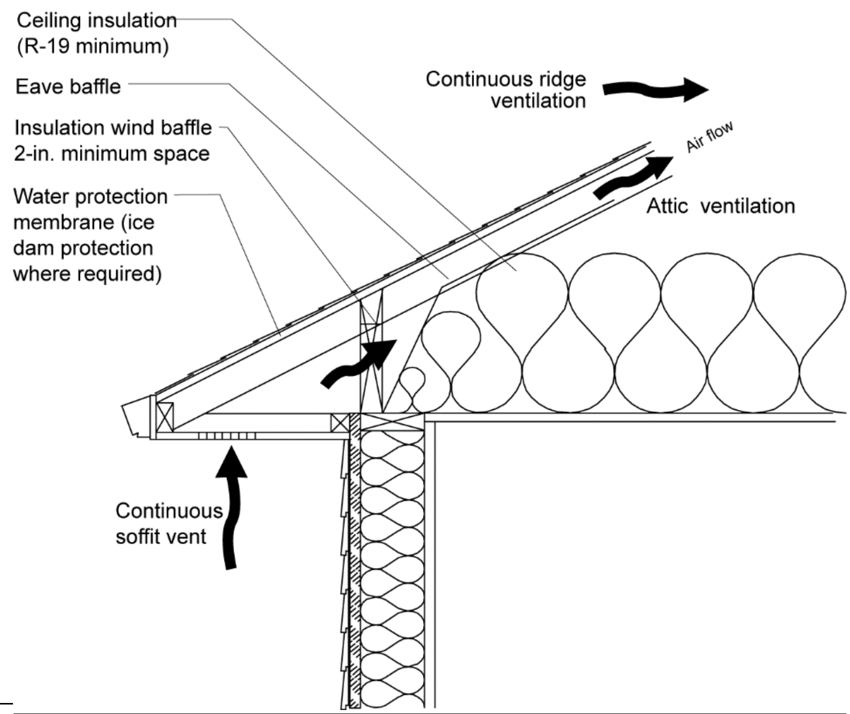
~~Ventilated openings are covered with corrosion resistant wire cloth screening or similar mesh material. When part of the vent area is blocked by meshes or louvers, the resulting "net free area" of the vent must be considered when meeting ventilation requirements.~~

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

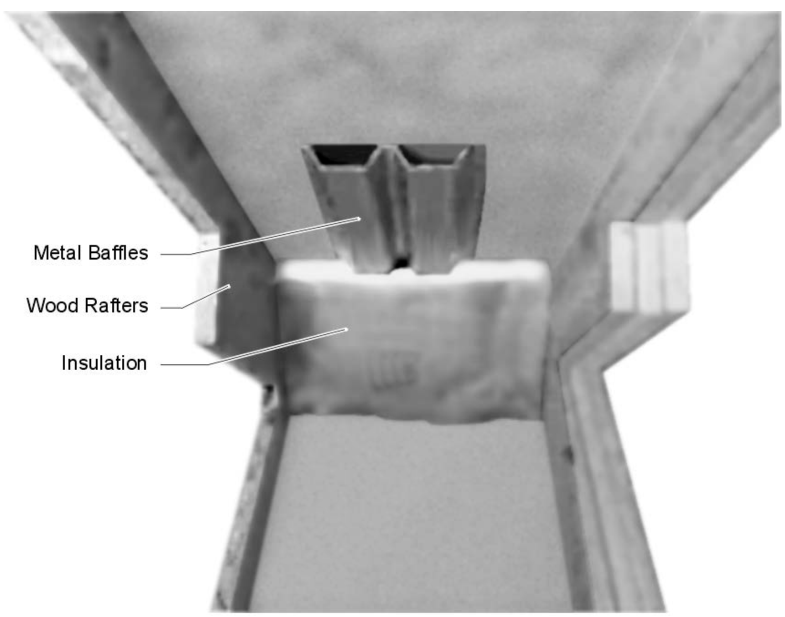
~~*b. Wood Rafter Constructions*~~

~~Ventilating framed rafter spaces is more difficult than ventilating attics because each framing cavity requires its own vent openings. It is common practice with loose-fill insulation material to completely fill the cavity so that there is no ventilation at all. With batt insulation it is possible to ventilate above the insulation using higher density (cathedral ceiling) batts because this material is specifically manufactured to allow a minimum of 1 inch above the top of the insulation to allow for ventilation. If spray polyurethane foam is used, it is applied to the underside of the roof deck leaving no ventilation space.~~

~~Attic ventilation, particularly in hotter climate zones, can provide an energy benefit. However, no energy credit is allowed for reducing the ventilation area below building code requirements.~~



~~*Figure 3-31 – Ceiling Insulation Construction Detail*~~
~~*Source: California Energy Commission*~~



Source: California Energy Commission

~~*Figure 3-32 – Baffles at the Eave in Attics*~~
~~*Source: California Energy Commission*~~

B. Insulated Roof Tiles

Insulating roof tile (IRT) is another option for improving the thermal performance of the roof assembly and lowering attic temperatures. IRT combines concrete/clay tiles with insulation as a packaged product. Most of the increase in R-value is due to the integration of insulation into the roofing product itself; however, additional thermal performance can be gained by combining IRT with rigid foam insulation inserts (Figure 3-37). These tiles are lighter than typical roof tiles and have better thermal performance than traditional tiles due to the insulation core.

Additionally, IRT can reduce radiant losses and maintain warmer roof deck temperatures, thereby reducing the potential for condensation. Using one of the options below provides additional R-value when conventional (ceiling) insulation is also installed. All four configurations (A-D) can be installed without any significant changes to conventional roof or attic design (such as changes to fascia dimensions, etc.), and IRT can be used in both vented and unvented attic configurations.

Figure 3-37 Insulated concrete tile

Source: Green Hybrid Roofing

(A)  (B) 

Figure 3-38 Insulated Roof Tile (IRT) (A) attached directly to roof deck and (B) attached to batten

Source: Green Hybrid Roofing

(C)  (D) 

Figure 3-39 Insulated Roof Tile (IRT) (C) attached directly to roof deck with wedged foam filling air space and (D) attached to battens with wedged foam filling air space

Source: Green Hybrid Roofing

Some IRTs are ASTM rated for Class A fire rating (ASTM E108) and have CRRC certification for cool roof tiles in several colors. Depending on the configuration selected from the four options (A-D) in Figure 3-~~38~~ and Figure 3-~~39~~, a U-factor between 0.18 and 0.10 can be achieved, with option D performing the best. It is best practice to check with individual manufacturers about each tile's ratings and certifications.

Product manufacturers cite several advantages of the product due to its light-weight construction and increased insulation properties – ease of installation, ability to install similar to traditional roof tiles but at a much faster pace, less weight on the roof structure, increased thermal resistance and improved thermal performance.

C. Raised Heel or Extension Truss (Energy Truss)

The use of an energy truss, usually referred to as a raised heel or extension truss, allows full depth, uncompressed insulation at the ceiling to continue to the ceiling edge where the roof and ceiling meet. For this strategy, the roof truss is assembled with an additional vertical wood framed section at the point where the top and bottom truss chords meet. The vertical section raises the top chord and provides increased space that can be filled with insulation. See Figure 3-40~~40Figure 5-13~~ for details of a raised heel truss. Benefits of this strategy include:

- To ~~H~~help~~s~~ realize full benefit of ceiling insulation
- ~~May P~~provide more space for air handler and duct systems if located in the attic
  ~~Truss manufacturers can customize trusses through pre-fabrication.~~

The 2016 CBECC-Res compliance software allows for the modeling of raised heel trusses and provides credit for the additional insulation at the edges.

Other methods to achieve the similar outcome include framing with a rafter on raised top plate (Figure 3-40~~Figure 5-13x~~40) or utilizing spray foam or rigid foam at the edge.

~~**Design Considerations for Raised Heel Truss:**~~

- ~~Requires coordination with roof truss manufacturer.~~
- ~~May change the aesthetics of the home.~~
- ~~May conflict with local ordinances on maximum building height.~~

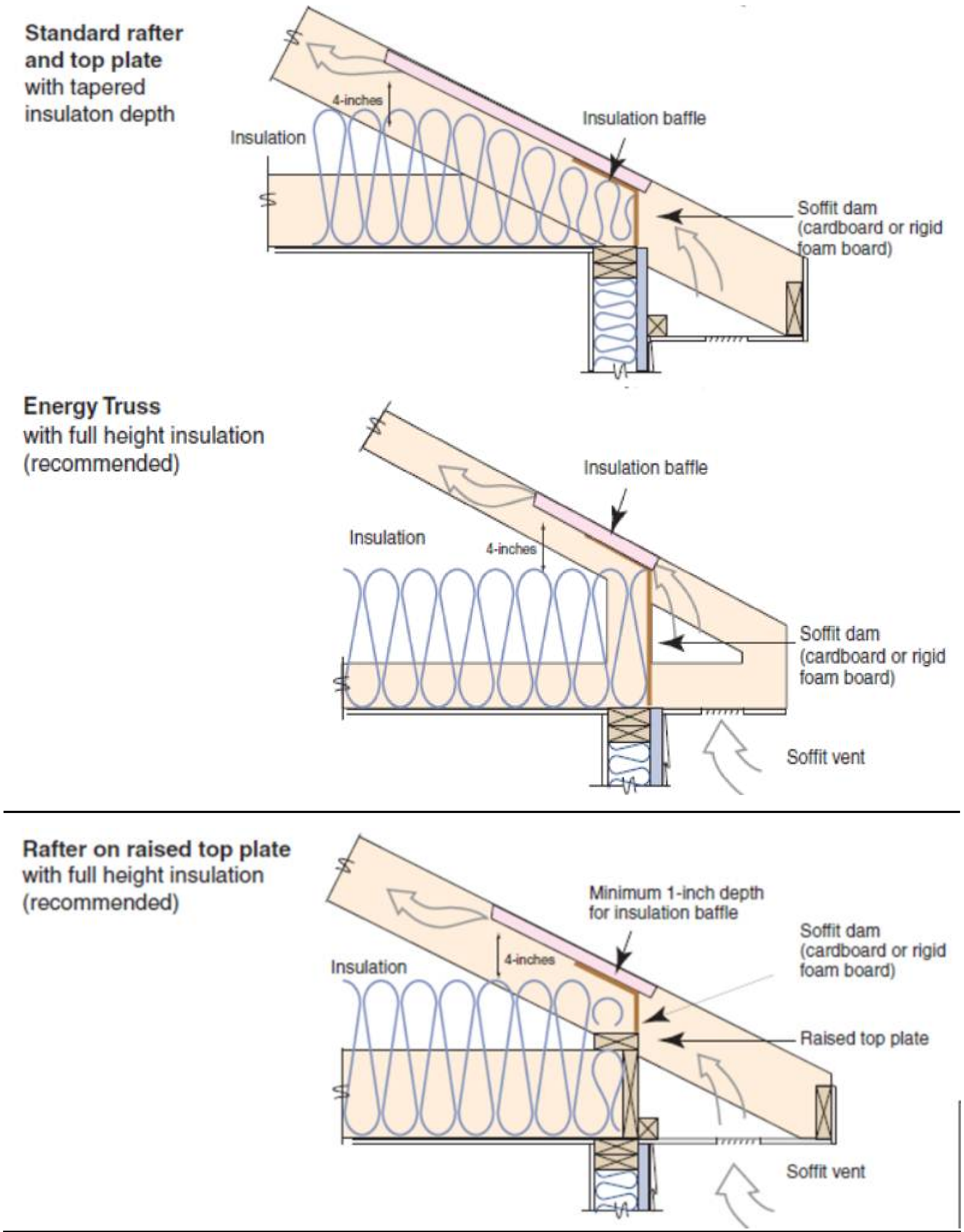


Figure 3-~~121440~~3-~~143~~-~~175~~-~~135~~-~~13.~~ Raised Heel Truss (Energy Truss)

Source: Building America Solutions Center

3.6.3.2 **Wall Assembly**

See Energy Commission videos

~~More insulation is almost always better than less. Insulation is one of the least expensive measures to improve building energy efficiency. Insulation requires no maintenance, helps improve indoor comfort, and provides excellent sound control. Adding extra insulation at a later time is much more expensive than maximizing insulation levels at the beginning of construction.~~

~~*Batt and Blanket Insulation*~~

~~Thermal batts of glass fiber, mineral and natural wool, and cotton material are some of the most widely used insulation in the marketplace. They offer ease of installation with R-values set by the manufacturer based on size and thickness. They are available with facings, some as vapor retarders, and have flanges to aid in installation to framed assemblies. They also are available as unfaced material and can be easily friction-fitted into framed cavities. Typically, batt and blanket thermal insulation material have more sound attenuation performance data available than other insulation type, except blown or sprayed insulation material from some manufacturers.~~

~~Batt and blanket insulation allow easy inspection and installation errors can readily be identified and remedied, including breeches in the air barrier system that allow air leakage. Nevertheless, care should always be taken to install the insulation properly, filling the entire cavity, and butting ends or sides of the batt material to ensure uniformity of the installation. Batt and blanket insulation material must be split to allow for wiring, plumbing, and other penetrations within the framed cavity area.~~

~~*Blown or Sprayed Insulation*~~

~~Blown or sprayed wall insulation can be an effective way to deal with the irregularities of wall cavities, especially the spaces around pipes, electric cables, junction boxes, and other equipment that is embedded in cavities. There are several commonly used types of insulation that have a blown or sprayed installation process, including: cellulose, fiberglass, and spray polyurethane foam (SPF). The R-value of blown or sprayed wall insulation material is determined by the applicator at the site. This differs from manufactured products such as fiberglass or mineral wool batts whose R-value has been tested and arrives at the construction site in preformed lengths with set R-value thicknesses.~~

~~Blown or sprayed wall insulation must be thoroughly checked to insure the R-value is achieved. Line of sight down a wall section can deceivingly hide imperfections in the installation leading to underachieving stated R-values. Depressions and voids within the insulated cavity are areas lacking in their R-value performance. Where netting is used, over-spraying can result in a higher installed density (higher R-value) but can be troublesome for attaching gypboard to wall framing. Where cavities have been under-sprayed, there may be voids or “soft” areas under the netting. These areas are often re-sprayed again, or the area is removed of its insulation material and a thermal batt is installed in its place.~~

~~*Loose Fill Cellulose Insulation*~~

~~Cellulose is basically paper that has been treated for flame- and insect-resistance. Loose fill cellulose is commonly used in attic applications. For walls, the cellulose material is typically mixed with a water- and starch-based binder. The binder causes the insulation to adhere to itself and stick to the surfaces of the wall cavity. Excess insulation that extends past the wall cavity is scraped off with a special tool and recycled into the insulation hopper with fresh material for further installations. R-value is dependent on the installed density of the material at the building site and the building official should ensure the installed density meets manufacturer~~

~~specifications. Cellulose insulation that dislodges from the cavity is often sprayed again, or the area is removed of cellulose and a thermal batt is installed in its place.~~

~~Loose Fill Fiberglass Insulation~~

~~Loose fill fiberglass insulation is made up of small glass fibers. The product is similar to lose fill fiberglass that is commonly used in attics, but for walls it can be installed behind a netting fabric or mixed with a water based adhesive. The adhesive causes the insulation to adhere to itself and stick to surfaces of the wall cavity. Excess insulation that extends past the wall cavity is scraped off and recycled. R-value is dependent on the installed density of the material at the building site and the building official should ensure the installed density meets manufacturer specifications.~~

~~Spray Polyurethane Foam (SPF)~~

~~Spray polyurethane foam insulation is a foamed plastic formed by the combination of chemicals and a blowing agent applied using a spray gun. SPF insulation is spray applied to fully adhere to the joist and other framing faces to form a complete air seal within the construction cavities. R-value is dependent on the installed thickness and the building official should ensure the thickness and uniformity of the SPF material within each cavity space of framed assemblies meets manufacturer specifications. SPF must be separated from the interior of the building, even attic spaces, by an approved thermal barrier consisting of 1/2-inch (12.7 mm) gypsum wallboard or equivalent thermal barrier material (Section 316.4, CBC).~~

~~There are two types of SPF insulation: medium-density closed cell (ccSPF), and light-density open cell (ocSPF) insulation. They have different insulating properties and compliance requirements as described below:~~

- ~~ccSPF has been assigned a default R-value of 5.8 per inch for compliance purposes and a nominal density of greater than 1.5 to less than 2.5 pounds per cubic foot (pcf). The average thickness of the foam insulation must meet or exceed the required R-value. Depressions in the foam insulation's surface shall not be greater than 1/2-inch of the required thickness at any given point of the surface area being insulated. ccSPF is not required to fill the cavity.~~

- ~~ocSPF has been assigned a default R-value of 3.6 per inch for compliance purposes and a nominal density of 0.4 to 1.5 pounds per cubic foot (pcf). ocSPF insulation is sprayed then expands to fill the framed cavity. Excess insulation is removed with a special tool. The average thickness of the foam insulation must meet or exceed the required R-value. Depressions in the foam insulation surface shall not be greater than 1 inch of the required thickness provided these depressions do not exceed 10% of the surface area being insulated. ocSPF must fill the cavity of 2x4 framing.~~

~~Table 3-10: Required Thickness of SPF Insulation to Achieve Default R-values~~

~~Thickness of SPF Insulation~~									
~~Required thickness of ccSPF Insulation (inches)~~	~~2.00~~	~~2.25~~	~~2.75~~	~~3.50~~	~~3.75~~	~~4.00~~	~~4.50~~	~~5.25~~	~~6.75~~
~~Required thickness of ocSPF Insulation (inches)~~	~~3.0~~	~~3.5~~	~~4.2~~	~~5.3~~	~~5.8~~	~~6.1~~	~~6.9~~	~~8.3~~	~~10.6~~

~~Alternatively, the total R-value may be calculated based on the thickness of insulation multiplied by the "tested R-value per inch" as listed in the Table of R-values or R-value Chart from the manufacturer's current ICC Evaluation Service Report (ESR) that shows compliance with~~ *~~Acceptance Criteria for Spray-Applied Foam Plastic Insulation--AC377~~*~~. Overall assembly U-factors are determined by selecting the assembly type, framing configuration, and cavity insulation rating from the appropriate Reference Joint Appendix JA4 table, other approved~~

~~method specified in Section JA4 of the Reference Appendices, or through Commission approved compliance simulation software.~~

~~*Rigid Insulation*~~

~~Rigid foam insulation can be manufactured from a variety of materials, most commonly expanded polystyrene (EPS), extruded polystyrene (XPS), or polyisocyanurate (ISO). It varies in thickness, and some products can provide up to R-6 per inch of thickness. Rigid insulation can be used continuously across the wall to eliminate thermal bridging at wall framing, and also reduce air infiltration and exfiltration. Continuous insulation may be used with a variety of structural systems and cladding materials.~~

~~In most cases, continuous foam insulation must be added to the interior or exterior of framed walls to achieve the Package A wall U-factors. The Department of Energy Building America website contains regularly updated information on proper continuous rigid insulation installation, including recommendations for button cap nails, furring strips, flashing, and design of the drainage plane.~~[5]

~~*Loose Fill Cellulose Insulation*~~

~~Cellulose is basically paper that has been treated for flame- and insect-resistance. Loose fill cellulose is commonly used in attic applications. For walls, the cellulose material is typically mixed with a water- and starch-based binder. The binder causes the insulation to adhere to itself and stick to the surfaces of the wall cavity. Excess insulation that extends past the wall cavity is scraped off with a special tool and recycled into the insulation hopper with fresh material for further installations. R-value is dependent on the installed density of the material at the building site and the building official should ensure the installed density meets manufacturer specifications. Cellulose insulation that dislodges from the cavity is often re-sprayed again, or the area is removed of cellulose and a thermal batt is installed in its place.~~

~~*Loose Fill Fiberglass Insulation*~~

~~Loose fill fiberglass insulation is made up of small glass fibers. The product is similar to lose fill fiberglass that is commonly used in attics, but for walls it can be installed behind a netting fabric or mixed with a water based adhesive. The adhesive causes the insulation to adhere to itself and stick to surfaces of the wall cavity. Excess insulation that extends past the wall cavity is scraped off and recycled. R-value is dependent on the installed density of the material at the building site and the building official should ensure the installed density meets manufacturer specifications.~~

~~*Spray Polyurethane Foam (SPF)*~~

~~Spray polyurethane foam insulation is a foamed plastic formed by the combination of chemicals and a blowing agent applied using a spray gun. SPF insulation is spray applied to fully adhere to the joist and other framing faces to form a complete air seal within the construction cavities. R-value is dependent on the installed thickness and the building official should ensure the thickness and uniformity of the SPF material within each cavity space of framed assemblies meets manufacturer specifications. When installed on the underside of the roof deck and exposed to the attic space below SPF must be separated from the interior of the building by an approved thermal barrier consisting of 1/2-inch (12.7 mm) gypsum wallboard or equivalent thermal barrier material (Section 316.4, CBC).~~

[5] ~~https://basc.pnnl.gov/building-components~~

There are two types of SPF insulation: medium-density closed cell (ccSPF), and light-density open cell (ocSPF) insulation. They have different insulating properties and compliance requirements as described below:

- ccSPF has been assigned a default R-value of 5.8 per inch for compliance purposes and a nominal density of greater than 1.5 to less than 2.5 pounds per cubic foot (pcf). The average thickness of the foam insulation must meet or exceed the required R-value. Depressions in the foam insulation's surface shall not be greater than 1/2-inch of the required thickness at any given point of the surface area being insulated. ccSPF is not required to fill the cavity.

- ocSPF has been assigned a default R-value of 3.6 per inch for compliance purposes and a nominal density of 0.4 to 1.5 pounds per cubic foot (pcf). ocSPF insulation is sprayed then expands to fill the framed cavity. Excess insulation is removed with a special tool. The average thickness of the foam insulation must meet or exceed the required R-value. Depressions in the foam insulation surface shall not be greater than 1 inch of the required thickness provided these depressions do not exceed 10% of the surface area being insulated. ocSPF must fill the cavity of 2x4 framing.

Table 3-10: Required Thickness of SPF Insulation to Achieve Default R-values

Thickness of SPF Insulation									
Required thickness of ccSPF Insulation (inches)	2.00	2.25	2.75	3.50	3.75	4.00	4.50	5.25	6.75
Required thickness of ocSPF Insulation (inches)	3.0	3.5	4.2	5.3	5.8	6.1	6.9	8.3	10.6

Alternatively, the total R-value may be calculated based on the thickness of insulation multiplied by the "tested R-value per inch" as listed in the Table of R-values or R-value Chart from the manufacturer's current ICC Evaluation Service Report (ESR) that shows compliance with *Acceptance Criteria for Spray-Applied Foam Plastic Insulation--AC377*. Overall assembly U-factors are determined by selecting the assembly type, framing configuration, and cavity insulation from the appropriate Reference Joint Appendix JA4 table or other approved method specified in Section JA4 of the Reference Appendices.

Rigid Iinsulation

Rigid foam insulation can be manufactured from a variety of materials, most commonly expanded polystyrene (EPS), extruded polystyrene (XPS), or polyisocyanurate (ISO). It varies in thickness, and some products can provide up to R-6 per inch of thickness. Rigid insulation can be used continuously across the wall or roof system to eliminate thermal bridging at wall framing, and also reduce air infiltration and exfiltration. Continuous insulation may be used with a variety of structural systems and cladding materials.

In most cases, continuous foam insulation must be added to the interior or exterior of framed walls to achieve the Package A wall U-factors. The Department of Energy Building America website contains regularly updated information on proper continuous rigid insulation installation, including recommendations for button cap nails, furring strips, flashing, and design of the drainage plane.[6]

[6] https://basc.pnnl.gov/building-components

~~*Figure 3-21 – Properly Installed Rigid Insulation with Flashing*~~

~~*Source*: 2015 International Residential Code~~

~~The 2015 California Residential Code (CRC) provides guidance on fastener penetration depth, diameter, and spacing for exterior foam sheathing in Section R703.11.2. CRC Tables 703.15.1 and 2, reproduced below in Figure 3-21, shows the fastener spacing for cladding attachment over foam sheathing to wood framing.~~

TABLE R703.15.1
CLADDING MINIMUM FASTENING REQUIREMENTS FOR DIRECT ATTACHMENT OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT[a]

CLADDING FASTENER THROUGH FOAD SHEATHING	CLADDING FASTENER TYPE AND MINIMUM SIZE[b]	CLADDING FASTENER VERTICAL SPACING (inches)	MAXIMUM THICKNESS OF FOAM SHEATHING[c] (inches)					
			16″ o.c. Fastener Horizontal Spacing			24″ o.c. Fastener Horizontal Spacing		
			Cladding Weight:			Cladding Weight:		
			3 psf	11 psf	25 psf	3 psf	11 psf	25 psf
Wood Framing (minimum $1^1/_4$-inch penetration)	0.113″ diameter nail	6	2	1	DR	2	0.75	DR
		8	2	1	DR	2	0.5	DR
		12	2	0.5	DR	2	DR	DR
	0.120″ diameter nail	6	3	1.5	0.5	3	0.75	DR
		8	3	1	DR	3	0.5	DR
		12	3	0.5	DR	2	DR	DR
	0.131″ diameter nail	6	4	2	0.75	4	1	DR
		8	4	1.5	0.5	4	0.75	DR
		12	4	0.75	DR	2	0.5	DR
	0.162″ diameter nail	6	4	4	1.5	4	2	1
		8	4	3	1	4	1.5	0.75
		12	4	2	0.75	4	1	DR

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.
DR = Design required.
o.c. = On center.
a. Wood framing shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.
b. Nail fasteners shall comply with ASTM F 1667, except nail length shall be permitted to exceed ASTM F 1667 standard lengths.
c. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C 578 or ASTM C 1289.

~~*A.* Figure 3-21 – Fastening Requirements Over Foam Sheathing~~

~~Source: 2015 International Residential Code~~

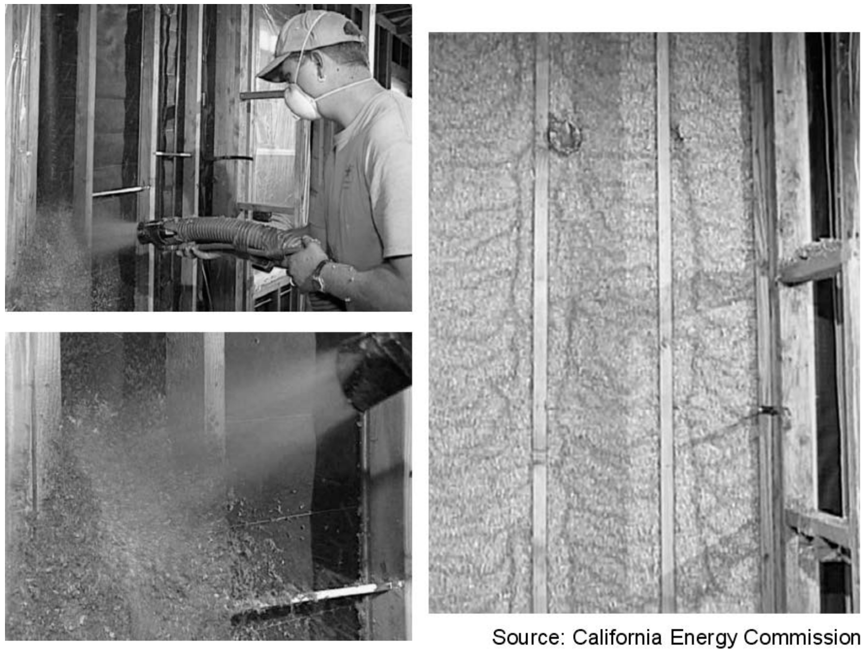
~~*B.*~~

~~*a. Air Barrier*~~

~~1. ccSPF installed as an air barrier shall be a minimum of 2.0 inches in thickness; alternatively, ccSPF insulation shall be installed at a thickness that meets an air~~

~~permeance no greater than 0.02 L/s-m² at 75 Pa pressure differential when tested in accordance to ASTM E2178 or ASTM E283.~~

2. ~~ocSPF installed as an air barrier shall be a minimum of 5.5 inches in thickness; alternatively, ocSPF insulation shall be installed at a thickness that meets an air permeance no greater than 0.02 L/s-m² at 75 Pa pressure differential when tested in accordance to ASTM E2178 or ASTM E283.~~



Source: California Energy Commission

~~Figure 3-34 – Cellulose Insulated Wall~~

~~b. Metal Framing~~

~~A change from wood framing to metal framing can significantly affect compliance. Metal framed assemblies are often chosen where greater structural integrity is necessary, or in climate conditions where greater durability is desired from the affects of excessive moisture exposure. Metal framed wall construction generally requires a continuous layer of rigid insulation to meet the mandatory minimum wall insulation levels and/or the prescriptive requirements since metal is more conductive than wood. In Reference Joint Appendix JA4, Tables 4.2.4 and 4.2.5 have U-factors for metal-framed ceiling/roof constructions. Table 4.3.4 has U-factors for metal-framed walls. Tables 4.4.4 and 4.4.5 have U-factors for metal-framed floors.~~

~~To comply prescriptively, a non-wood framed assembly, such as a metal framed assembly, must have an assembly U-factor that is equal or less than the U-factor of the wood framed assembly for that climate zone. Compliance credit is available through the performance approach for metal framed assemblies that exceed the prescriptive requirements of the equivalent wood framed assemblies.~~

~~c. Log Homes~~

~~Log homes are an alternative construction type used in some parts of the state. Log home companies promote the aesthetic qualities of solid wood construction and can "package" the logs and deliver them directly to a building site. Some companies provide log wall, roof, and floor systems with special insulating "channels" or other techniques to minimize the effect of air infiltration between log members and to increase the thermal benefit of the logs.~~

~~Log walls do not have framing members like conventional wood stud walls. Therefore, the mandatory requirement for a minimum of R-13 wall insulation does not apply.~~

~~Otherwise, in prescriptive compliance log walls must meet the same thermal requirements as other construction types. For performance compliance, consult the compliance software vendor's documentation for any unique modeling requirements for mass walls using values from Reference Appendices. In prescriptive compliance, the walls will qualify as either light mass or heavy mass walls depending on the thickness – remember a heat capacity (HC) of 8.0 Btu/°F-ft² is equivalent to a heavy mass wall (40 lb/ft³). The prescriptive requirements for heavy mass walls are less stringent than the criteria for wood-framed walls. Reduced insulation is allowed because the effects of the thermal mass (interior and exterior) can compensate for less insulation.~~

~~The thermal performance of log walls is shown in Reference Joint Appendix JA4, Table 4.3.11. The U-factor ranges from 0.133 for a 6-inch wall to 0.053 for a 16-inch wall. The U-factor of an 8-inch wall is 0.102, which complies with the R-13 prescriptive requirements. U-factors for other log wall constructions (not shown in Reference Joint Appendix JA4) would have to be approved by the Energy Commission through the exceptional methods process.~~

~~Log walls have a heat capacity that is in excess of conventional construction. Reference Joint Appendix JA4 [Table 4.3.11 Thermal Properties of Log Home Walls] shows that a 6-inch wall has an HC of 4.04 which increases to 10.77 for a 16-inch wall. The thermal mass effects of log home construction can be accounted for within the performance approach.~~

~~Air infiltration between log walls can be considerably different among manufacturers depending upon the construction technique used. For purposes of compliance, infiltration is always assumed to be equivalent to a wood-frame building. However, the builder should consider using a blower door test to find and seal leaks through the exterior walls.~~

~~*d. Straw Bale*~~

~~Straw bale construction is regulated within the CBC and specific guidelines are established for moisture content, bale density, seismic bracing, weather protection, and other structural requirements.~~

~~The Energy Commission has determined specific thermal properties for straw bale walls and thermal mass benefits associated with this type of construction. The performance compliance approach can be used to model the heat capacity characteristics of straw bales.~~

~~Straw bales that are 23 inch by 16 inch are assumed to have a thermal resistance of R-30, whether stacked so the walls are 23 inch wide or 16 inch wide. The minimum density of load bearing walls is 7.0 lb/ft3, and this value or the actual density may be used for modeling straw bale walls in the performance approach. Specific heat is set to 0.32 Btu/lb-°F. Volumetric heat capacity (used in some computer programs) is calculated as density times specific heat. At a density of 7 lb/ft³, for example, the volumetric heat capacity is 2.24 Btu/ft³-°F.~~

~~The minimum dimension of the straw bales when placed in the walls must be 22 inch by 16 inch and there are no restrictions on how the bales are stacked. Due to the higher resistance to heat flow across the grain of the straw, a bale laid on edge with a nominal 16-inch horizontal thickness has the same R-Value (R-30) as a bale laid flat.~~

~~*e. Structural Insulated Panels (SIPS)*~~

~~Structural Insulated Panels (SIPS) are a non-framed advanced construction system that consists of rigid insulation (usually expanded polystyrene) sandwiched between two sheets of OSB or plywood. Little or no structural framing penetrates the insulation layer. Panels are typically manufactured at a factory and shipped to the job site in assemblies that can be as large as 8 ft by 24 ft.~~

~~In the field, the SIPS panels are joined in one of three ways: (1) single or double 2x splines, (2) I-joists, or (3) with OSB splines. The choice of these options affects thermal performance and structural capacity. The 2x and I-joist spline types each fit in a recess of~~

~~the foam core, between the two layers of plywood or OSB. Reference Joint Appendix JA4, Table 4.2.3 contains U-factors for roof/ceiling assemblies, Table 4.3.2 has U-factors for SIPS wall assemblies and Table 4.4.3 has U-factors for SIPS floor constructions. U-factors used for compliance must be taken from these tables, through the EZ-Frame assembly calculator, or by using approved performance compliance software.~~

Source: California Energy Commission

~~Figure 3-35 – Methods of Joining SIPS Panels~~

~~f. Insulating Concrete Forms (ICF)~~

~~Insulating Concrete Forms (ICFs) are a concrete forming system that uses stay-in-place panels made from a variety of insulating materials for constructing cast-in-place solid concrete walls. Three factors contribute to the energy efficiency of buildings using an ICF wall: (1) continuous rigid insulation on both sides of a high-mass core, (2) elimination of thermal bridging from wood framing components, and (3) a high degree of air-tightness inherent to this method of construction.~~

~~Climate zones with large daily temperature fluctuations have the greatest potential to benefit from the time lag and temperature dampening effects of these high-mass envelope systems. However, this combination of mass and insulation is beneficial in almost all climates with the possible exception of mild coastal climate zones.~~

~~There are three basic types of ICFs: flat wall, waffle-grid and screen-grid. A flat wall ICF results in a wall with a consistent and continuous thickness of concrete. A waffle-grid ICF creates a concrete waffle pattern, an uninterrupted-grid, with some concrete sections thicker than others. A screen-grid ICF consists of a discrete post-and-beam structure with the concrete completely encapsulated by the foam insulation, except at the intersection of posts and beams. The insulating panels for all three ICF types are most commonly made from expanded polystyrene (EPS) and extruded polystyrene (XPS) rigid insulation boards. Insulating panels are also made from polyurethane, composites of cement and EPS, and composites of cement and shredded wood fiber, although these tend to be proprietary materials developed by the ICF manufacturer.~~

~~Plastic or metal cross-ties, consisting of two flanges and a web, separate the insulating panels and provide structural integrity during the concrete pour resulting in a uniform wall thickness. A variety of wall thicknesses can be obtained by changing the length of the web. The area of attachment of the cross-ties to the insulating form provides a secure connection surface located at standard spacings for mechanical attachment of finish materials to the interior and exterior of the wall. ICFs can be used to construct load-~~

~~bearing and non-load bearing walls, above- and below-grade walls, and can be designed to structurally perform in any seismic zone.~~
~~The ICF system is modular and stackable with interlocking edges. The materials can be delivered as pre-assembled blocks or as planks that require the flanges and web to be assembled during construction. The forms vary in height from 12" - 24" and are either 4' or 8' long. Vertical panels come in similar modules, but are stacked vertically. ICF panels are typically available with core thickness ranging from 4" to 12".~~
The thermal aspects of ICFs are represented in the Reference Joint Appendix JA4, Table 4.3.13.

~~g.~~A. Advanced Wall System (AWS)

Advanced Wall Systems (AWS), also known as Optimum Value Engineering (OVE), refers to a set of framing techniques and practices that minimize the amount of wood and labor necessary to build a structurally sound, safe and durable, energy efficient building. AWS improves energy and resource efficiency while reducing first costs.

Reducing the amount of wood in wood framed exterior walls improves energy efficiency, allowing more insulation to be installed, and has greater resource efficiency for the materials being used. In addition, fewer framing studs reduces the effects of "thermal bridging" and increases the amount of insulation in the wall, resulting in a more energy efficient building envelope. The framing factor assumed for calculating the energy performance of a wood framed 2x4 wall at 16"oc is 25%. When AWS is used, the framing factor is reduced to 17%, reflecting the improved energy performance of the wall system.

While AWS represents a range of practices, it must be adequately inspected to ensure framing contractors have adhered to all best practice construction throughout the exterior envelope. Examples of construction practices for AWS~~s~~ that ~~should be followed and that~~ can be used as a general guide for enforcement are provided below:

1. Use ~~at~~ of a minimum 2x6 at 24" on-center wall framing
2. Use precise engineering of headers on load-bearing walls
3. Install 2x4, 2x6, or I-joist headers on exterior non-load-bearing walls
4. Eliminate cripple studs at window and door openings less than 4 feet in width
5. Align window/door openings with standard stud spacing
6. The king stud, on at least one side of the window/door opening, must take the place of an on-layout AWS stud
7. Use an insulated corner, either a two-stud corner or a California (3-stud) corners, as in the examples provided in Figure 3-41
8. Nailing for interior gypsum board can be accomplished with drywall clips, 1x nailer strip, recycled plastic nailing strip. Drywall clips reduce the potential for drywall cracking
9. Ladder block where interior partitions intersect exterior walls, instead of 3-stud channels
10. Eliminate unnecessary double floor joists underneath non-bearing walls
11. Use metal let-in T-bracing or other methods on non-shear walls to allow full insulation
12. Include detailed framing plans and elevations on the construction permit plan set
13. Optimize house design for efficient material use (e.g. reducing header spans, designing exterior surfaces in two foot modules, designing clear spans to eliminate interior bearing walls)
14. Build with "insulated headers" (a "sandwich" of two solid or engineered lumber components with a layer of foam insulation in the middle or on one or both sides of the header). An example of a single-ply insulated header is provided in Figure 3-

~~X2~~42. Insulated headers may also earn QII compliance credits by installing R-2 insulation in one of three ways:

a. Two-member header with insulation in between. The header and insulation must fill the wall cavity. There are pre-fabricated 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.
b. 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.
c. 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.

Wood structural panel box headers may also be used as load-bearing headers in exterior wall construction, when built in accordance with 2015 C~~I~~RC Figure R602.7.3 and Table R602.7.3.

15. Use engineered lumber. Examples include: “I”-joists, open web floor trusses; 2x “raised heel” roof trusses, glulam beams, laminated veneer lumber (LVL), laminated strand lumber (LSL), parallel strand lumber (PSL), oriented strand board (OSB)
16. Eliminate trimmers at window and door opening headers less than 4 ft~~eet~~ in width, only when rated hangers are utilized and noted on the plans.
17. Use 2x4 or 2x3 interior non-load-bearing walls
18. Integrate framing design with HVAC system
19. Use “inset” shear wall panels

~~19.~~

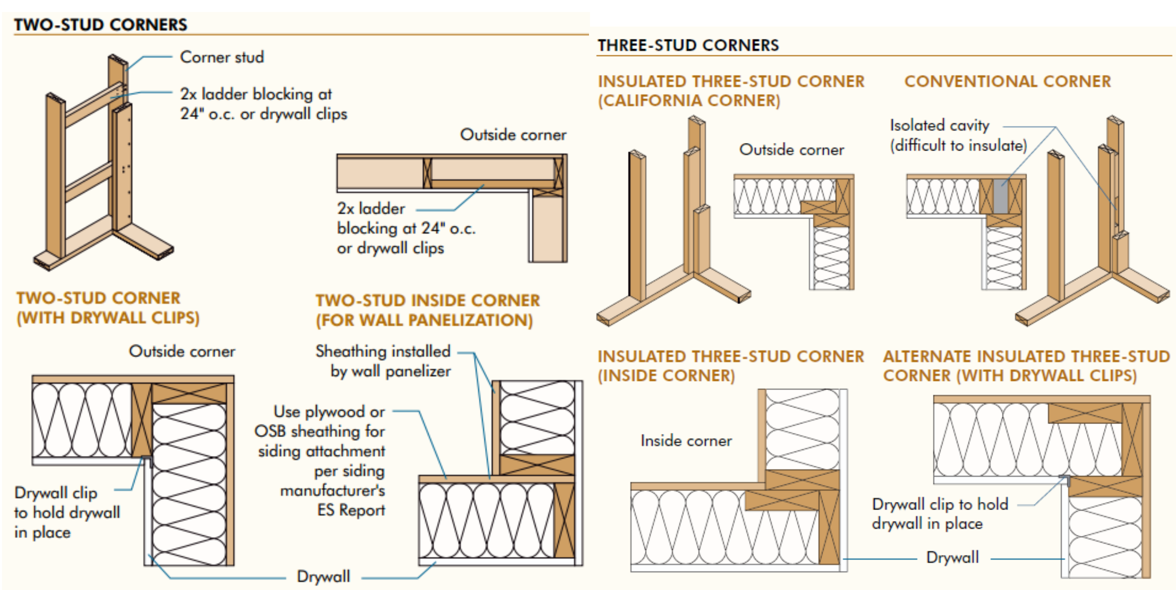


Figure 3-~~X1~~ 41 – Advanced Framing Corners
Source: APA Advanced Framing Guide

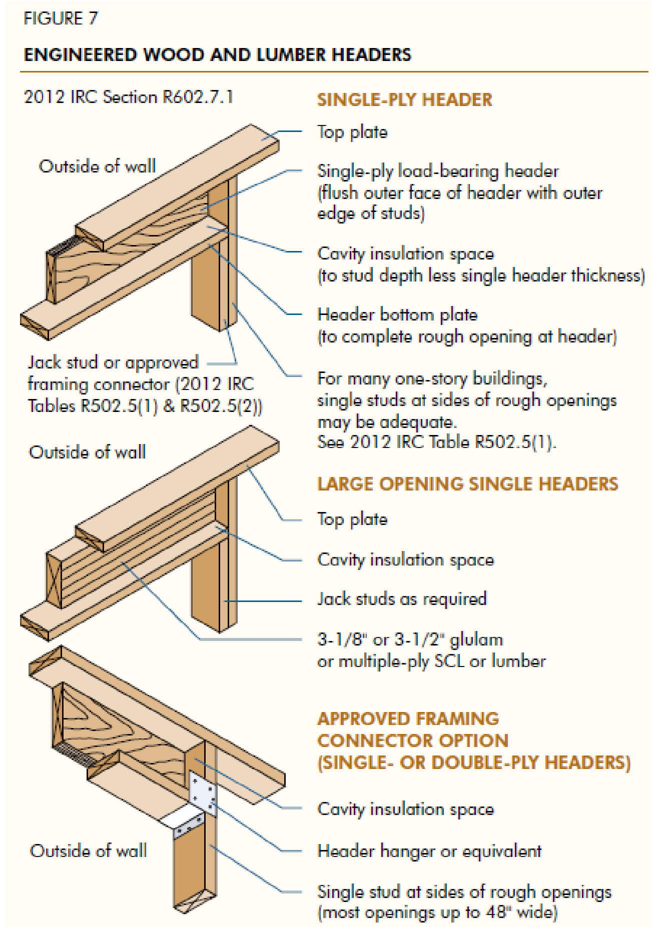


Figure 3-~~X2~~ 42 – Headers Designs with Cavity Insulation Space
Source: APA Advanced Framing Guide

Figure 3-~~36~~ 43 below is a description of one AWS and the assembly characteristics that are used in the prescriptive and performance compliance approaches. This assembly meets a U-factor of 0.051 with an exterior insulation of R-4, due to 24” stud spacing and R-7~~10.7~~ header assemblies. Note that the building official must ensure during planning, check the accuracy of the parallel heat flow calculation~~,~~ and during ~~the~~ framing, inspection that all elements of AWS have been met.

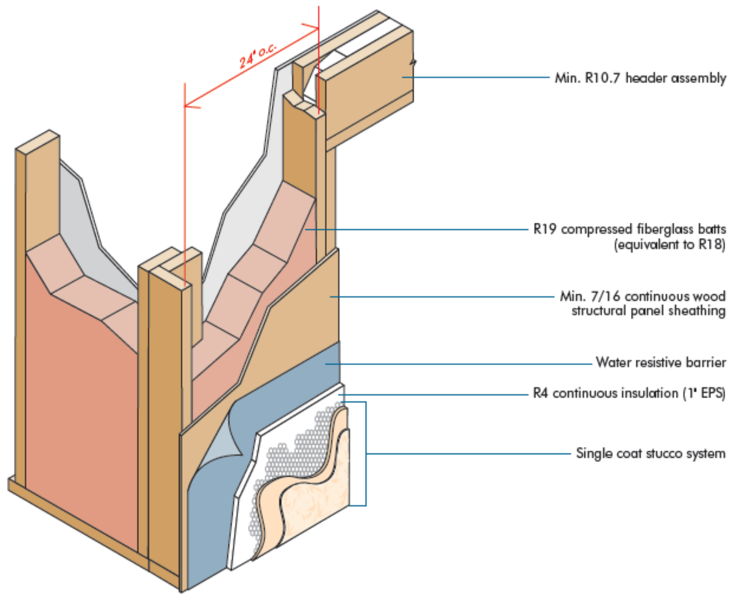


Figure 3-~~36~~ 43 – Wood Framed Wall, 2x6 @ 24" oc, AWF with 3-stud corners
Source: ~~California Energy Commission~~APA, The Engineered Wood Association

Table 3-~~11~~ 6 – Assumptions

Layer	**Assembly Type: Wall 2x6 @ 24" oc AWS**	**R-Value**		
	Framing Material: Wood	~~Framing Factor~~ ~~17~~		
	Assembly Components	**Cavity (R_c)**	**Frame (R_f)**	**Header (R_h)**
0	Frame Factor	78%	18%	4%
1	Outside air film	0.17	0.17	0.17
2	Building paper	0.06	0.06	0.06
3	~~7/8 inch 3-coat~~3/8 inch single coat stucco	0.0~~1~~8	0.0~~1~~8	0.08
4	R4 continuous insulation (1" EPS)	4	4	4
~~3~~5	~~3~~7/~~8~~ 16 inch continuous ~~wood structural panel~~oriented strand board sheathing (OSB)	0.~~47~~44	0.~~47~~44	0.44
~~4~~6	R-18 compressed fiberglass batts	~~21~~188.0	--	--
7	Header assembly – 3.5" wood			3.46
8	Header assembly – 1 inch of R4 foam			4
~~5~~9	2x6 douglass fir framing @ R-1.086/inch	--	5.973	--
~~6~~10	½ inch gypboard	0.45	0.45	0.45
~~7~~11	Inside air film	0.68	0.68	0.68
	Subtotal R-Values	23.~~01~~875	~~7.983~~11.848	13.335
	U-Factors (Frame % x 1/R)	0.0327	0.0152	0.0030
	~~[1/R_c x (1-Frame% / 100)] + [(1/R_f)] x (Frame% / 100)] =~~ Assembly U-factor	**Assembly U-factor**	**0.0510~~17~~**	

Assumptions: Values in Table 3-~~11~~ 6 were calculated using the parallel heat flow calculation method, documented in the 2009 ASHRAE Handbook of Fundamentals and outlined in Joint Appendices JA4.1.2 and JA4.6. The construction assembly in Table 4.6.1 in JA4.6 assumes an exterior air film of R-0.17, a ~~7~~3/8 inch layer of stucco of R-0.~~1~~08 (SC01), building paper of R-0.06 (BP01), sheathing or continuous insulation layer if present, the cavity insulation / framing layer, ½ inch gypsum board of R-0.45 (GP01), and an interior air film 0.68. The framing factor is assumed to be 25% for 16 inch stud spacing, 22% for 24 inch spacing, and 17 percent for Advanced Wall System (AWS).
Actual cavity depth is 3.5 inch for 2x4, 5.5 inch for 2x6. ~~The thickness of the stucco is assumed to be reduced to 3/8 inch (R-0.08) when continuous insulation is applied.~~

B. Double and Staggered Wall Assemblies

Double wall and staggered wall systems were developed to better accommodate electrical and plumbing systems, allow higher levels of insulation, and provide greater sound attenuation. The advantages of these types of wall systems are ~~that~~:

1. Smaller dimensional lumber can be used
2. It is e~~E~~asier to install installation properly
3. It ~~E~~eliminates thermal bridging through the framing
4. It ~~R~~reduces sound transmission through the wall

With double walls, insulation may be on one side of the wall or on both (higher R-values). It is not uncommon to find double walls with insulation installed within the outside wall cavities, leaving the inside wall sections open for wiring and plumbing purposes (See Figure 3-44).

With staggered walls, thermal batt insulation may be installed horizontally or vertically, butting the sides of the insulation until the cavity across the entire wall section is completely filled.

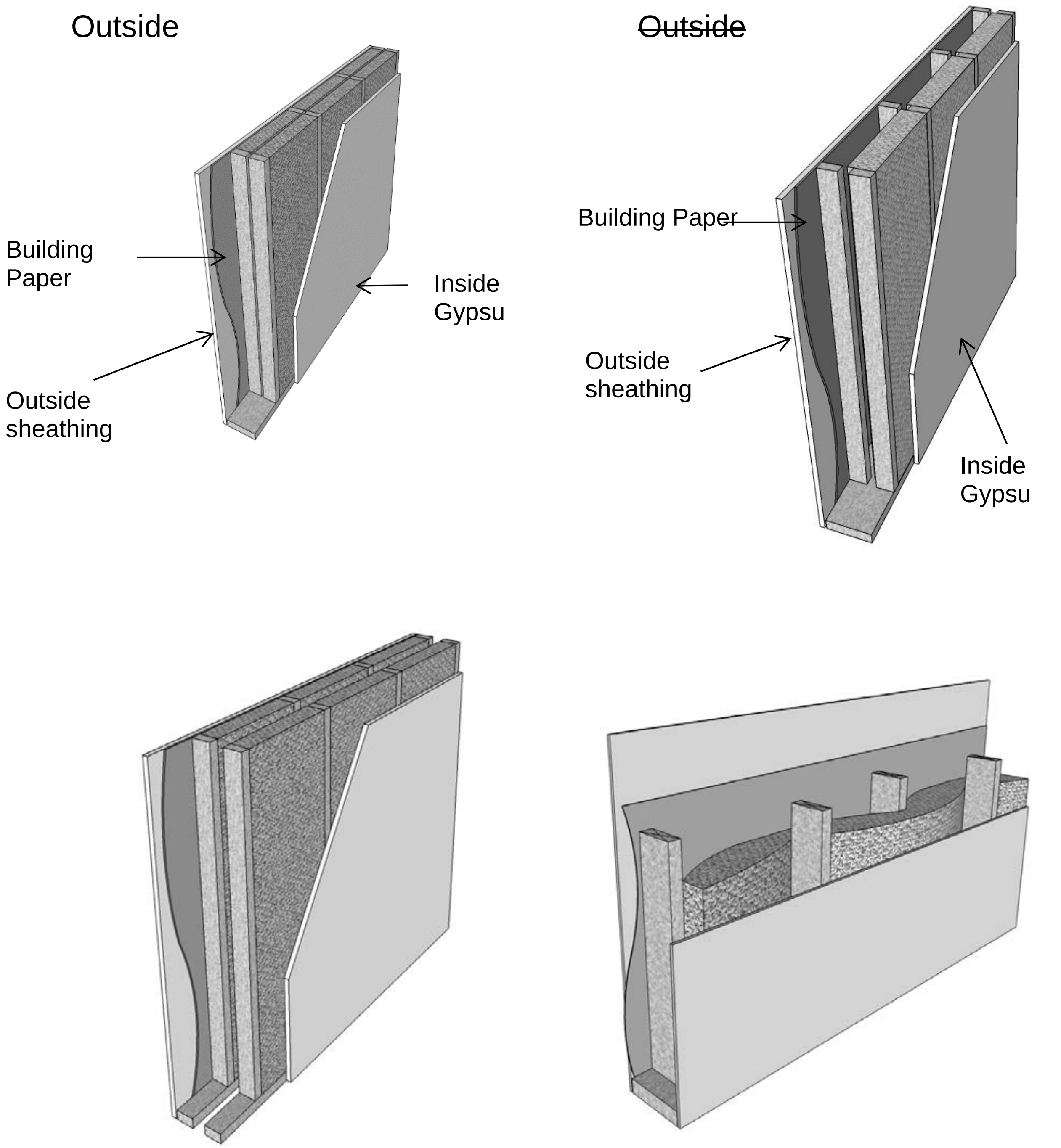


Figure 3-~~37~~44 – Typical Double and Staggered Wall Systems
Source: California Energy Commission

C. **Metal Framing**

A change from wood framing to metal framing can significantly affect compliance. Metal framed assemblies are often chosen where greater structural integrity is necessary, or in climate conditions where greater durability is desired from the ~~affects~~effects of excessive moisture exposure. Metal framed wall construction generally requires a continuous layer of rigid insulation to meet the mandatory minimum wall insulation levels and/or the prescriptive requirements since metal is more conductive than wood. In JA4, Tables 4.2.4

and 4.2.5 have U-factors for metal-framed ceiling/roof constructions. Table 4.3.4 has U-factors for metal-framed walls. Tables 4.4.4 and 4.4.5 have U-factors for metal-framed floors.

To comply prescriptively, a non-wood framed assembly, such as a metal framed assembly, must have an assembly U-factor that is equal to or less than the U-factor of the wood framed assembly for that climate zone. Compliance credit is available through the performance approach for metal framed assemblies that exceed the prescriptive requirements of the equivalent wood framed assemblies.

3.6.3.3 Floor Assembly

A. Controlled Ventilation Crawlspace (CVC)

CVC Eligibility Criteria in 201~~3~~6 ~~Reference Appendices, Residential Appendix~~ RA4.5.1

Buildings that have crawlspace foundations must meet mandatory and prescriptive requirements for insulation of a raised floor separating the unconditioned crawlspace from conditioned space above (§150.0(d) and §150.1(c)1C). An alternative to under floor insulation is insulating the stem wall of the foundation crawlspace. Insulating the crawlspace foundation can improve the thermal efficiency of the floor system by:

1. Reducing heat transfer into the unconditioned crawlspace,
2. Reducing moisture buildup in the crawlspace, and
3. Minimizing insulation exposed to adverse weather prior to enclosure of the building shell

An energy credit can be taken in ~~performance~~ compliance software for Controlled Ventilation Crawlspace (CVC). This credit requires insulating the foundation stem wall, the use of automatically controlled crawlspace vents, and vapor retarder covering the entire ground soil area for moisture control on the crawlspace floor ~~(see Section 3.3. V, Vapor Retarder)~~.

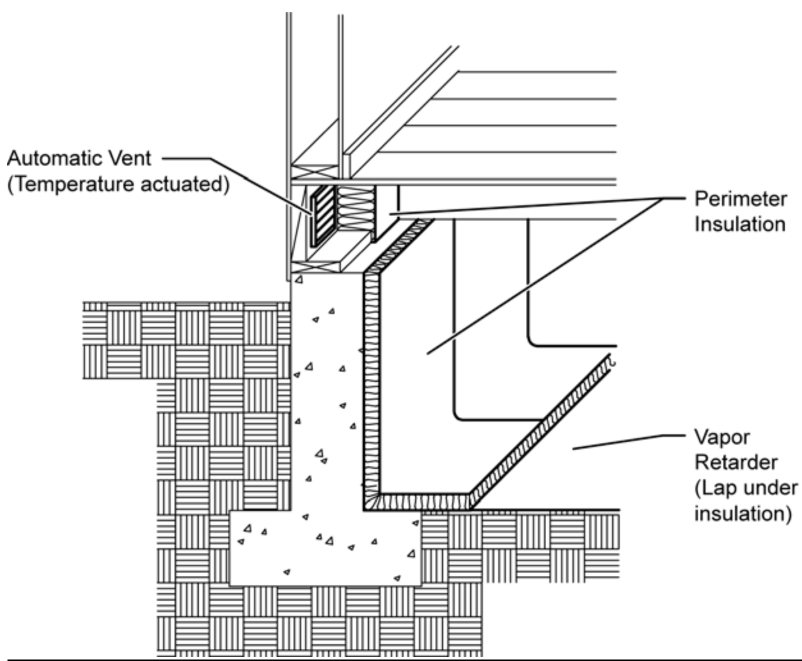


Figure 3-~~38~~45 ~~3-1315~~3~~-13~~3~~-18~~5~~-14~~5~~-14~~3~~-126–~~ Controlled Ventilation Crawl Space
Source: California Energy Commission

All building designs should ensure that proper site engineering and drainage away from the building is maintained, this includes landscaping techniques that emphasize sound water management strategies:

1. **Drainage:** Crawlspace buildings in particular are susceptible to moisture ponding when good drainage and/or moisture removal designs are not employed.
2. **Ground water and soils:** Local ground water tables at maximum winter recharge elevation should be below the lowest excavated elevation of the site foundation. Sites that are well drained and that do not have surface water problems are generally good candidates for this stem wall insulation strategy. However, allowance for this alternative insulating technique is entirely at the ~~building officials'~~enforcement agency's discretion. The building permit applicant should be prepared to provide supporting information that site drainage strategies (e.g., perimeter drainage techniques) will prevent potential moisture concerns.

The following eligibility criteria in~~(see Reference Appendices, Residential Appendix~~ RA4.5.1~~)~~ are required in order to use the CVC energy credit:

1. **Ventilation:** All crawlspace vents must have automatic vent dampers. Automatic vent dampers must be shown on the building plans and installed. Dampers shall be temperature actuated to be fully closed at approximately 40°F and fully open at approximately 70°F. Cross-ventilation consisting of the required vent area shall be distributed between opposing foundation walls.
2. **Insulation:** The R-value of insulation placed on the foundation stem wall shall be equal to or greater than the wall insulation above the raised floor. Stem wall insulation shall run vertically along the stem wall and horizontally across the crawlspace floor for a distance of 2 ft~~eet~~ (24 inches).
3. **Direct Earth Contact**~~—~~: Foam plastic insulation used for crawlspace insulation having direct earth contact shall be a closed cell water resistant material and meet the slab edge insulation requirements for water absorption and water vapor transmission rate specified in the mandatory requirements (§110.8(g)1).

A Class I or Class II vapor retarder rated as 1.0 perm or less must be placed over the earth floor of the crawl space to reduce moisture entry and protect insulation from condensation in accordance with ~~Reference Residential Appendix~~ RA4.5.1~~2~~. This requires essentially a polyethylene type ground cover having a minimum 6 mil thickness (0.006 inch) or approved equal. The vapor retarder must be overlapped a minimum of 6 inches at joints and shall extend over the top of footings and piers. All overlapping of joints shall be sealed with tape, caulk or mastic.

- Penetrations, tears and holes in the vapor barrier shall be sealed with tape, caulk or mastic.
- Edges of the vapor retarder shall be turned up a minimum of 4 inches at the stem wall and securely fastened before insulation is installed.
- In sloping crawlspace ground soil areas, the vapor retarder shall be securely held in place, such as spiked with 5 inch gutter nails then have proper sealing of penetration holes.
- The vapor retarder shall be shown on the plans.

~~3.11~~3.6.3.4 Advanced Assembly Systems

The Energy Commission encourages the use of energy saving techniques and designs for showing compliance with the S~~s~~tandards. Many standard products with traditional construction practices can be used in ways that improve building efficiency beyond requirements set by the S~~s~~tandards. In addition, innovative construction techniques and building products are being used more often by designers and builders who recognize the value of energy efficient high performance buildings. When the performance compliance method is used, an energy credit can be taken for design strategies that reduce building energy use below the standard design energy budget (compliance credit). Some strategies may require third-party verification by a HERS rater, others do not.

~~3.12~~A. Insulation Installation in Framed Assemblies

~~All insulation shall be installed properly throughout the entire building and when this credit is taken on compliance documentation a third-party HERS rater is required to verify the integrity of the installed insulation. The installer shall provide evidence with compliance documentation that all insulation specified on compliance documentation is installed to meet specified R-values and assembly U-factors.~~

Insulation is one of the least expensive measures to improve building energy efficiency. Insulation requires no maintenance, helps improve indoor comfort, and provides excellent sound control. Adding extra insulation at a later time is much more expensive than maximizing insulation levels at the beginning of construction. General insulation types are ~~shown in Table 3-9 below. More detailed explanation is provided in the wall insulation discussion of Section 3.3.2, 3.6.1, and in Reference Appendices, Residential Appendix RA3.5.~~discussed below.

Documentation of insulation R-values and assembly U-factors includes product data sheets, manufacturer specifications and installation guidelines, insulation product and assembly testing information, and U-factor calculations following the procedures specified in ~~Reference Appendices, Joint Appendix~~ JA4, through use of the EZ-Frame Assembly Calculator, or from results of approved performance compliance computer software. The third-party HERS rater shall verify that all insulation has been installed properly and is integral with the air barrier being used throughout the building.

~~Insulation Types – Framed Assemblies~~

There are ~~four~~ five basic types of insulation, or insulation "systems", installed in residential buildings and their use varies based on the design and type of construction:

1. **Batt and Blanket**: Batt and blanket insulation is made of mineral fiber and mineral wool -- either processed fiberglass, rock or slag wool; natural wool products—animal wool or cotton based products; or cellulose materials. These products are used to insulate below floors, above ceilings, below roofs, and within walls. They offer ease of installation with R-values set by the manufacturer based on size and thickness. They are available with facings, some as vapor retarders, and have flanges to aid in installation to framed assemblies. They also are available as unfaced material and can be easily friction-fitted into framed cavities.

   Batt and blanket insulation allow easy inspection and installation errors can readily be identified and remedied, including breeches in the air barrier system that allow air leakage. Nevertheless, care should always be taken to install the insulation properly, filling the entire cavity, and butting ends or sides of the batt material to ensure uniformity of the installation. Batt and blanket insulation material must be split to allow for wiring, plumbing, and other penetrations within the framed cavity area.

2. **Blown or Sprayed Insulation:** There are several commonly used types of insulation that have a blown or sprayed installation process, including: cellulose, fiberglass, and spray polyurethane foam (SPF). Blown or sprayed wall insulation can be an effective way to deal with the irregularities of wall cavities, especially the spaces around pipes, electric cables, junction boxes, and other equipment that is embedded in cavities. The R-value of blown or sprayed wall insulation material is determined by the applicator at the site. This differs from manufactured products such as fiberglass or mineral wool batts whose R-value has been tested and arrives at the construction site in preformed lengths with set R-value thicknesses.

Blown or sprayed wall insulation must be thoroughly checked to e~~i~~nsure the R-value is achieved. Line of sight down a wall section can deceivingly hide imperfections in the installation leading to underachieving stated R-values. Depressions and voids within the insulated cavity are areas lacking in their R-value performance. Where netting is used, over-spraying can result in a higher installed density (higher R-value) but can be troublesome for attaching gypsum board to wall framing. Where cavities have been under-sprayed, there may be voids or “soft” areas under the netting. These areas are often re-sprayed again, or the area is removed of its insulation material and a thermal batt is installed in its place.

3. **Loose-fill**: Loose-fill insulation includes loose fibers or fiber pellets that are blown into building cavities or attics using special equipment. Loose-fill insulations typically are produced using mineral fiber, mineral or natural wool (animal or cotton based products), or cellulose. They are installed in walls, floors, attics and below roofs using a dry-pack process or a moist-spray technique, and may include a netting material.

Loose fill cellulose (shown in Figure 3-~~34~~46) is basically paper that has been treated for flame- and insect-resistance. Loose fill cellulose is commonly used in attic applications. For walls, the cellulose material is typically mixed with a water- and starch-based binder. The binder causes the insulation to adhere to itself and stick to the surfaces of the wall cavity. Excess insulation that extends past the wall cavity is scraped off with a special tool and recycled into the insulation hopper with fresh material for further installations. R-value is dependent on the installed density of the material at the building site and the building official should ensure the installed density meets manufacturer specifications. Cellulose insulation that dislodges from the cavity is often sprayed again, or the area is removed of cellulose and a thermal batt is installed in its place.

Loose fill fiberglass insulation is made up of small glass fibers. The product is similar to loose fill fiberglass that is commonly used in attics, but for walls it can be installed behind a netting fabric or mixed with ~~a water~~water based adhesive. The adhesive causes the insulation to adhere to itself and stick to surfaces of the wall cavity. Excess insulation that extends past the wall cavity is scraped off and recycled. R-value is dependent on the installed density of the material at the building site and the building official should ensure the installed density meets manufacturer specifications.

Source: California Energy Commission

Figure 3-~~34~~46 – Cellulose Insulated Wall

4. **Spray Polyurethane Foam (SPF)**: A two-part liquid foamed plastic (such as polyurethane or modified urethane) material formed by the reaction of an isocyanurate and a polyol that uses a blowing agent to develop a cellular structure when spray applied onto a substrate. SPF insulation is a two-component reactive system mixed at a spray gun or a single-component system that cures by exposure to humidity. The liquid is sprayed through a nozzle into wall, roof/ceiling, and floor cavities. SPF insulation can be formulated to have specific physical properties (i.e., density, compressive strength, fire resistance and R-value).

   SPF insulation is spray applied to fully adhere to the joist and other framing faces to form a complete air seal within the construction cavities. SPF must be separated from the interior of the building, even attic spaces, by an approved thermal barrier consisting of 1/2-inch (12.7 mm) gypsum wallboard or equivalent thermal barrier material (Section 316.4, CBC). There are two types of SPF insulation:

   a. *Low Density Open-Cell SPF (ocSPF) Insulation*: A spray applied polyurethane foam insulation having an open cellular structure resulting in an installed nominal density of 0.4 to 1.5 pounds per cubic foot (pcf). ocSPF has been assigned a default R-value of 3.6 per inch for compliance purposes. ocSPF insulation is sprayed then expands to fill the framed cavity. Excess insulation is removed with a special tool. The average thickness of the foam insulation must meet or exceed the required R-value. Depressions in the foam insulation surface shall not be greater than 1 inch of the required thickness provided these depressions do not exceed 10% of the surface area being insulated. ocSPF must fill the cavity of 2x4 framing.

   b. *Medium Density Closed-Cell SPF (ccSPF) Insulation*: A spray applied polyurethane foam insulation having a closed cellular structure resulting in an installed nominal density of greater than 1.5 to less than 2.5 pounds per cubic foot (pcf). ccSPF has been assigned a default R-value of 5.8 per inch for compliance purposes. The average thickness of the foam insulation must meet or exceed the required R-value. Depressions in the foam insulation's surface shall not be greater than 1/2-inch of the required thickness at any given point of the surface area being insulated. ccSPF is not required to fill the cavity.

SPF R-value is dependent on the installed thickness and the building official should ensure the thickness and uniformity of the SPF material within each cavity space of framed assemblies meets manufacturer specifications. Default R-values assigned to SPF are shown in Table 3-~~10~~7.

Table 3-~~10~~7: Required Thickness of SPF Insulation to Achieve Default R-values

Thickness of SPF Insulation									
Required thickness of ccSPF Insulation (inches)	2.00	2.25	2.75	3.50	3.75	4.00	4.50	5.25	6.75
Required thickness of ocSPF Insulation (inches)	3.0	3.5	4.2	5.3	5.8	6.1	6.9	8.3	10.6

Alternatively, the total R-value may be calculated based on the thickness of insulation multiplied by the "tested R-value per inch" as listed in the Table of R-values or R-value Chart from the manufacturer's current ICC Evaluation Service Report (ESR) that shows compliance with *Acceptance Criteria for Spray-Applied Foam Plastic Insulation--AC377*. Overall assembly U-factors are determined by selecting the assembly type, framing configuration, and cavity insulation rating from the appropriate ~~Reference Joint Appendix~~ JA4 table, other approved method specified in ~~Section~~ JA4 ~~of the Reference Appendices,~~ or using the ~~through~~ Energy Commission approved compliance simulation software.

~~3~~5. **Rigid Insulation**: Rigid board insulation sheathing is made from fiberglass, expanded polystyrene (EPS), extruded polystyrene (XPS), polyisocyanurate (ISO), or polyurethane. ~~Rigid foam insulation can be manufactured from a variety of materials, most commonly expanded polystyrene (EPS), extruded polystyrene (XPS), or polyisocyanurate (ISO).~~ It varies in thickness, and some products can provide up to R-6 per inch of thickness.

This type of insulation is used for above roof decks, exterior walls, cathedral ceilings, basement walls, as perimeter insulation at concrete slab edges, and to insulate special framing situations such as window and door headers, and around metal seismic bracing. Rigid board insulation may also be integral to exterior siding materials. ~~Rigid~~ Rigid insulation can be used continuously across ~~the~~ an envelope ~~wall~~ surface to eliminate thermal bridging at ~~wall~~ framing, and also reduce air infiltration and exfiltration. ~~Continuous insulation may be used with a variety of structural systems and cladding materials.~~

~~In most cases, continuous foam insulation must be added to the interior or exterior of framed walls to achieve the Package A wall U-factors.~~ The Department of Energy Building America website contains regularly updated information on proper continuous rigid insulation installation, including recommendations for button cap nails, furring strips, flashing, and design of the drainage plane. ~~7~~ An image showing proper rigid insulation installation is shown in Figure 3-~~21~~47.

~~[7] https://basc.pnnl.gov/building-components~~

Figure 3-~~21~~47 – Properly Installed Rigid Insulation with Flashing
Source: 2015 International Residential Code

The 2015 California Residential Code (CRC) provides guidance on fastener penetration depth, diameter, and spacing for exterior foam sheathing in Section R703.11.2. CRC Table 703.15.1 , reproduced below in Figure 3-~~22~~48~~1~~, shows the fastener spacing for cladding attachment over foam sheathing to wood framing.

TABLE R703.15.1
CLADDING MINIMUM FASTENING REQUIREMENTS FOR DIRECT ATTACHMENT OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT[a]

CLADDING FASTENER THROUGH FOAD SHEATHING	CLADDING FASTENER TYPE AND MINIMUM SIZE[b]	CLADDING FASTENER VERTICAL SPACING (inches)	MAXIMUM THICKNESS OF FOAM SHEATHING[c] (inches)					
			16″ o.c. Fastener Horizontal Spacing			24″ o.c. Fastener Horizontal Spacing		
			Cladding Weight:			Cladding Weight:		
			3 psf	11 psf	25 psf	3 psf	11 psf	25 psf
Wood Framing (minimum 1 1/4-inch penetration)	0.113″ diameter nail	6	2	1	DR	2	0.75	DR
		8	2	1	DR	2	0.5	DR
		12	2	0.5	DR	2	DR	DR
	0.120″ diameter nail	6	3	1.5	0.5	3	0.75	DR
		8	3	1	DR	3	0.5	DR
		12	3	0.5	DR	2	DR	DR
	0.131″ diameter nail	6	4	2	0.75	4	1	DR
		8	4	1.5	0.5	4	0.75	DR
		12	4	0.75	DR	2	0.5	DR
	0.162″ diameter nail	6	4	4	1.5	4	2	1
		8	4	3	1	4	1.5	0.75
		12	4	2	0.75	4	1	DR

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.
DR = Design required.
o.c. = On center.
a. Wood framing shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.
b. Nail fasteners shall comply with ASTM F 1667, except nail length shall be permitted to exceed ASTM F 1667 standard lengths.
c. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C 578 or ASTM C 1289.

Figure 3-~~22~~48~~1~~ –Fastening Requirements Over Foam Sheathing
Source: 2015 International Residential Code

~~Table 3-9 – Insulation Types~~

	~~There are four basic types of insulation, or insulation "systems", installed in residential buildings and their use varies based on the design and type of construction:~~ ~~1. **Batt and Blanket**: Batt and blanket insulation is made of mineral fiber and mineral wool -- either processed fiberglass, rock or slag wool; natural wool products—animal wool or cotton based products; or cellulose materials. These products are used to insulate below floors, above ceilings, below roofs, and within walls.~~ ~~2. **Loose-fill**: Loose-fill insulation includes loose fibers or fiber pellets that are blown into building cavities or attics using special equipment. Loose-fill insulations typically are produced using mineral fiber, mineral or natural wool (animal or cotton based products), or cellulose. They are installed in walls, floors, attics and below roofs using a dry-pack process or a moist-spray technique, and may include a netting material.~~ ~~3. **Rigid Board**: Rigid board insulation sheathing is made from fiberglass, expanded polystyrene (EPS), extruded polystyrene (XPS), polyisocyanurate, or polyurethane. This type of insulation is used for above roof decks, exterior walls, cathedral ceilings, basement walls, as perimeter insulation at concrete slab edges, and to insulate special framing situations such as window and door headers, and around metal seismic bracing. Rigid board insulation may also be integral to exterior siding materials.~~ ~~4. **Spray Polyurethane Foam (SPF)**: A two-part liquid foamed plastic (such as polyurethane or modified urethane) material formed by the reaction of an isocyanurate and a polyol that uses a blowing agent to develop a cellular structure when spray applied onto a substrate. SPF insulation is a two-component reactive system mixed at a spray gun or a single-component system that cures by exposure to humidity. The liquid is sprayed through a nozzle into wall, roof/ceiling, and floor cavities. SPF insulation can be formulated to have specific physical properties (i.e., density, compressive strength, fire resistance and R-value). There are two types of SPF insulation:~~ ~~a. *Low Density Open-Cell SPF (ocSPF) Insulation*: A spray applied polyurethane foam insulation having an open cellular structure resulting in an installed nominal density of 0.4 to 1.5 pounds per cubic foot (pcf).~~ ~~b. *Medium Density Closed-Cell SPF (ccSPF) Insulation*: A spray applied polyurethane foam insulation having a closed cellular structure resulting in an installed nominal density of greater than 1.5 to less than 2.5 pounds per cubic foot (pcf).~~
~~Insulation Types--non-framed assemblies~~	~~4.~~

~~More insulation is almost always better than less. Insulation is one of the least expensive measures to improve building energy efficiency. Insulation requires no maintenance, helps improve indoor comfort, and provides excellent sound control. Adding extra insulation at a later time is much more expensive than maximizing insulation levels at the beginning of construction.~~

~~*Batt and Blanket Insulation*~~

~~Thermal batts of glass fiber, mineral and natural wool, and cotton material are some of the most widely used insulation in the marketplace. They offer ease of installation with R-values set by the manufacturer based on size and thickness. They are available with facings, some as vapor retarders, and have flanges to aid in installation to framed assemblies. They also are available as unfaced material and can be easily friction-fitted into framed cavities. Typically, batt and blanket thermal insulation material have more sound attenuation performance data available than other insulation type, except blown or sprayed insulation material from some manufacturers.~~

~~Batt and blanket insulation allow easy inspection and installation errors can readily be identified and remedied, including breeches in the air barrier system that allow air leakage. Nevertheless, care should always be taken to install the insulation properly, filling the entire cavity, and butting ends or sides of the batt material to ensure uniformity of the installation. Batt and blanket insulation material must be split to allow for wiring, plumbing, and other penetrations within the framed cavity area.~~

~~Blown or Sprayed Insulation~~

~~Blown or sprayed wall insulation can be an effective way to deal with the irregularities of wall cavities, especially the spaces around pipes, electric cables, junction boxes, and other equipment that is embedded in cavities. There are several commonly used types of insulation that have a blown or sprayed installation process, including: cellulose, fiberglass, and spray polyurethane foam (SPF). The R-value of blown or sprayed wall insulation material is determined by the applicator at the site. This differs from manufactured products such as fiberglass or mineral wool batts whose R-value has been tested and arrives at the construction site in preformed lengths with set R-value thicknesses.~~

~~Blown or sprayed wall insulation must be thoroughly checked to insure the R-value is achieved. Line of sight down a wall section can deceivingly hide imperfections in the installation leading to underachieving stated R-values. Depressions and voids within the insulated cavity are areas lacking in their R-value performance. Where netting is used, over-spraying can result in a higher installed density (higher R-value) but can be troublesome for attaching gypboard to wall framing. Where cavities have been under-sprayed, there may be voids or “soft” areas under the netting. These areas are often re-sprayed again, or the area is removed of its insulation material and a thermal batt is installed in its place.~~

~~Loose Fill Cellulose Insulation~~

~~Cellulose is basically paper that has been treated for flame- and insect-resistance. Loose fill cellulose is commonly used in attic applications. For walls, the cellulose material is typically mixed with a water- and starch-based binder. The binder causes the insulation to adhere to itself and stick to the surfaces of the wall cavity. Excess insulation that extends past the wall cavity is scraped off with a special tool and recycled into the insulation hopper with fresh material for further installations. R-value is dependent on the installed density of the material at the building site and the building official should ensure the installed density meets manufacturer specifications. Cellulose insulation that dislodges from the cavity is often sprayed again, or the area is removed of cellulose and a thermal batt is installed in its place.~~

~~Loose Fill Fiberglass Insulation~~

~~Loose fill fiberglass insulation is made up of small glass fibers. The product is similar to lose fill fiberglass that is commonly used in attics, but for walls it can be installed behind a netting fabric or mixed with a water based adhesive. The adhesive causes the insulation to adhere to itself and stick to surfaces of the wall cavity. Excess insulation that extends past the wall cavity is scraped off and recycled. R-value is dependent on the installed density of the material at the building site and the building official should ensure the installed density meets manufacturer specifications.~~

~~*Spray Polyurethane Foam (SPF)*~~

~~Spray polyurethane foam insulation is a foamed plastic formed by the combination of chemicals and a blowing agent applied using a spray gun. SPF insulation is spray applied to fully adhere to the joist and other framing faces to form a complete air seal within the construction cavities. R-value is dependent on the installed thickness and the building official should ensure the thickness and uniformity of the SPF material within each cavity space of framed assemblies meets manufacturer specifications. SPF must be separated from the interior of the building, even attic spaces, by an approved thermal barrier consisting of 1/2-inch (12.7 mm) gypsum wallboard or equivalent thermal barrier material (Section 316.4, CBC).~~

~~There are two types of SPF insulation: medium-density closed cell (ccSPF), and light-density open cell (ocSPF) insulation. They have different insulating properties and compliance requirements as described below:~~

~~ccSPF has been assigned a default R-value of 5.8 per inch for compliance purposes and a nominal density of greater than 1.5 to less than 2.5 pounds per cubic foot (pcf). The average thickness of the foam insulation must meet or exceed the required R-value. Depressions in the foam insulation's surface shall not be greater than 1/2-inch of the required thickness at any given point of the surface area being insulated. ccSPF is not required to fill the cavity.~~

~~ocSPF has been assigned a default R-value of 3.6 per inch for compliance purposes and a nominal density of 0.4 to 1.5 pounds per cubic foot (pcf). ocSPF insulation is sprayed then expands to fill the framed cavity. Excess insulation is removed with a special tool. The average thickness of the foam insulation must meet or exceed the required R-value. Depressions in the foam insulation surface shall not be greater than 1 inch of the required thickness provided these depressions do not exceed 10% of the surface area being insulated. ocSPF must fill the cavity of 2x4 framing.~~

~~Table 3-10: Required Thickness of SPF Insulation to Achieve Default R-values~~

~~**Thickness of SPF Insulation**~~	~~**R11**~~	~~**R13**~~	~~**R15**~~	~~**R19**~~	~~**R21**~~	~~**R22**~~	~~**R25**~~	~~**R30**~~	~~**R38**~~
~~Required thickness of ccSPF Insulation (inches)~~	~~2.00~~	~~2.25~~	~~2.75~~	~~3.50~~	~~3.75~~	~~4.00~~	~~4.50~~	~~5.25~~	~~6.75~~
~~Required thickness of ocSPF Insulation (inches)~~	~~3.0~~	~~3.5~~	~~4.2~~	~~5.3~~	~~5.8~~	~~6.1~~	~~6.9~~	~~8.3~~	~~10.6~~

~~Alternatively, the total R-value may be calculated based on the thickness of insulation multiplied by the "tested R-value per inch" as listed in the Table of R-values or R-value Chart from the manufacturer's current ICC Evaluation Service Report (ESR) that shows compliance with *Acceptance Criteria for Spray-Applied Foam Plastic Insulation--AC377*. Overall assembly U-factors are determined by selecting the assembly type, framing configuration, and cavity insulation rating from the appropriate Reference Joint Appendix JA4 table, other approved method specified in Section JA4 of the Reference Appendices, or through Commission approved compliance simulation software.~~

~~*Rigid Insulation*~~

~~Rigid foam insulation can be manufactured from a variety of materials, most commonly expanded polystyrene (EPS), extruded polystyrene (XPS), or polyisocyanurate (ISO). It varies in thickness, and some products can provide up to R-6 per inch of thickness. Rigid insulation can be used continuously across the wall to eliminate thermal bridging at wall framing, and also~~

~~reduce air infiltration and exfiltration. Continuous insulation may be used with a variety of structural systems and cladding materials.~~

~~In most cases, continuous foam insulation must be added to the interior or exterior of framed walls to achieve the Package A wall U-factors. The Department of Energy Building America website contains regularly updated information on proper continuous rigid insulation installation, including recommendations for button cap nails, furring strips, flashing, and design of the drainage plane.~~[8]

~~*Figure 3-21 – Properly Installed Rigid Insulation with Flashing*~~
~~*Source*: 2015 International Residential Code~~

~~The 2015 California Residential Code (CRC) provides guidance on fastener penetration depth, diameter, and spacing for exterior foam sheathing in Section R703.11.2. CRC Table 703.15.1 , reproduced below in Figure 3-21, shows the fastener spacing for cladding attachment over foam sheathing to wood framing.~~

[8] ~~https://basc.pnnl.gov/building-components~~

TABLE R703.15.1
CLADDING MINIMUM FASTENING REQUIREMENTS FOR DIRECT ATTACHMENT OVER FOAM PLASTIC SHEATHING TO SUPPORT CLADDING WEIGHT[a]

CLADDING FASTENER THROUGH FOAD SHEATHING	CLADDING FASTENER TYPE AND MINIMUM SIZE[b]	CLADDING FASTENER VERTICAL SPACING (inches)	MAXIMUM THICKNESS OF FOAM SHEATHING[c] (inches)					
			16″ o.c. Fastener Horizontal Spacing			24″ o.c. Fastener Horizontal Spacing		
			Cladding Weight:			Cladding Weight:		
			3 psf	11 psf	25 psf	3 psf	11 psf	25 psf
Wood Framing (minimum $1^{1}/_{4}$-inch penetration)	0.113″ diameter nail	6	2	1	DR	2	0.75	DR
		8	2	1	DR	2	0.5	DR
		12	2	0.5	DR	2	DR	DR
	0.120″ diameter nail	6	3	1.5	0.5	3	0.75	DR
		8	3	1	DR	3	0.5	DR
		12	3	0.5	DR	2	DR	DR
	0.131″ diameter nail	6	4	2	0.75	4	1	DR
		8	4	1.5	0.5	4	0.75	DR
		12	4	0.75	DR	2	0.5	DR
	0.162″ diameter nail	6	4	4	1.5	4	2	1
		8	4	3	1	4	1.5	0.75
		12	4	2	0.75	4	1	DR

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 0.0479 kPa, 1 pound per square inch = 6.895 kPa.
DR = Design required.
o.c. = On center.
a. Wood framing shall be Spruce-pine-fir or any wood species with a specific gravity of 0.42 or greater in accordance with AWC NDS.
b. Nail fasteners shall comply with ASTM F 1667, except nail length shall be permitted to exceed ASTM F 1667 standard lengths.
c. Foam sheathing shall have a minimum compressive strength of 15 psi in accordance with ASTM C 578 or ASTM C 1289.

~~*Figure 3-21 - Fastening Requirements Over Foam Sheathing*~~
~~*Source: 2015 International Residential Code*~~

~~*Air Barrier*~~

- ~~ccSPF installed as an air barrier shall be a minimum of 2.0 inches in thickness; alternatively, ccSPF insulation shall be installed at a thickness that meets an air permeance no greater than 0.02 L/s-m^2 at 75 Pa pressure differential when tested in accordance to ASTM E2178 or ASTM E283.~~
- ~~ocSPF installed as an air barrier shall be a minimum of 5.5 inches in thickness; alternatively, ocSPF insulation shall be installed at a thickness that meets an air permeance no greater than 0.02 L/s-m^2 at 75 Pa pressure differential when tested in accordance to ASTM E2178 or ASTM E283.~~

Source: California Energy Commission

~~*Figure 3-34 – Cellulose Insulated Wall*~~

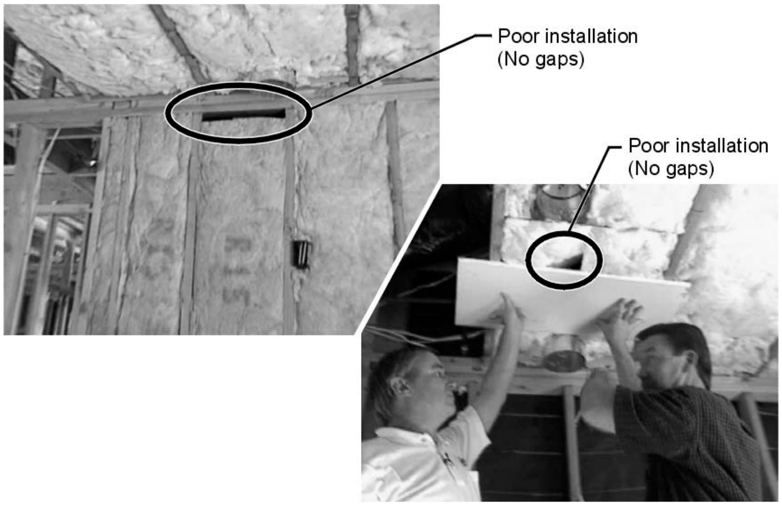
B. Quality Insulation Installation (QII)

Energy Commission videos
~~*Reference Residential Appendix*~~ *RA3.5*

All insulation shall be installed properly throughout the entire building.~~ and w~~ When compliance ~~this~~ credit is taken ~~on~~for QII,~~ compliance documentation~~ a third-party HERS rater is required to verify the integrity of the installed insulation. The installer shall provide evidence with compliance documentation that all insulation specified on compliance documentation is installed to meet specified R-values and assembly U-factors.

Many residential 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 inhibit its ability to limit air leakage.
2. Insulation is not in contact with the air barrier creating air spaces that short-circuits the insulation’s thermal control when the air barrier is not limiting air leakage properly.
3. The insulation has voids or gaps resulting in portions of the construction assembly that are not insulated and, therefore, has 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.



Source: California Energy Commission

Figure 3-~~26~~ 49 – Examples of Poor Quality Insulation Installation

An energy credit for correctly installing an air barrier and insulation to eliminate or reduce common problems associated with poor installation are provided in the ~~Reference Appendices, Residential Appendix~~ RA3.5. This compliance credit applies to framed and non-framed assemblies. Residential construction may incorporate multiple frame types; for example, using a combination of non-framed walls with a framed roof/ceiling. Likewise, multiple insulation materials are often used. Framed assemblies include wood and steel construction insulated with batts of mineral fiber, mineral and natural wool, and cellulose; loose fill insulation of mineral fiber, mineral and natural wool, and cellulose, and light and medium density spray polyurethane foam; and for rigid board insulation used on the exterior or interior of framed and non-framed assemblies. Non-framed assemblies include structural insulated panels, insulated concrete forms, and mass walls of masonry, concrete and concrete sandwich panels, log walls, and straw bale.

This compliance credit can only be taken for the whole building—roof/ceilings, walls and floors, and requires field verification by a third-party HERS rater. Further explanation is provided below:

1. Compliance credit is not allowed for walls alone; or for roofs/ceilings but not walls also.
2. Compliance credit is allowed for a building built on a slab floor, where the slab has no requirement for insulation. However, if insulation is installed (i.e., slab edge insulation for radiant floor heating) then the integrity of the slab edge insulation must also be field verified in addition to the air barrier and insulation system for walls and the roof/ceiling.
3. Combinations of insulation types (hybrid systems) are allowed.
4. An air barrier shall be installed for the entire envelope.
5. Compliance credit is allowed for additions to existing buildings where energy compliance has been demonstrated for the “addition alone” (§150.2(a)2A).
6. Compliance credit is not allowed for additions to existing buildings where the “existing plus alteration plus addition” approach is used (§150.2(a)2B).

~~6.~~7. Compliance credit is not allowed when using the PV Trade-off Package.

Approved computer compliance modeling software automatically reduces the effectiveness of insulation for compliance purposes. This reduction is accounted for in developing the Energy Standards and prescribing the required prescriptive measures for each climate zone to establish the standard design energy budget in performance compliance calculations. The effect of a poorly installed air barrier system and envelope insulation results in higher wall heat loss and heat gain than standard R-value and U-factor calculations would indicate. Similar increases in heat loss and heat gain are experienced for roof/ceilings where construction and installation flaws are present.

B. Structural Bracing, Tie-Downs, Steel Structural Framing

~~Reference Residential Appendix~~ RA3.5.5.2.8

When metal bracing, tie-downs or steel structural framing is used to connect to wood framing for structural or seismic purposes the QII energy credit still can be taken if:

1. Metal bracing, tie-downs or steel structural framing is identified on the structural plans, and
2. Insulation is installed in a manner that restricts the thermal bridging through the structural framing assembly, and
3. Insulation fills the entire cavity and/or adheres to all sides and ends of structural assembly that separates conditioned from unconditioned space.

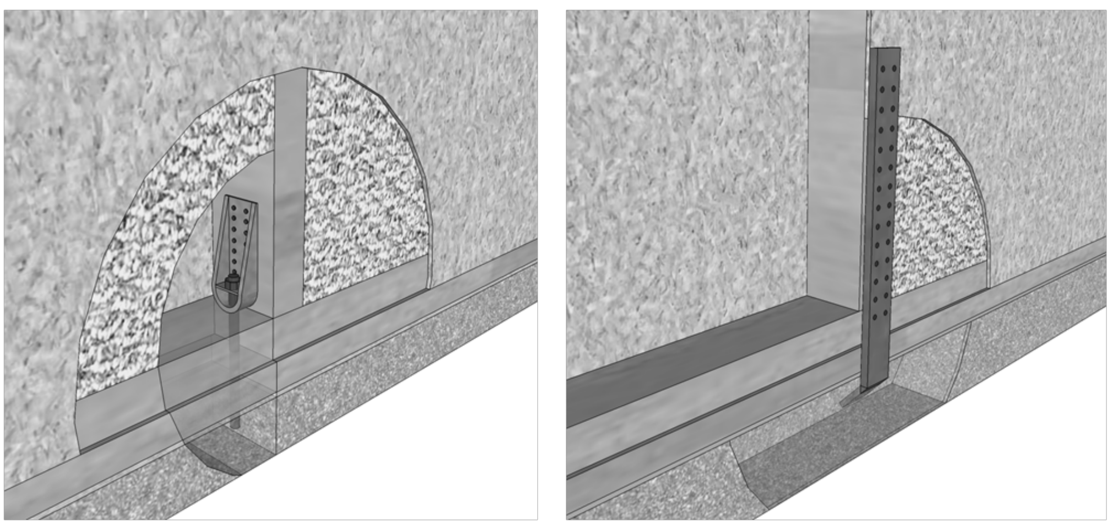


Figure 3-~~27~~ 50 – STRUCTURAL BRACING, TIE-DOWNS
Source: California Energy Commission

To take advantage of the QII energy credit, two primary installation criteria must be adhered to and they both ~~will~~must be field verified by a HERS rater:

C. Air Barrier

~~Reference Residential Appendix~~ RA3.5.2

An air barrier shall be installed enclosing the entire building and when this credit is shown to be taken on compliance documentation a third-party HERS rater is required to verify the integrity of the air barrier system. The air barrier must be installed in a continuous manner across all components of framed and non-framed envelope assemblies. The installer shall provide evidence with compliance documentation that the air barrier system meets one or more of the air barrier specifications shown in Table 3-8 below. 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. The third-party HERS rater shall verify that the air barrier has been installed properly and is integral with the insulation being used throughout the building.

Table 3-8 – Continuous Air Barrier

<table>
<tr>
<td>Continuous Air Barrier</td>
<td>A combination of interconnected materials and assemblies joined and sealed together to provide a continuous barrier to air leakage through the building envelope separating conditioned from unconditioned space, or adjoining conditioned spaces of different occupancies or uses. An air barrier is required in all thermal envelope assemblies to limit air movement between unconditioned/outside spaces and conditioned/inside spaces and must meet one of the following:

1. Using individual materials that have an air permeance not exceeding 0.004cfm/ft^2 under a pressure differential of 0.3in. w.g. (1.57psf) (0.02 L/s.m^2 at 75 pa) when tested in accordance with ASTM E2178; or

2. Using assemblies of materials and components that have an average air leakage not to exceed 0.04 cfm/ft2 under a pressure differential of 0.3 in. w.g (1.57psf) (0.2 L/s.m^2 at 75 pa) when tested in accordance with ASTM E2357, ASTM E1677, ASTM E1680 or ASTM E283; or

3. Testing the completed building and demonstrating that the air leakage rate of the building envelope does not exceed 0.40 cfm/ft^2 at a pressure differential of 0.3 in w.g. (1.57 psf) (2.0 L/s.m^2 at 75 pa) in accordance with ASTM E779 or an equivalent approved method.

Individual materials and assemblies of materials that can demonstrate compliance with the air barrier testing requirements must be installed according to the manufacturer's instructions and a HERS rater shall verify the integrity of the installation. Below are example materials meeting the air permeance testing performance levels of 1 above. Manufacturers of these and other product types must provide a specification or product data sheet showing compliance to the ASTM testing requirements to be considered as an air barrier.

• Plywood – minimum 3/8 inch
• Oriented strand board – minimum. 3/8 inches
• Extruded polystyrene insulation board – minimum. ½ inch
• Foil-back polyisocyanurate insulation board – minimum. ½ inch
• Foil backed urethane foam insulation (1 inch)

-- Closed cell spray polyurethane foam (ccSPF) with a minimum density of 2.0 ~~pcf and~~pcf and a minimum thickness of 2.0 inches. Alternatively, ccSPF insulation shall be installed at a thickness that meets an air permeance no greater than 0.02 L/s-m2 at 75 Pa pressure differential when tested in accordance to ASTM E2178 or ASTM E283.

-- Open cell spray polyurethane (ocSPF) foam with a minimum density of 0.4 to1.5 pcf and a ~~minimum thickness~~minimum thickness of 5½ inches. Alternatively, ocSPF insulation shall be installed at a thickness that meets an air permeance no greater than 0.02 L/s-m2 at 75 Pa pressure differential when tested in accordance to ASTM E2178 or ASTM E283.

• Exterior or interior gypsum board - minimum 1/2 inch
• Cement board - minimum 1/2 inch
• Built up roofing membrane
• Modified bituminous roof membrane
• Particleboard-minimum 1/2 inch
• Fully adhered single-ply roof membrane
• Portland cement/sand parge ,or gypsum plaster minimum 5/8 inch
• Cast-in-place and precast concrete.</td>
</tr>
</table>

	• Fully grouted uninsulated and insulated concrete block masonry • Sheet steel or aluminum

~~C.~~D. Reduced Building Air Leakage

~~Reference Appendices, Residential Appendix~~ RA3.8

An energy credit is allowed through the performance approach when the building's rate of envelope air leakage is less than the air leakage rate assumed for the standard design building. A third-party HERS rater shall verify the air leakage rate shown on compliance documentation through diagnostic testing of the building's air leakage.

The air leakage testing process (i.e., blower door) involves closing all the windows and doors, pressurizing the house with a special fan, usually positioned in a doorway (see Figure 3-~~28~~51), and measuring the leakage rate, measured in cubic feet per minute at a 50 Pa pressure difference (CFM50). This measurement procedure is described in the ~~Reference Appendices, Residential Appendix~~ RA3.8. It is derived from the Residential Energy Services Network's (RESNET) Mortgage Industry National Home Energy Rating Standards, Standard 800, which is based on ASTM E779 air tightness measurement protocols. This procedure requires the use of software consistent with ASTM E779. This test method is intended to produce a measure of the air tightness of a building envelope for determining the energy credit allowance for reduced building air leakage. Further explanations are described below:

~~A.~~1. This procedure shall only be used to verify the building air leakage rate before the building construction permit is finalized when an energy credit for reduced air leakage is being claimed on compliance documentation.

~~B.~~2. The Home Energy Rating System (HERS) rater shall measure the building air leakage rate to ensure measured air leakage is less than or equal to the building air leakage rate stated on the Certificate of Compliance, and all other required compliance documentation. HERS verified building air leakage shall be documented on compliance forms.

3. This is a whole building credit; therefore, no credit is allowed for the installation of individual envelope measures that may help in reducing the building's air leakage rate, such as for an exterior air retarding wrap, or for an air barrier material or assembly meeting the requirements describe in Table 3-~~9~~ 8 above.

Figure 3-~~28~~51 – Blower Door Testing

E. Structural Insulated Panels (SIPS)

RA3.5.7

Structural Insulated Panels (SIPS) are a non-framed advanced construction system that consists of rigid foam insulation ~~(usually expanded polystyrene)~~ sandwiched between two sheets of ~~OSB or plywood~~ board. The board can be sheet metal, plywood, cement or oriented strand board (OSB) and the foam is either expanded polystyrene foam (EPS), extruded polystyrene foam (XPS) or polyurethane foam. SIPs combine several components of conventional building, such as studs and joists, insulation, vapor barrier and air barrier. They can be used for many different applications, such as exterior walls, roofs, floors, and foundation systems. Little or no structural framing penetrates the insulation layer. Panels are typically manufactured at a factory and shipped to the job site in assemblies that can be as large as 8 ft by 24 ft.

In the field, the SIPS panels are joined in one of three ways: (1) single or double 2x splines, (2) I-joists, or (3) with OSB splines. The choice of these options affects thermal performance and structural capacity. The 2x and I-joist spline types each fit in a recess of the foam core, between the two layers of plywood or OSB. ~~Reference Joint Appendix~~JA4, Table 4.2.3 contains U-factors for roof/ceiling assemblies, JA4 Table 4.3.2 has U-factors for SIPS wall assemblies and JA4 Table 4.4.3 has U-factors for SIPS floor constructions. U-factors used for compliance must be taken from these tables, through the EZ-Frame assembly calculator, or by using approved performance compliance software.

Source: California Energy Commission

Figure 3-~~35~~52 – Methods of Joining SIPS Panels

F. Insulating Concrete Forms (ICF)

RA3.5.8

Insulating Concrete Forms (ICFs) is a system of formwork for concrete that stays in place as permanent building insulation is used for cast-in-place, reinforced above and below-grade concrete walls, floors, and roofs. ICFs are interlocking modular units that can be dry-stacked (without mortar) and filled with concrete as a single concrete masonry unit (CMU). ICFs lock together externally and have internal metal or plastic ties to hold the outer layer(s) of insulation to create a concrete form for the structural walls, roof/ceilings, or floors of a building. ICFs are manufactured from several materials including: expanded and extruded polystyrene foam, polyurethane foam, cement-bonded wood fiber, and cement-bonded polystyrene beads.~~are a concrete forming system that uses stay-in-place panels made from a variety of insulating materials for constructing cast-in-place solid concrete walls.~~

Three factors contribute to the energy efficiency of buildings using an ICF wall: (1) continuous rigid insulation on both sides of a high-mass core, (2) elimination of thermal bridging from wood framing components, and (3) a high degree of air-tightness inherent to this method of construction.

Climate zones with large daily temperature fluctuations have the greatest potential to benefit from the time lag and temperature dampening effects of these high-mass envelope systems. However, this combination of mass and insulation is beneficial in almost all climates with the possible exception of mild coastal climate zones.

There are three basic types of ICFs: flat wall, waffle-grid and screen-grid. A flat wall ICF results in a wall with a consistent and continuous thickness of concrete. A waffle-grid ICF creates a concrete waffle pattern, an uninterrupted-grid, with some concrete sections thicker than others. A screen-grid ICF consists of a discrete post-and-beam structure with the concrete completely encapsulated by the foam insulation, except at the intersection of posts and beams. The insulating panels for all three ICF types are most commonly made from expanded polystyrene (EPS) and extruded polystyrene (XPS) rigid insulation boards. Insulating panels are also made from polyurethane, composites of cement and EPS, and composites of cement and shredded wood fiber, although these tend to be proprietary materials developed by the ICF manufacturer.

Plastic or metal cross-ties, consisting of two flanges and a web, separate the insulating panels and provide structural integrity during the pouring of concrete resulting in a uniform wall thickness. A variety of wall thicknesses can be obtained by changing the length of the web. The area of attachment of the cross-ties to the insulating form provides a secure connection surface located at standard spacings for mechanical attachment of finished materials to the interior and exterior of the wall. ICFs can be used to construct load-bearing and non-load bearing walls, above- and below-grade walls, and can be designed to structurally perform in any seismic zone.

The ICF system is modular and stackable with interlocking edges. The materials can be delivered as pre-assembled blocks or as planks that require the flanges and web to be assembled during construction. The forms vary in height from 12” - 24” and are either 4’ or 8’ long. Vertical panels come in similar modules, but are stacked vertically. ICF panels are typically available with core thickness ranging from 4” to 12”.

The thermal aspects of ICFs are represented in the ~~Reference Joint Appendix~~ JA4, Table 4.3.13.

Source: California Energy Commission

Figure 3-28 – Blower Door Testing

~~A.~~G. Thermal Mass

Mass walls typically fall into two categories:

1. Masonry types include clay and concrete units, which may be solid or hollow, and glazed or unglazed. Other masonry unit types include cast stone and calcium silicate units. Concrete masonry units (CMU) are made from a mixture of Portland

cement and aggregates under controlled conditions. Concrete masonry units can be manufactured in different sizes and with a variety of face textures.

2. Concrete and concrete sandwich panels typically use a pre-cast form by casting concrete in a reusable mold or "form" which is then cured in a controlled environment, transported to the construction site and lifted into place. Precast stone is distinguished from precast concrete by using a fine aggregate in the mixture giving the appearance of naturally occurring rock or stone.

Thermal mass consists of exposed tile floors over concrete, mass walls such as stone or brick, and other heavy elements within the building envelope that serve to stabilize indoor temperatures. Thermal mass helps temper interior temperature, storing heat or cooling for use at a later time. In California's central valley and desert climates, the summer temperature range between night and day can be 30°F or more and thermal mass can be an effective strategy to reduce daytime cooling loads.

When thermal mass exists in exterior walls, it works to stabilize temperatures in two ways. First, there is a time delay between when the outside temperature of the wall reaches its peak and when the inside of the wall reaches its peak. For an 8-inch to 12-inch concrete wall, this time delay is on the order of 6 to 10 hours. Second, there is a dampening effect whereby the temperature range on the inside of the house is less than the temperature range on the outside of the house. These effects are illustrated in the following figure.

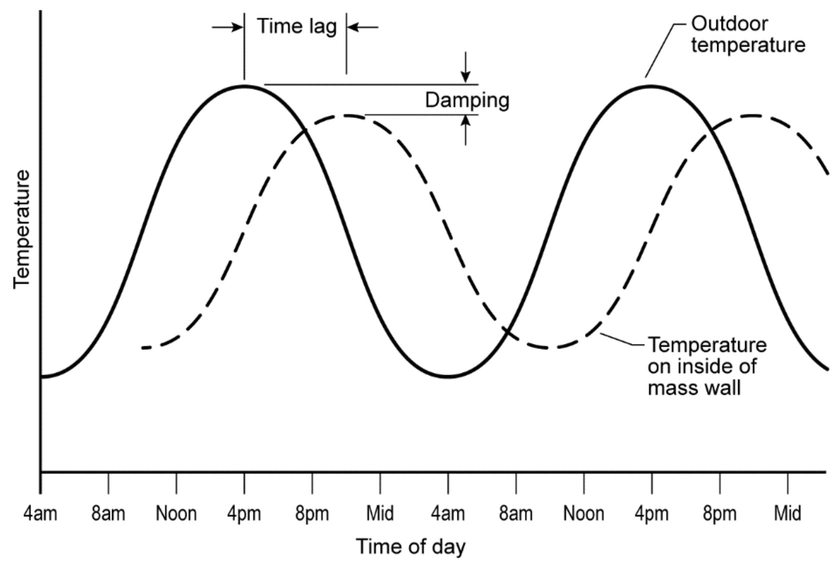


Figure 3-~~39~~53 – Thermal Mass Performance
Source: California Energy Commission

When the performance method is used, credit is offered for increasing thermal mass in buildings. However, credit for thermal mass in the proposed design may be considered only when the proposed design qualifies as a high mass building. A high mass building is one with thermal mass equivalent to having 30%~~ percent~~ of the conditioned slab floor exposed and 15%~~ percent~~ of the conditioned non-slab floor exposed with the equivalent of 2 inch-(50 mm) thick concrete. This procedure is automated in Energy Commission approved computer compliance software~~.~~

~~C. **METAL FRAMING**~~

~~A change from wood framing to metal framing can significantly affect compliance. Metal framed assemblies are often chosen where greater structural integrity is necessary, or in climate conditions where greater durability is desired from the affects of excessive moisture exposure. Metal framed wall construction generally requires a continuous layer of rigid insulation to meet the mandatory minimum wall insulation levels and/or the prescriptive requirements since metal is more conductive than wood. In Reference Joint Appendix JA4, Tables 4.2.4 and 4.2.5 have U-factors for metal-framed ceiling/roof constructions. Table 4.3.4 has U-factors for metal-framed walls. Tables 4.4.4 and 4.4.5 have U-factors for metal-framed floors.~~

~~To comply prescriptively, a non-wood framed assembly, such as a metal framed assembly, must have an assembly U-factor that is equal or less than the U-factor of the wood framed assembly for that climate zone. Compliance credit is available through the performance approach for metal framed assemblies that exceed the prescriptive requirements of the equivalent wood framed assemblies.~~

~~D.~~H. Log Homes

Log walls are typically made from trees that have been cut into logs that have not been milled into conventional lumber. Logs used for walls, roofs and/or floor systems may be milled and/or laminated by the manufacturer or supplier to meet specific dimensions and fitting and finishing conditions.

Log homes are an alternative construction type used in some parts of the state. Log home companies promote the aesthetic qualities of solid wood construction and can "package" the logs and deliver them directly to a building site. Some companies provide log wall, roof, and floor systems with special insulating "channels" or other techniques to minimize the effect of air infiltration between log members and to increase the thermal benefit of the logs.

Log walls do not have framing members like conventional wood stud walls. Therefore, the mandatory requirement for a minimum of R-13 wall insulation does not apply.

Otherwise, in prescriptive compliance, log walls must meet the same thermal requirements as other construction types. For performance compliance, consult the compliance software vendor’s documentation for any unique modeling requirements for mass walls using values from Reference Appendices (RA). In prescriptive compliance, the walls will qualify as either light mass or heavy mass walls depending on the thickness – remember a heat capacity (HC) of 8.0 Btu/°F-ft^2 is equivalent to a heavy mass wall (40 lb/ft^3). The prescriptive requirements for heavy mass walls are less stringent than the criteria for wood-framed walls. Reduced insulation is allowed because the effects of the thermal mass (interior and exterior) can compensate for less insulation.

The thermal performance of log walls is shown in ~~Reference Joint Appendix~~ JA4, Table 4.3.11. The U-factor ranges from 0.133 for a 6-inch wall to 0.053 for a 16-inch wall. The U-factor of an 8-inch wall is 0.102, which complies with the R-13 prescriptive requirements. U-factors for other log wall constructions (not shown in ~~Reference Joint Appendix~~ JA4) would have to be approved by the Energy Commission through the exceptional methods process.

Log walls have a heat capacity that is in excess of conventional construction. ~~Reference Joint Appendix~~ JA4, ~~[~~Table 4.3.11 (Thermal Properties of Log Home Walls)~~]~~ shows that a 6-inch wall has an HC of 4.04 which increases to 10.77 for a 16-inch wall. The thermal mass effects of log home construction can be accounted for within the performance approach.

Air infiltration between log walls can be considerably different among manufacturers depending upon the construction technique used. For purposes of compliance, infiltration is always assumed to be equivalent to a wood-frame building. However, the builder should consider using a blower door test to find and seal leaks through the exterior walls.

~~E.~~I. Straw Bale

Straw bale construction is a building method that uses bales of straw (commonly wheat, rice, rye and oat straw) as structural and insulating elements of the building. Straw bale construction is regulated within the CBC and specific guidelines are established for moisture content, bale density, seismic bracing, weather protection, and other structural requirements.

The Energy Commission has determined specific thermal properties for straw bale walls and thermal mass benefits associated with this type of construction. The performance compliance approach can be used to model the heat capacity characteristics of straw bales.

Straw bales that are 22~~3~~ inch by 16 inch are assumed to have a thermal resistance of R-30, whether stacked so the walls are 23 inch wide or 16 inch wide. The minimum density of load bearing walls is 7.0 lb/ft3, and this value or the actual density may be used for modeling straw bale walls in the performance approach. Specific heat is set to 0.32 Btu/lb-°F. Volumetric heat capacity (used in some computer programs) is calculated as density times specific heat. At a density of 7 lb/ft^3, for example, the volumetric heat capacity is 2.24 Btu/ft^3-°F.

The minimum dimension of the straw bales when placed in the walls must be 22 inch by 16 inch and there are no restrictions on how the bales are stacked. Due to the higher resistance to heat flow across the grain of the straw, a bale laid on edge with a nominal 16-inch horizontal thickness has the same R-Value (R-30) as a bale laid flat.

~~*F.* STRUCTURAL INSULATED PANELS (SIPS)~~

~~Structural Insulated Panels (SIPS) are a non-framed advanced construction system that consists of rigid insulation (usually expanded polystyrene) sandwiched between two sheets of OSB or plywood. Little or no structural framing penetrates the insulation layer. Panels are typically manufactured at a factory and shipped to the job site in assemblies that can be as large as 8 ft by 24 ft.~~

~~In the field, the SIPS panels are joined in one of three ways: (1) single or double 2x splines, (2) I-joists, or (3) with OSB splines. The choice of these options affects thermal performance and structural capacity. The 2x and I-joist spline types each fit in a recess of the foam core, between the two layers of plywood or OSB. Reference Joint Appendix JA4, Table 4.2.3 contains U-factors for roof/ceiling assemblies, Table 4.3.2 has U-factors for SIPS wall assemblies and Table 4.4.3 has U-factors for SIPS floor constructions. U-factors used for compliance must be taken from these tables, through the EZ-Frame assembly calculator, or by using approved performance compliance software.~~

Source: California Energy Commission

~~Figure 3-35 – Methods of Joining SIPS Panels~~

~~G. INSULATING CONCRETE FORMS (ICF)~~

~~Insulating Concrete Forms (ICFs) are a concrete forming system that uses stay-in-place panels made from a variety of insulating materials for constructing cast-in-place solid concrete walls. Three factors contribute to the energy efficiency of buildings using an ICF wall: (1) continuous rigid insulation on both sides of a high-mass core, (2) elimination of thermal bridging from wood framing components, and (3) a high degree of air-tightness inherent to this method of construction.~~

~~Climate zones with large daily temperature fluctuations have the greatest potential to benefit from the time lag and temperature dampening effects of these high-mass envelope systems. However, this combination of mass and insulation is beneficial in almost all climates with the possible exception of mild coastal climate zones.~~

~~There are three basic types of ICFs: flat wall, waffle-grid and screen-grid. A flat wall ICF results in a wall with a consistent and continuous thickness of concrete. A waffle-grid ICF creates a concrete waffle pattern, an uninterrupted-grid, with some concrete sections thicker than others. A screen-grid ICF consists of a discrete post-and-beam structure with the concrete completely encapsulated by the foam insulation, except at the intersection of posts and beams. The insulating panels for all three ICF types are most commonly made from expanded polystyrene (EPS) and extruded polystyrene (XPS) rigid insulation boards. Insulating panels are also made from polyurethane, composites of cement and EPS, and composites of cement and shredded wood fiber, although these tend to be proprietary materials developed by the ICF manufacturer.~~

~~Plastic or metal cross-ties, consisting of two flanges and a web, separate the insulating panels and provide structural integrity during the concrete pour resulting in a uniform wall thickness. A variety of wall thicknesses can be obtained by changing the length of the web. The area of attachment of the cross-ties to the insulating form provides a secure connection surface located at standard spacings for mechanical attachment of finish materials to the interior and exterior of the wall. ICFs can be used to construct load-bearing and non-load bearing walls, above- and below-grade walls, and can be designed to structurally perform in any seismic zone.~~

~~The ICF system is modular and stackable with interlocking edges. The materials can be delivered as pre-assembled blocks or as planks that require the flanges and web to be assembled during construction. The forms vary in height from 12” - 24” and are either 4’ or 8’ long. Vertical panels come in similar modules, but are stacked vertically. ICF panels are typically available with core thickness ranging from 4” to 12”.~~

~~The thermal aspects of ICFs are represented in the Reference Joint Appendix JA4, Table 4.3.13.~~

~~H.~~

Source: California Energy Commission

~~Figure 3-28 – Blower Door Testing~~

~~3.12.2 *Conventional and Non-Conventional/Advanced Assemblies*~~

~~1. **Roof Assembly**~~

~~The construction techniques described below are assemblies that can be used in residential construction to help exceed minimum prescriptive requirements, particularly when using the performance compliance approach. This section describes typical constructions for~~ unvented attics and ~~roof deck insulation and raised heel trusses (also called “energy trusses”).~~

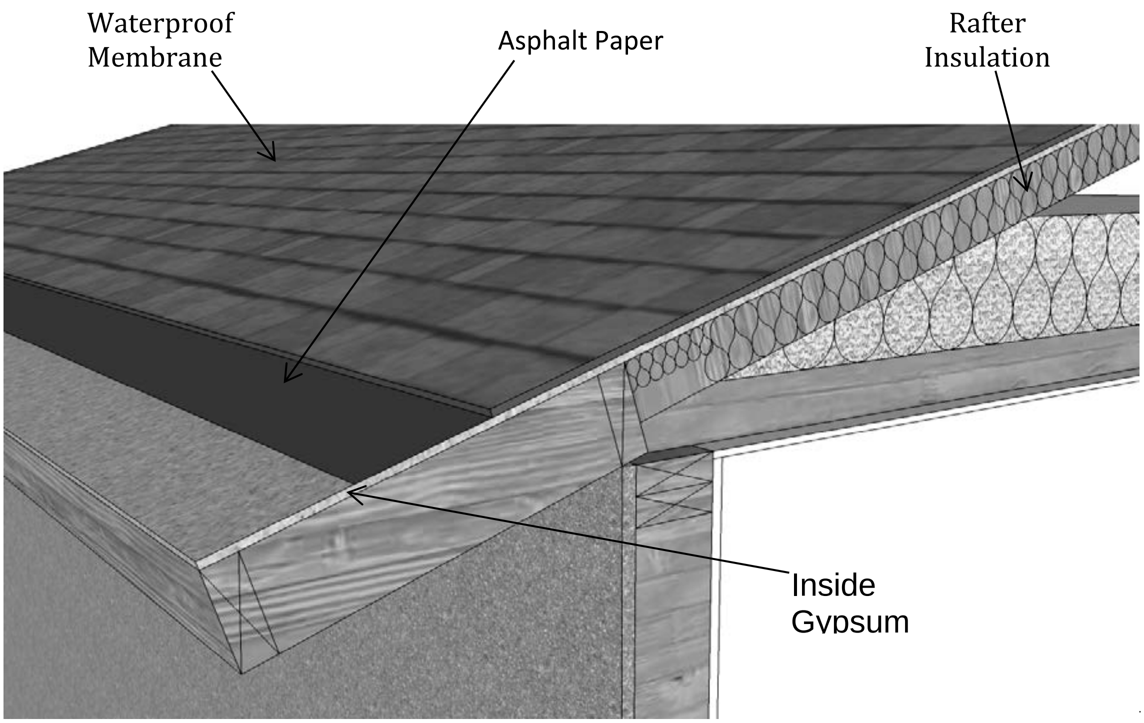
~~a. Roof Deck Insulation~~

~~An assembly and insulation alternative that helps augment conventional attic insulation that can achieve an energy compliance credit is to install insulation either directly above or directly below the roof deck. In addition, using roof deck insulation, either with conventional attic insulation that is laid horizontally over the bottom cord of the roof truss, or roof deck insulation (above or below the roof deck) without conventional horizontal attic insulation, can provide an energy tradeoff with~~

~~other prescriptive measures or used to help meet high performance building energy codes in local jurisdictions, Tier 1 and Tier 2 of the CalGreen Code, or other energy efficiency targets, such as LEED© for Homes and Energy Star.~~

~~*b. Below Roof Deck Insulation*~~

~~Insulation installed directly below the roof deck (i.e., batt, spray foam, rigid board) can be placed between the truss members and pinned in place. Other options that can provide somewhat higher R-values are to install loose fill glass fiber or cellulose between roof trusses which has netting underneath. For all cases, the attic can usually be conventionally vented using soffit, eave, and ridge vents, or other acceptable means.~~ When insulation is installed below the roof deck the effect of radiant barrier is to be neglected. ~~The radiant barrier is to be installed with the shiny side facing down toward the attic space. The radiant barrier is a reflective material that reduces radiant heat transfer caused by solar heat gain in the roof. For the radiant barrier to work properly it must not have insulation abutting to the shiny side.~~

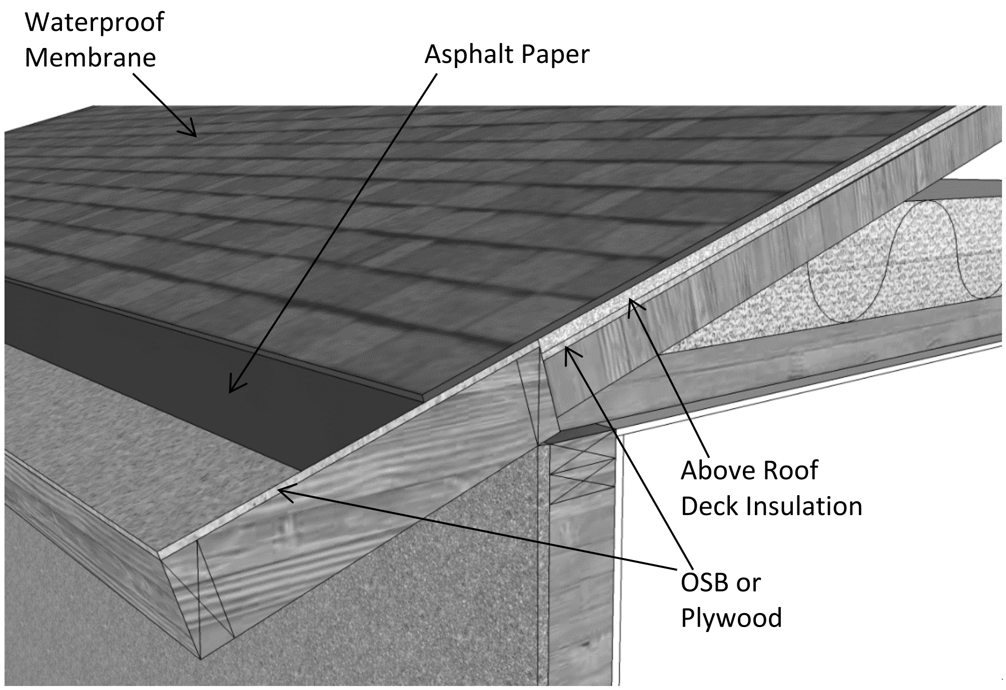


~~*Figure 3-29 – Below Roof Deck Insulation*~~
~~Source: California Energy Commission~~

~~NOTE: In some climates, placing insulation directly below the roof deck can create a condensation plane on the underside of the roof deck during the winter months. Whenever the outside air temperature is well below the dewpoint temperature of the indoor air (about 40°F to 45°F) there is potential for moisture to condense. For climate zones 11, 12, 13, 15 and 16, above deck insulation may be a better choice, particularly with a vented attic. R-8 of continuous insulation above the roof deck is approximately thermally equivalent to a R-13 batt insulation below the roof deck.~~

~~*c. Above Roof Deck Insulation*~~

~~Above deck insulation can also add effective R-value to the thermal integrity of the roof system. Using rigid board insulation with a minimum of R-4 helps provide additional R-value when conventional ceiling insulation is also installed and an energy credit can be taken even with a vented attic.~~



~~*Figure 3-30 – Above Roof Deck Insulation*~~
~~*Source: California Energy Commission*~~

~~Compliance software can model the thermal effects and energy benefits of both above deck and below deck insulation, and the effects of a vented versus unvented attic.~~

4. ~~**Wall Assembly**~~

~~*See Energy Commission videos*~~

~~More insulation is almost always better than less. Insulation is one of the least expensive measures to improve building energy efficiency. Insulation requires no maintenance, helps improve indoor comfort, and provides excellent sound control. Builders and designers who tout meeting minimum insulation requirements for new buildings are not providing consumers and homeowners with a home of great value. Buildings that comply minimally with the standards represent the worst buildings allowed by code. Adding extra insulation at a later time is much more expensive than simply maximizing insulation levels at the beginning of construction.~~

~~*h. Batt and Blanket Insulation*~~

~~Thermal batts of glass fiber, mineral and natural wool, and cotton material are some of the most widely used insulation in the marketplace. They offer ease of installation with R-values set by the manufacturer based on size and thickness. They are available with facings, some as vapor retarders, and have flanges to aid in installation to framed assemblies. They also are available as unfaced material and can be easily friction-fitted into framed cavities. Batt and blanket thermal insulation material have more testing for sound attenuation than any other insulation type. However, in some instances manufacturers of blown or sprayed insulation material may have testing information~~

~~supporting their product's sound performance for special applications with higher values typically found for thermal batts.~~

~~Batt and blanket insulation allow easy inspection and installation errors can readily be identified and remedied, including breeches in the air barrier system that allow air leakage. Nevertheless, care should always be taken to install the insulation properly, filling the entire cavity, and butting ends or sides of the batt material to ensure uniformity of the installation. Batt and blanket insulation material must be split to allow for wiring, plumbing, and other penetrations within the framed cavity area.~~

~~i. Blown or Sprayed Insulation~~

~~Blown or sprayed wall insulation can be an effective way to deal with the irregularities of wall and ceiling cavities, especially the spaces around pipes, electric cables, junction boxes, and other equipment that is embedded in cavities. There are several commonly used types of insulation that have a blown or sprayed process for its installation, including: cellulose, fiberglass, and spray polyurethane foam (SPF). The R-value of blown or sprayed wall insulation material is determined by the applicator at the site. This differs from manufactured products such as fiberglass or mineral wool batts whose R-value has been tested and arrives at the construction site in preformed lengths with set R-value thicknesses.~~

~~Blown or sprayed wall insulation must be thoroughly checked to insure the R-value is achieved. Line of sight down a wall section can deceivingly hide imperfections in the installation leading to underachieving stated R-values. Depressions and voids within the insulated cavity are areas lacking in their R-value performance. Where netting is used, over-spraying can result in a higher installed density (higher R-value) but can be troublesome for attaching gypboard to wall framing. Where cavities have been under-sprayed, there may be voids or "soft" areas under the netting. These areas are often re-sprayed again, or the area is removed of its insulation material and a thermal batt is installed in its place.~~

~~j. Loose Fill Cellulose Insulation~~

~~Cellulose is basically paper that has been treated for flame- and insect-resistance. Loose fill cellulose is commonly used in attic applications. For walls, the cellulose material is typically mixed with a water- and starch-based binder. The binder causes the insulation to adhere to itself and stick to the surfaces of the wall cavity. Excess insulation that extends past the wall cavity is scraped off with a special tool and recycled into the insulation hopper with fresh material for further installations. R-value is dependent on the installed density of the material at the building site and the building official should ensure the installed density meets manufacturer specifications. Cellulose insulation that dislodges from the cavity is often re-sprayed again, or the area is removed of cellulose and a thermal batt is installed in its place.~~

~~k. Loose Fill Fiberglass Insulation~~

~~Loose fill fiberglass insulation is made up of small glass fibers. The product is similar to lose fill fiberglass that is commonly used in attics, but for walls it can be installed behind a netting fabric or mixed with a water based adhesive. The adhesive causes the insulation to adhere to itself and stick to surfaces of the wall cavity. Excess insulation that extends past the wall cavity is scraped off and recycled. R-value is dependent on the installed density of the material at the building site and the building official should ensure the installed density meets manufacturer specifications.~~

~~l. Spray Polyurethane Foam (SPF)~~

~~Spray polyurethane foam insulation is a foamed plastic formed by the combination of chemicals and a blowing agent applied using a spray gun. SPF insulation is spray applied to fully adhere to the joist and other framing faces to form a complete air seal within the construction cavities. R-value is dependent on the installed thickness and the building official should ensure the thickness~~

~~and uniformity of the SPF material within each cavity space of framed assemblies meets manufacturer specifications. When installed on the underside of the roof deck and exposed to the attic space below SPF must be separated from the interior of the building by an approved thermal barrier consisting of 1/2-inch (12.7 mm) gypsum wallboard or equivalent thermal barrier material (Section 316.4, CBC).~~

~~There are two types of SPF insulation: medium-density closed cell (ccSPF), and light-density open cell (ocSPF) insulation. They have different insulating properties and compliance requirements as described below:~~

~~A. ccSPF has been assigned a default R-value of 5.8 per inch for compliance purposes and a nominal density of greater than 1.5 to less than 2.5 pounds per cubic foot (pcf). The average thickness of the foam insulation must meet or exceed the required R-value. Depressions in the foam insulation's surface shall not be greater than 1/2-inch of the required thickness at any given point of the surface area being insulated. ccSPF is not required to fill the cavity.~~

~~B. ocSPF has been assigned a default R-value of 3.6 per inch for compliance purposes and a nominal density of 0.4 to 1.5 pounds per cubic foot (pcf). ocSPF insulation is sprayed then expands to fill the framed cavity. Excess insulation is removed with a special tool. The average thickness of the foam insulation must meet or exceed the required R-value. Depressions in the foam insulation surface shall not be greater than 1 inch of the required thickness provided these depressions do not exceed 10% of the surface area being insulated. ocSPF must fill the cavity of 2x4 framing.~~

~~Table 3-10: Required Thickness of SPF Insulation to Achieve Default R-values~~

~~**Thickness of SPF Insulation**~~	~~**R11**~~	~~**R13**~~	~~**R15**~~	~~**R19**~~	~~**R21**~~	~~**R22**~~	~~**R25**~~	~~**R30**~~	~~**R38**~~
~~Required thickness of ccSPF Insulation (inches)~~	~~2.00~~	~~2.25~~	~~2.75~~	~~3.50~~	~~3.75~~	~~4.00~~	~~4.50~~	~~5.25~~	~~6.75~~
~~Required thickness of ocSPF Insulation (inches)~~	~~3.0~~	~~3.5~~	~~4.2~~	~~5.3~~	~~5.8~~	~~6.1~~	~~6.9~~	~~8.3~~	~~10.6~~

~~Alternatively, the total R-value may be calculated based on the thickness of insulation multiplied by the "tested R-value per inch" as listed in the Table of R-values or R-value Chart from the manufacturer's current ICC Evaluation Service Report (ESR) that shows compliance with *Acceptance Criteria for Spray-Applied Foam Plastic Insulation--AC377*. Overall assembly U-factors are determined by selecting the assembly type, framing configuration, and cavity insulation from the appropriate Reference Joint Appendix JA4 table or other approved method specified in Section JA4 of the Reference Appendices.~~

~~*m. Air Barrier*~~

~~3. ccSPF installed as an air barrier shall be a minimum of 2.0 inches in thickness; alternatively, ccSPF insulation shall be installed at a thickness that meets an air permeance no greater than 0.02 L/s-m^2 at 75 Pa pressure differential when tested in accordance to ASTM E2178 or ASTM E283.~~

~~4. ocSPF installed as an air barrier shall be a minimum of 5.5 inches in thickness; alternatively, ocSPF insulation shall be installed at a thickness that meets an air permeance no greater than 0.02 L/s-m^2 at 75 Pa pressure differential when tested in accordance to ASTM E2178 or ASTM E283.~~

Source: California Energy Commission

~~*Figure 3-34 – Cellulose Insulated Wall*~~

~~*n. Metal Framing*~~

~~A change from wood framing to metal framing can significantly affect compliance. Metal framed assemblies are often chosen where greater structural integrity is necessary, or in climate conditions where greater durability is desired from the affects of excessive moisture exposure. Metal framed wall construction generally requires a continuous layer of rigid insulation to meet the mandatory minimum wall insulation levels and/or the prescriptive requirements since metal is more conductive than wood. In Reference Joint Appendix JA4, Tables 4.2.4 and 4.2.5 have U-factors for metal-framed ceiling/roof constructions. Table 4.3.4 has U-factors for metal-framed walls. Tables 4.4.4 and 4.4.5 have U-factors for metal-framed floors.~~

~~To comply prescriptively, a non-wood framed assembly, such as a metal framed assembly, must have an assembly U-factor that is equal or less than the U-factor of the wood framed assembly for that climate zone. Compliance credit is available through the performance approach for metal framed assemblies that exceed the prescriptive requirements of the equivalent wood framed assemblies.~~

~~*o. Log Homes*~~

~~Log homes are an alternative construction type used in some parts of the state. Log home companies promote the aesthetic qualities of solid wood construction and can "package" the logs and deliver them directly to a building site. Some companies provide log wall, roof, and floor systems with special insulating "channels" or other techniques to minimize the effect of air infiltration between log members and to increase the thermal benefit of the logs.~~

~~Log walls do not have framing members like conventional wood stud walls. Therefore, the mandatory requirement for a minimum of R-13 wall insulation does not apply.~~

~~Otherwise, in prescriptive compliance log walls must meet the same thermal requirements as other construction types. For performance compliance, consult the compliance software vendor's documentation for any unique modeling requirements~~

~~for mass walls using values from Reference Appendices. In prescriptive compliance, the walls will qualify as either light mass or heavy mass walls depending on the thickness – remember a heat capacity (HC) of 8.0 Btu/°F-ft^2 is equivalent to a heavy mass wall (40 lb/ft^3). The prescriptive requirements for heavy mass walls are less stringent than the criteria for wood-framed walls. Reduced insulation is allowed because the effects of the thermal mass (interior and exterior) can compensate for less insulation.~~

~~The thermal performance of log walls is shown in Reference Joint Appendix JA4, Table 4.3.11. The U-factor ranges from 0.133 for a 6-inch wall to 0.053 for a 16-inch wall. The U-factor of an 8-inch wall is 0.102, which complies with the R-13 prescriptive requirements. U-factors for other log wall constructions (not shown in Reference Joint Appendix JA4) would have to be approved by the Energy Commission through the exceptional methods process.~~

~~Log walls have a heat capacity that is in excess of conventional construction. Reference Joint Appendix JA4 [Table 4.3.11 Thermal Properties of Log Home Walls] shows that a 6-inch wall has an HC of 4.04 which increases to 10.77 for a 16-inch wall. The thermal mass effects of log home construction can be accounted for within the performance approach.~~

~~Air infiltration between log walls can be considerably different among manufacturers depending upon the construction technique used. For purposes of compliance, infiltration is always assumed to be equivalent to a wood-frame building. However, the builder should consider using a blower door test to find and seal leaks through the exterior walls.~~

~~*p. Straw Bale*~~

~~Straw bale construction is regulated within the CBC and specific guidelines are established for moisture content, bale density, seismic bracing, weather protection, and other structural requirements.~~

~~The Energy Commission has determined specific thermal properties for straw bale walls and thermal mass benefits associated with this type of construction. The performance compliance approach can be used to model the heat capacity characteristics of straw bales.~~

~~Straw bales that are 23 inch by 16 inch are assumed to have a thermal resistance of R-30, whether stacked so the walls are 23 inch wide or 16 inch wide. The minimum density of load bearing walls is 7.0 lb/ft3, and this value or the actual density may be used for modeling straw bale walls in the performance approach. Specific heat is set to 0.32 Btu/lb-°F. Volumetric heat capacity (used in some computer programs) is calculated as density times specific heat. At a density of 7 lb/ft^3, for example, the volumetric heat capacity is 2.24 Btu/ft^3-°F.~~

~~The minimum dimension of the straw bales when placed in the walls must be 22 inch by 16 inch and there are no restrictions on how the bales are stacked. Due to the higher resistance to heat flow across the grain of the straw, a bale laid on edge with a nominal 16-inch horizontal thickness has the same R-Value (R-30) as a bale laid flat.~~

~~*q. Structural Insulated Panels (SIPS)*~~

~~Structural Insulated Panels (SIPS) are a non-framed advanced construction system that consists of rigid insulation (usually expanded polystyrene) sandwiched between two sheets of OSB or plywood. Little or no structural framing penetrates the insulation layer. Panels are typically manufactured at a factory and shipped to the job site in assemblies that can be as large as 8 ft by 24 ft.~~

~~In the field, the SIPS panels are joined in one of three ways: (1) single or double 2x splines, (2) I-joists, or (3) with OSB splines. The choice of these options affects thermal performance and structural capacity. The 2x and I-joist spline types each fit in a recess of the foam core, between the two layers of plywood or OSB. Reference Joint Appendix JA4, Table 4.2.3 contains U-factors for roof/ceiling assemblies, Table 4.3.2 has U-factors for SIPS wall assemblies and Table 4.4.3 has U-factors for SIPS floor constructions. U-factors used for compliance must be taken from these tables, through the EZ-Frame assembly calculator, or by using approved performance compliance software.~~

Source: California Energy Commission

~~Figure 3-35 – Methods of Joining SIPS Panels~~

~~r. Insulating Concrete Forms (ICF)~~

~~Insulating Concrete Forms (ICFs) are a concrete forming system that uses stay-in-place panels made from a variety of insulating materials for constructing cast-in-place solid concrete walls. Three factors contribute to the energy efficiency of buildings using an ICF wall: (1) continuous rigid insulation on both sides of a high-mass core, (2) elimination of thermal bridging from wood framing components, and (3) a high degree of air-tightness inherent to this method of construction.~~

~~Climate zones with large daily temperature fluctuations have the greatest potential to benefit from the time lag and temperature dampening effects of these high-mass envelope systems. However, this combination of mass and insulation is beneficial in almost all climates with the possible exception of mild coastal climate zones.~~

~~There are three basic types of ICFs: flat wall, waffle-grid and screen-grid. A flat wall ICF results in a wall with a consistent and continuous thickness of concrete. A waffle-grid ICF creates a concrete waffle pattern, an uninterrupted-grid, with some concrete sections thicker than others. A screen-grid ICF consists of a discrete post-and-beam structure with the concrete completely encapsulated by the foam insulation, except at the intersection of posts and beams. The insulating panels for all three ICF types are most commonly made from expanded polystyrene (EPS) and extruded polystyrene (XPS) rigid insulation boards. Insulating panels are also made from polyurethane, composites of cement and EPS, and composites of cement and shredded wood fiber, although these tend to be proprietary materials developed by the ICF manufacturer.~~

~~Plastic or metal cross-ties, consisting of two flanges and a web, separate the insulating panels and provide structural integrity during the concrete pour resulting in a uniform wall thickness. A variety of wall thicknesses can be obtained by changing the length of the web. The area of attachment of the cross-ties to the insulating form provides a secure connection surface located at standard spacings for mechanical attachment of finish materials to the interior and exterior of the wall. ICFs can be used to construct load-bearing and non-load bearing walls, above- and below-grade walls, and can be designed to structurally perform in any seismic zone.~~

~~The ICF system is modular and stackable with interlocking edges. The materials can be delivered as pre-assembled blocks or as planks that require the flanges and web to be assembled during construction. The forms vary in height from 12" - 24" and are either 4' or 8' long. Vertical panels come in similar modules, but are stacked vertically. ICF panels are typically available with core thickness ranging from 4" to 12".~~

~~The thermal aspects of ICFs are represented in the Reference Joint Appendix JA4, Table 4.3.13.~~

~~s. Advanced Wall System (AWS)~~

~~Advanced Wall Systems (AWS), also known as Optimum Value Engineering (OVE), refers to a set of framing techniques and practices that minimize the amount of wood and labor necessary to build a structurally sound, safe and durable, energy efficient building. AWS improves energy and resource efficiency while reducing first costs.~~

~~Reducing the amount of wood in wood framed exterior walls improves energy efficiency, allowing more insulation to be installed, and has greater resource efficiency for the materials being used. In addition, fewer framing studs reduces the effects of "thermal bridging" and increases the amount of insulation in the wall, resulting in a more energy efficient building envelope. The framing factor assumed for calculating the energy performance of a wood framed 2x4 wall at 16"oc is 25%. When AWS is used the framing factor is reduced to 17%, reflecting the improved energy performance of the wall system.~~

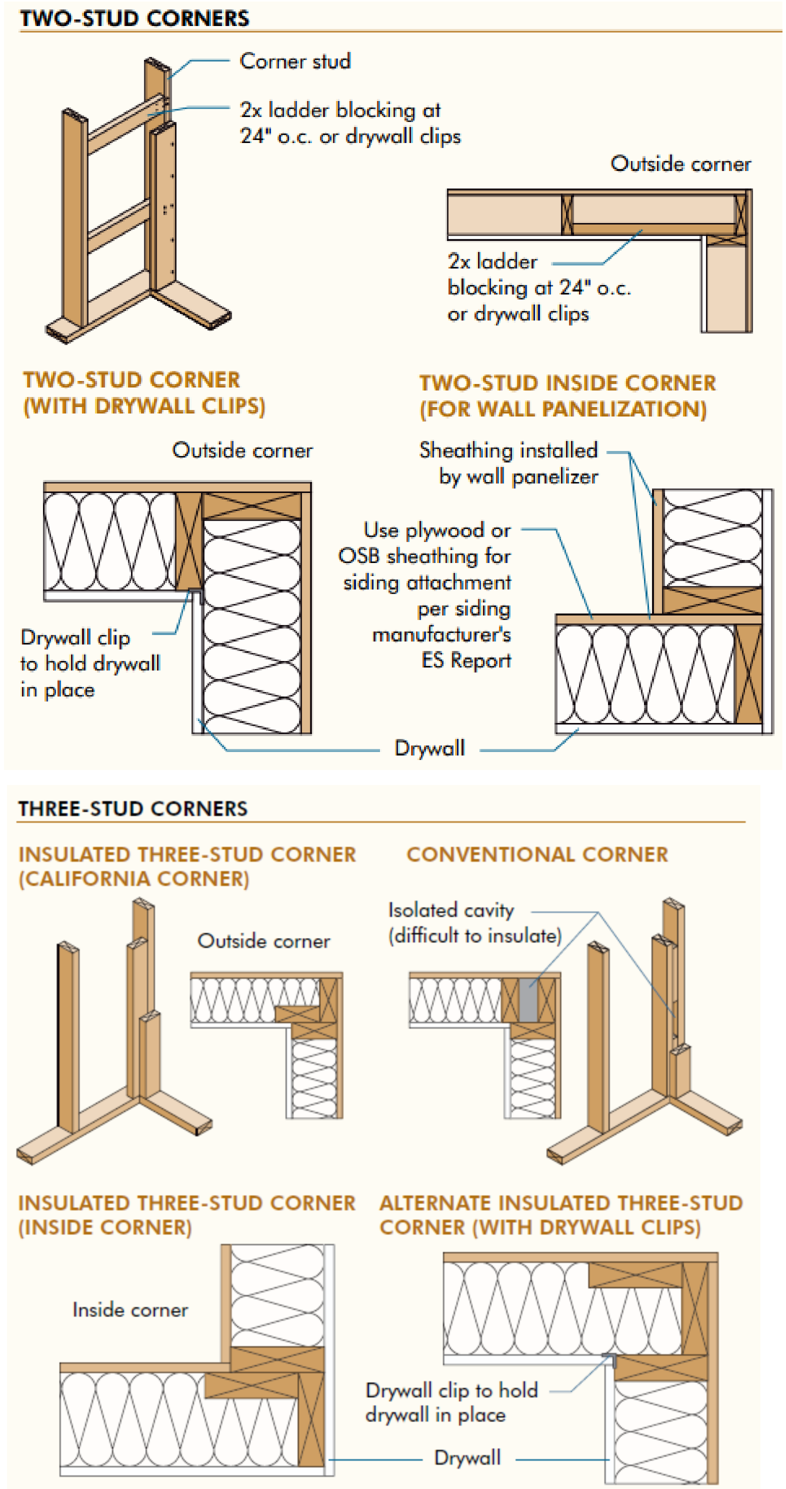
~~While AWS represents a range of practices, it must be adequately inspected to ensure framing contractors have adhered to all best practice construction throughout the exterior envelope. Examples of construction practices for AWSs that should be followed and that can be used as a general guide for enforcement are provided below:~~

20. ~~Use at a minimum 2x6 at 24" on-center wall framing~~
21. ~~Use precise engineering of headers on load-bearing walls~~
22. ~~Install 2x4, 2x6, or I-joist headers on exterior non-load-bearing walls~~
23. ~~Eliminate cripple studs at window and door openings less than 4 feet in width~~
24. ~~Align window/door openings with standard stud spacing~~
25. ~~The king stud, on at least one side of the window/door opening, must take the place of an on-layout AWS stud~~
26. ~~Use an insulated corner, either a two-stud corners or a instead of California (3-stud) corners, as in the examples provided in Figure 3-X1~~
27. ~~Nailing for interior gypsum board can be accomplished with drywall clips, 1x nailer strip, recycled plastic nailing strip. Drywall clips reduce the potential for drywall cracking~~
28. ~~Ladder block where interior partitions intersect exterior walls, instead of 3-stud channels~~
29. ~~Eliminate unnecessary double floor joists underneath non-bearing walls~~
30. ~~Use metal let-in T-bracing or other methods on non-shear walls to allow full insulation~~
31. ~~Include detailed framing plans and elevations on the construction permit plan set~~

32. ~~Optimize house design for efficient material use (e.g. reducing header spans, designing exterior surfaces in two foot modules, designing clear spans to eliminate interior bearing walls)~~
- ~~Build with "insulated headers" (a "sandwich" of two solid or engineered lumber components with a layer of foam insulation in the middle or on one or both sides of the header). An example of an single-ply insulated header is provided in Figure 3-X2. Insulated headers may also earn QII compliance credits by installing R-2 insulation in one of three ways:~~
    - ~~Two-member header with insulation in between. The header and insulation must fill the wall cavity. There are pre-fabricated 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.~~
    - ~~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.~~

  ~~a. Wood structural panel box headers may also be used as load-bearing headers in exterior wall construction, when built in accordance with 2015 IRC Figure R602.7.3 and Table R602.7.3.~~
33. ~~Use engineered lumber. Examples include: "I"-joists, open web floor trusses; 2x "raised heel" roof trusses, glulam beams, laminated veneer lumber (LVL), laminated strand lumber (LSL), parallel strand lumber (PSL), oriented strand board (OSB)~~
34. ~~Eliminate trimmers at window and door opening headers less than 4 feet in width, only when rated hangers are utilized and noted on the plans.~~
35. ~~Use 2x4 or 2x3 interior non-load-bearing walls~~
36. ~~Integrate framing design with HVAC system~~
37. ~~Use "inset" shear wall panels~~

~~The graphic below is a description of a typical AWS and the assembly characteristics that are used in the prescriptive and performance compliance approaches to support it use. But note, the building official must ensure during the framing inspection that all elements of AWS have been met.~~

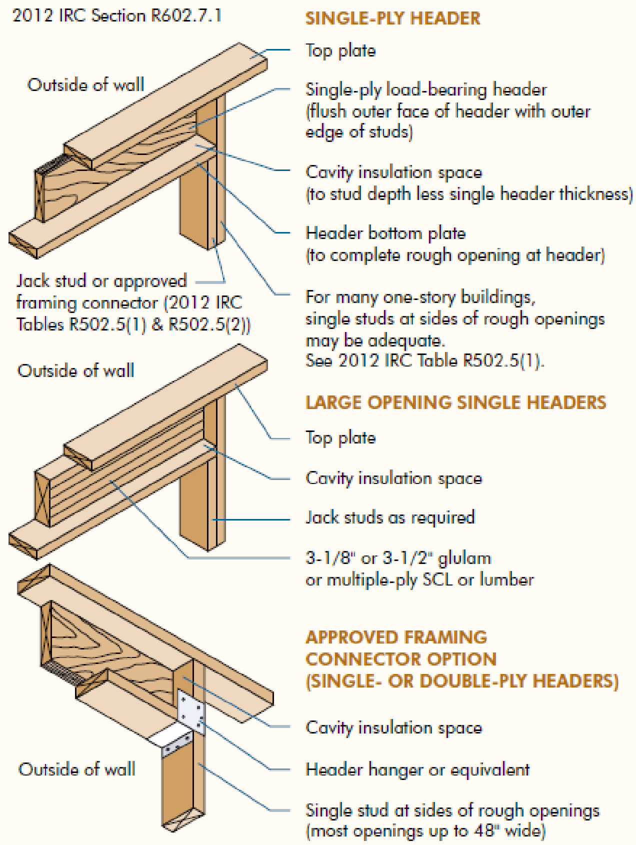


~~Figure 3-X1 – Advanced Framing Corners~~

~~Source: APA Advanced Framing Guide~~

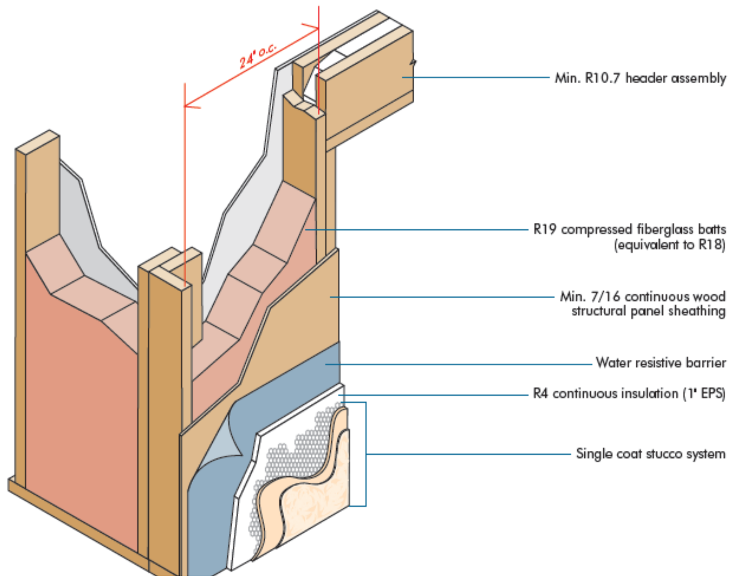
FIGURE 7

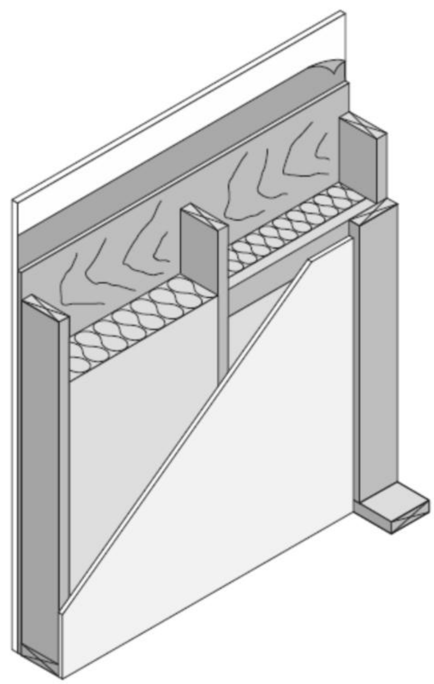
ENGINEERED WOOD AND LUMBER HEADERS



~~Figure 3-X2X – Wood Framed Wall, 2x6 @ 24" oc, AWF with 2-stud corners~~Headers Designs with Cavity Insulation Space
Source: APA Advanced Framing Guide

~~Figure 3-36 below is a description of one AWS and the assembly characteristics that are used in the prescriptive and performance compliance approaches. This assembly meets a U-factor of 0.051 with an exterior insulation of R-4, due to 24" stud spacing and R10.7 header assemblies. Note that the building official must ensure during the framing inspection that all elements of AWS have been met.~~





~~Figure 3-36 – Wood Framed Wall, 2x6 @ 24" oc, AWF with 2~~3~~-stud corners~~

~~Source: California Energy Commission~~

~~Table 3-11 – Assumptions~~

~~Layer~~	~~**Assembly Type: Wall 2x6 @ 24" oc AWS**~~	~~**R-Value**~~	
	~~Framing Material: Wood~~	~~Framing Factor~~	~~17~~
	~~**Assembly Components**~~	~~**Cavity (R_c)**~~	~~**Frame (R_f)**~~
~~1~~	~~Outside air film~~	~~0.17~~	~~0.17~~
~~2~~	~~7/8 inch 3-coat stucco~~	~~0.18~~	~~0.18~~

~~3~~	~~3/8 inch sheathing~~	~~0.47~~	~~0.47~~
~~4~~	~~R-21 insulation~~	~~21.0~~	~~--~~
~~5~~	~~2x6 douglass fir framing @ R-1.086/inch~~	~~--~~	~~5.973~~
~~6~~	~~½ inch gypboard~~	~~0.45~~	~~0.45~~
~~7~~	~~Inside air film~~	~~0.68~~	~~0.68~~
	~~Subtotal~~	~~23.01~~	~~7.983~~
	~~[1/R_c x (1-Frame% / 100)] + [(1/R_f)] x (Frame% / 100)] = Assembly U-factor~~	**~~Assembly U-factor~~**	**~~0.057~~**

Assumptions: ~~Values in Table 3-11 were calculated using the parallel heat flow calculation method, documented in the 2009 ASHRAE Handbook of Fundamentals. The construction assembly assumes an exterior air film of R-0.17, a 7/8 inch layer of stucco of R-0.18 (SC01), building paper of R-0.06 (BP01), sheathing or continuous insulation layer if present, the cavity insulation / framing layer, ½ inch gypsum board of R-0.45 (GP01), and an interior air film 0.68. The framing factor is assumed to be 25 percent for 16 inch stud spacing, 22 percent for 24 inch spacing, and 17 percent for Advanced Wall System (AWS).~~

~~Actual cavity depth is 3.5 inch for 2x4, 5.5 inch for 2x6. The thickness of the stucco is assumed to be reduced to 3/8 inch (R-0.08) when continuous insulation is applied.~~

~~t. Double and Staggered Wall Assemblies~~

~~Double wall and staggered wall systems were developed to better accommodate electrical and plumbing systems, allow higher levels of insulation, and provide greater sound attenuation. The advantages of these types of wall systems are that:~~

~~1. Smaller dimensional lumber can be used~~

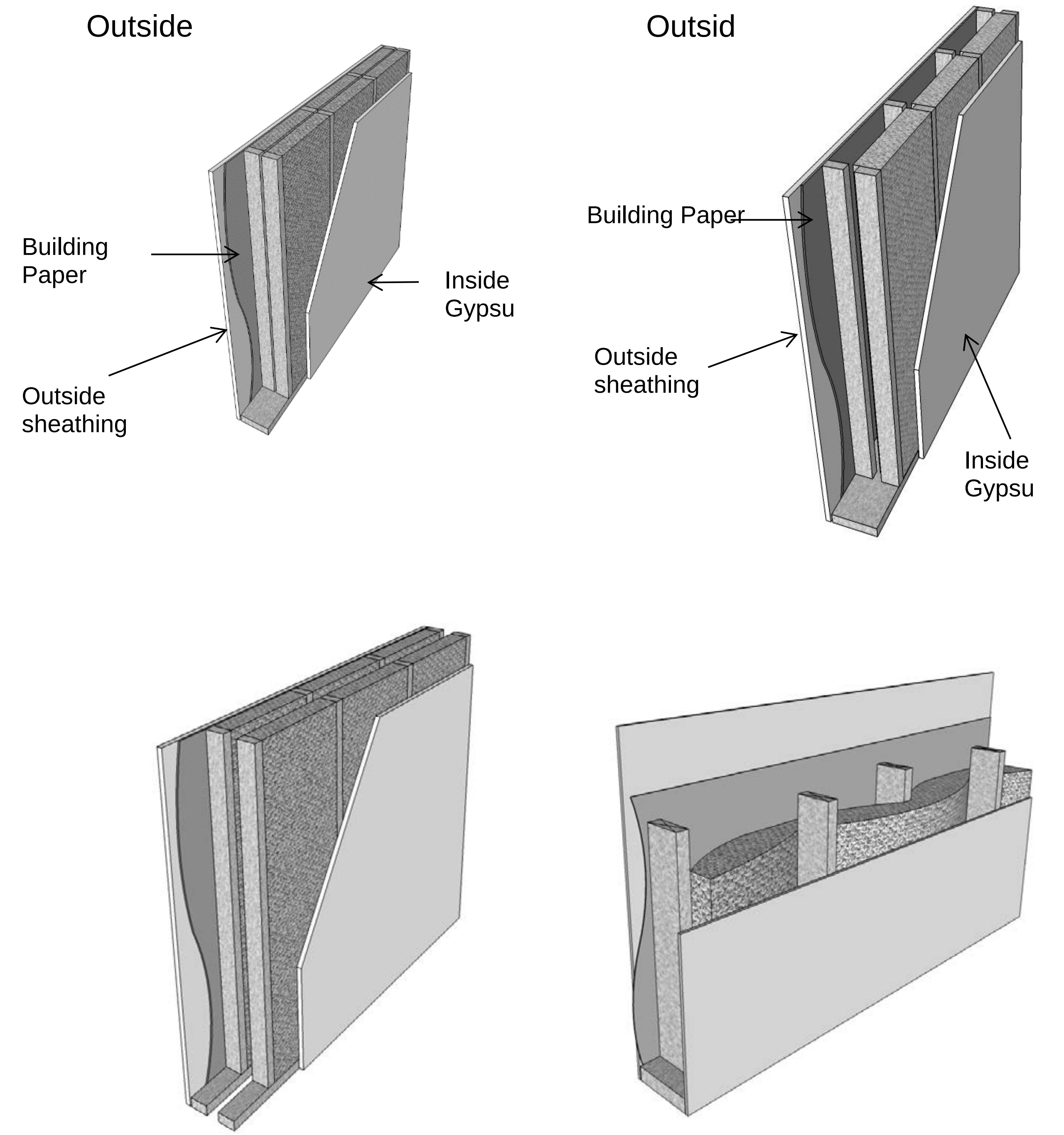
~~2. Easier to install installation properly~~

~~3. Eliminates thermal bridging through the framing~~

~~4. Reduces sound transmission through the wall~~

~~With double walls, insulation may be on one side of the wall or on both (higher R-values). It is not uncommon to find double walls with insulation installed within the outside wall cavities, leaving the inside wall sections open for wiring and plumbing purposes.~~

~~With staggered walls, thermal batt insulation may be installed horizontally or vertically, butting the sides of the insulation until the cavity across the entire wall section is completely filled.~~



~~*Figure 3-37 – Typical Double and Staggered Wall Systems*~~
~~*Source: California Energy Commission*~~

~~5. **Floor Assembly**~~

~~A. Controlled Ventilation Crawlspace (CVC)~~

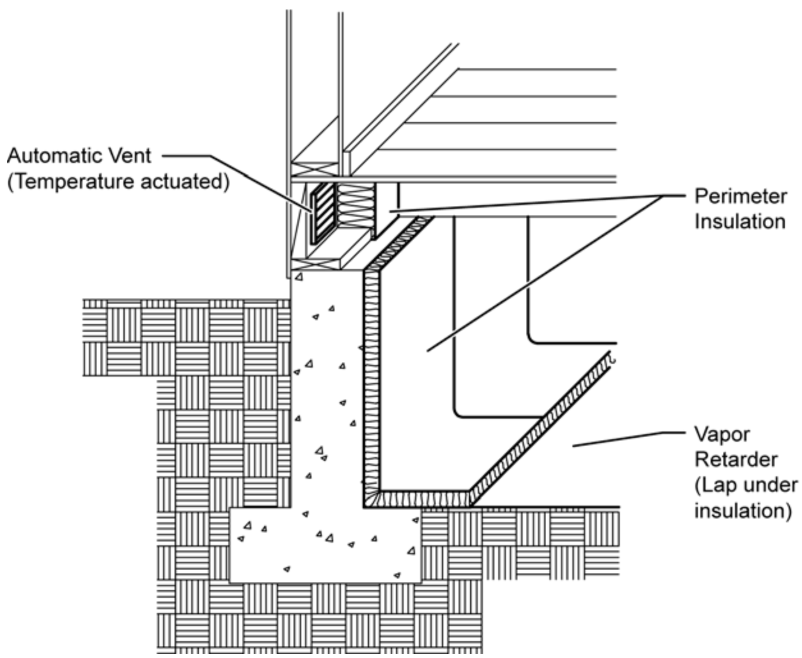
~~*CVC Eligibility Criteria in 2013 Reference Appendices, Residential Appendix RA4.5.1*~~

~~Buildings having crawlspace foundations must meet mandatory and prescriptive requirements for insulation of a raised floor separating the unconditioned crawlspace from conditioned space above (§150.0(d) and §150.1(c)1C). An alternative to under floor insulation is insulating~~

~~the stem wall of the foundation crawlspace. Insulating the crawlspace foundation can improve the thermal efficiency of the floor system by:~~

~~1. Reducing heat transfer into the unconditioned crawlspace,~~
~~2. Reducing moisture buildup in the crawlspace, and~~
~~3. Minimizing insulation exposed to adverse weather prior to enclosure of the building shell~~

~~An energy credit can be taken in performance compliance software for Controlled Ventilation Crawlspace (CVC). This credit requires insulating the foundation stem wall, the use of automatically controlled crawlspace vents, and vapor retarder covering the entire ground soil area for moisture control on the crawlspace floor (see Section 3.3. V, Vapor Retarder).~~



~~*Figure 3-38 642- Controlled Ventilation Crawl Space*~~
~~*Source: California Energy Commission*~~

~~All building designs should ensure that proper site engineering and drainage away from the building is maintained, this includes landscaping techniques that emphasize sound water management strategies:~~

~~1. **Drainage:** Crawlspace buildings in particular are susceptible to moisture ponding when good drainage and/or moisture removal designs are not employed.~~
~~2. **Ground water and soils:** Local ground water tables at maximum winter recharge elevation should be below the lowest excavated elevation of the site foundation. Sites that are well drained and that do not have surface water problems are generally good candidates for this stem wall insulation strategy. However, allowance for this alternative insulating technique is entirely at the building officials' discretion. The building permit applicant should be prepared to provide supporting information that site drainage strategies (e.g., perimeter drainage techniques) will prevent potential moisture concerns.~~

~~The following eligibility criteria (see Reference Appendices, Residential Appendix RA4.5.1) are required in order to use the CVC energy credit:~~

~~3. **Ventilation:** All crawlspace vents must have automatic vent dampers. Automatic vent dampers must be shown on the building plans and installed. Dampers shall be~~

~~temperature actuated to be fully closed at approximately 40°F and fully open at approximately 70°F. Cross-ventilation consisting of the required vent area shall be distributed between opposing foundation walls.~~

~~4. **Insulation:** The R-value of insulation placed on the foundation stem wall shall be equal to or greater than the wall insulation above the raised floor. Stem wall insulation shall run vertically along the stem wall and horizontally across the crawlspace floor for a distance of 2 feet (24 inches).~~

~~5. **Direct Earth Contact**—Foam plastic insulation used for crawlspace insulation having direct earth contact shall be a closed cell water resistant material and meet the slab edge insulation requirements for water absorption and water vapor transmission rate specified in the mandatory requirements (§110.8(g)1).~~

~~A Class I or Class II vapor retarder must be placed over the earth floor of the crawl space to reduce moisture entry and protect insulation from condensation in accordance with Reference Residential Appendix RA4.5.2. This requires essentially a polyethylene type ground cover having a minimum 6 mil thickness (0.006 inch) or approved equal. The vapor retarder must be overlapped a minimum of 6 inches at joints and shall extend over the top of footings and piers. All overlapping of joints shall be sealed with tape, caulk or mastic.~~

~~Penetrations, tears and holes in the vapor barrier shall be sealed with tape, caulk or mastic.~~

~~The vapor retarder shall be Class I or Class II and rated as 1.0 perm or less.~~

~~Edges of the vapor retarder shall be turned up a minimum of 4 inches at the stem wall and securely fastened before insulation is installed.~~

~~In sloping crawlspace ground soil areas, the vapor retarder shall be securely held in place, such as spiked with 5 inch gutter nails then have proper sealing of penetration holes.~~

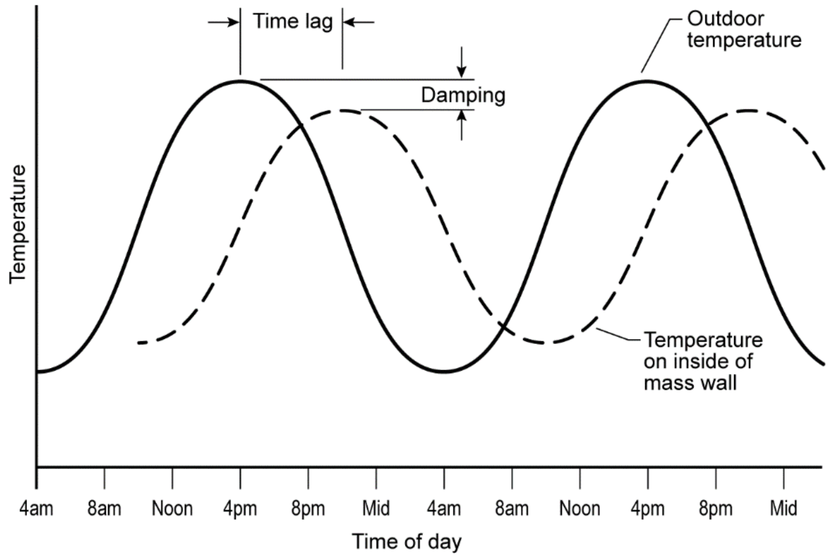
~~The vapor retarder shall be shown on the plans.~~

~~6. Other Assemblies~~

~~B. Thermal Mass~~

~~Thermal mass consists of exposed tile floors over concrete, mass walls such as stone or brick, and other heavy elements within the building envelope that serve to stabilize indoor temperatures. Thermal mass helps temper interior temperature, storing heat or cooling for use at a later time. In California’s central valley and desert climates, the summer temperature range between night and day can be 30°F or more and thermal mass can be an effective strategy to reduce daytime cooling loads.~~

~~When thermal mass exists in exterior walls, it works to stabilize temperatures in two ways. First, there is a time delay between when the outside temperature of the wall reaches its peak and when the inside of the wall reaches its peak. For an 8-inch to 12-inch concrete wall, this time delay is on the order of 6 to 10 hours. Second, there is a dampening effect whereby the temperature range on the inside of the house is less than the temperature range on the outside of the house. These effects are illustrated in the following figure.~~



~~*Figure 3-39 – Thermal Mass Performance*~~
~~*Source: California Energy Commission*~~

~~When the performance method is used, credit is offered for increasing thermal mass in buildings. However, credit for thermal mass in the proposed design may be considered only when the proposed design qualifies as a high mass building. A high mass building is one with thermal mass equivalent to having 30 percent of the conditioned slab floor exposed and 15 percent of the conditioned non-slab floor exposed with the equivalent of 2 inch-(50 mm) thick concrete. This procedure is automated in Energy Commission approved computer.~~

~~3.13~~3.7 Compliance and Enforcement

For buildings ~~for~~in which the Certificate of Compliance (CF1R) requires HERS field verification for compliance with the Energy ~~s~~Standards, a HERS rater must visit the site to perform field verification and diagnostic testing~~,~~ to complete the applicable ~~Envelope~~ envelope portions of a Certificate of Field Verification and Diagnostic Testing (CF3R).

The following measures require field verification and diagnostic testing if they are used in the proposed design for compliance, and are listed on the CF1R as special features requiring HERS rater verification:

1. Building Envelope Sealing
2. Quality Insulation Installation (QII)

Field verification is necessary only when credit is taken for the measure. For example, Building Envelope Sealing need only be HERS verified if Building Envelope Sealing was used to achieve credit in the proposed design.

Registration of the CF3R is required. The HERS rater must submit the CF3R information to the HERS provider data registry as described in Chapter 2. For additional detail describing HERS verification and the registration procedure, refer to ~~Reference Residential Appendix~~ RA2.

~~A.~~3.7.1 *Design*

The initial compliance documentation consists of the Certificate of Compliance (CF1R). ~~With the 2008 update,~~ MF-1R is no longer a checklist, but a statement of the mandatory features that must ~~to~~ be included with the CF1R forms. The mandatory features are also included in the CF2R forms. The CF1R must be filed on the plans and specifications. Included on the CF1R is a section where special envelope features are listed. The following are envelope features that should be listed in this section if they exist in the proposed design:

1. Inter-zone ventilation
2. Radiant barriers
3. Multiple Orientation
4. Controlled ventilation crawlspace
5. Non-standard ventilation height differences
6. Standard free ventilation area greater than 10% ~~percent~~ of the window area
7. Metal-framed walls
8. Sunspace with interzone surfaces
9. Roofing products (Cool roof)
10. Air retarding wrap

Plan checkers should verify that insulation levels, fenestration U-factors, and SHGCs listed on the CF1R are consistent with the plans and specifications.

If registration of the CF1R is required (see Chapter 2 for requirements), the building owner, or the person responsible for the design must submit the CF1R to the HERS provider data registry for retention following the procedures described in Chapter 2 and in ~~Reference Residential Appendix~~ RA2.

~~B.~~3.7.2 *Construction*

During the construction process, the contractor and/or the sub-contractors shall complete the necessary sections of the Certificate of Installation (CF2R):

1. Fenestration/Glazing. The glazing contractor lists all the fenestration products that are installed in the building along with the model number, the manufacturer number, the U-factor and the SHGC. The installer should ~~E~~ensure that the dynamic glazing controls are functional with Energy Management Systems or similar.
2. Building Envelope Leakage Diagnostics. This is applicable only if the builder/contractor does blower door testing to reduce building envelope leakage.
3. Insulation Installation Quality Certificate. The insulation contractor documents the insulation installation quality features that have been followed as shown on the CF2R checklist.
4. Description of Insulation. The insulation contractor documents the insulation materials installed in the walls, roofs, and floors along with the brand name of the materials and the thermal resistance.

The building official (field inspector) will visit the site multiple times during the construction process. The purpose of these visits is to verify that the equipment and materials installed are consistent with the plans and specifications.

If registration of the CF2R is required, the licensed person responsible for the installation must submit the portion of the CF2R information that applies to the installation to a HERS provider data registry using procedures described in Chapter 2 and in ~~Reference Residential Appendix~~ RA2.

~~3.14~~3.8 ~~Glossary/~~References

~~The Reference Joint Appendices~~ JA1 contains a glossary of terms. The following terms either ~~expand~~expands on those listed in the Reference Appendices or are provided here to better clarify compliance issues for the building envelope.

~~A.~~3.8.1 *Building Orientation*

~~B.~~ Orientation of the building, particularly walls and fenestration, can impact its energy use. Orientation is also critical for sizing and installing renewable energy sources, such as solar thermal collectors for domestic water heating and solar electric collectors to help offset electrical demand.

~~C.~~A. **East-Facing-** "East-facing is oriented to within 45 degrees of true east, including 45°0'0" south of east (SE), but excluding 45°0'0" north of east (NE)." [§100.1] The designation "East-Facing" is also used in production buildings using orientation restrictions (e.g., Shaded Areas: East-Facing).

~~D.~~B. **North-Facing-** "North-facing is oriented to within 45 degrees of true north, including 45°0'0" east of north (NE), but excluding 45°0'0" west of north (NW)." [§100.1]

~~E.~~C. **South-Facing-** "South-facing is oriented to within 45 degrees of true south, including 45°0'0" west of south (SW), but excluding 45°0'0" east of south (SE)." [§100.1] The designation "South-Facing" is also used in production buildings using orientation restrictions (e.g., Shaded Areas: East-Facing).

~~F.~~D. **West-Facing-** "West-facing is oriented to within 45 degrees of true west, including 45°0'0" due north of west (NW) but excluding 45°0'0" south of west (SW)." [§100.1]. The designation "West-Facing" is also used in production buildings using orientation restrictions (e.g., Shaded Areas: West-Facing).

~~1.~~3.8.2 *Fenestration Terminology*

~~**A. General Terms**~~

The following terms are used in describing fenestration products~~.~~:

~~1.~~A. **Center of Glass.** ~~U-factor, Solar Heat Gain Coefficient (SHGC) and Visible Transmittance (VT).~~ The U-factor, SHGC and VT are measured only through glass at least 2.5 inches from the edge of the glass or dividers.

~~2.~~B. **Clear glass:** ~~L~~ has ~~l~~little if any observable tint ~~with~~. A~~an IG unit with an SHGC of 0.5 or greate~~r.

C. **Divider (Muntin)**. An element that actually or visually divides different lites of glass. It may be a true divided lite, between the panes, and/or applied to the exterior or interior of the glazing.

D. **Dynamic Glazing.** ~~is g~~ Glazing systems that have the ability to reversibly change their performance properties, including U-factor, Solar Heat Gain Coefficient (SHGC), and/or Visible Transmittance (VT) between well-defined end points.

~~**Dynamic Glazing:**~~

~~1.~~ Includes active materials (e.g. electrochromic) and passive materials (e.g. photochromic and thermochromic) permanently integrated into the glazing assembly. Electro-chromatic glass ~~that~~ darkens by demand or lightens up when more free daylight or solar heat is desired. ~~?~~ Improved glasses decreases the Solar Heat Gain Coefficient (SHGC) in the summer and reduces heat loss in the winter and are glazing systems that have the ability to reversibly change their performance properties, including U-factor, Solar

Heat Gain Coefficient (SHGC), and/or Visible Transmittance (VT) between well-defined end points.

Integrated shading systems is a class of ~~fenestration~~, products including an active layer: e.g. shades, louvers, blinds or other materials ~~permanently integrated between two or more glazing layers~~ and that has the ability to reversibly change ~~their~~ performance properties, including U-factor, Solar Heat Gain Coefficient (SHGC), and/or Visible Transmittance (VT) between well-defined end points.

E. **Chromogenic** is a class of switchable glazing which includes active materials (e.g. electrochromic) and passive materials (e.g. photochromic and thermochromic) permanently integrated into the glazing assembly.

~~Integrated shading systems is a class of fenestration products including an active layer: e.g. shades, louvers, blinds or other materials permanently integrated between two or more glazing layers.~~

F. **Fixed glass~~:~~.** The fenestration product cannot be opened.

G. **Gap Width.** The distance between glazings in multi-glazed systems (e.g., double-or triple-glazing). This dimension is measured from inside surface to inside surface. Some manufacturers may report "overall" IG unit thickness which is measured from outside surface to outside surface.

H. **Grille**. See Divider.

I. **IG Unit**. Insulating glass unit. An IG unit includes the glazings, spacer(s), films (if any), gas infills, and edge caulking.

J. **Hard Coat.** A pyrolytic low-e coating that is generally more durable but less effective than a soft coat. See separate glossary term for low-e coating.

K. **Light or Lite**. A layer of glazing material, especially in a multi-layered IG unit. Referred to as panes in §110.6 when the lites are separated by a spacer from inside to outside of the fenestration.

Low-e Coatings.

L. Low-emissivity coatings are special coatings applied to the second ~~or third~~, surfaces in double-glazed windows or skylights. As the name implies the surface has a low emittance. This means that radiation from that surface to the surface it “looks at” is reduced. Since radiation transfer from the hot side ~~of the window~~ to the cool side ~~of the window~~ is a major component of heat transfer in glazing, low-e coatings are very effective in reducing the U-factor. They do nothing, however, to reduce losses through the frame.

In the residential market, there are two kinds of low-e coatings:

1. ~~l~~Low solar gain ~~and high solar gain. Low-solar gain~~ low-e coatings are formulated to reduce air conditioning loads. Fenestration products with low solar gain low-e coatings typically have an SHGC of 0.40 or less. Low-solar gain low-e coatings are sometimes called spectrally selective coatings because they filter much of the infrared and ultra-violet portions of the sun’s radiation while allowing visible light to pass through.
2. High solar gain low-e coatings, by contrast, are formulated to maximize solar gains. Such coatings would be preferable in passive solar applications or where there is little air conditioning.

Another advantage of low-e coatings, especially low solar gain low-e coatings, is that when they filter the sun’s energy, they generally remove between 80 percent and 85 percent of the ultraviolet light that would otherwise pass through the window and damage fabrics and other interior furnishings. This is a major advantage for homeowners and can be a selling point for builders.

~~**Low-e Coating.** A transparent or semitransparent metallic coating applied to glazing that reduces the emittance of the surface and that usually affects the solar heat gain of the glass. Low-e stands for low-emissivity. The coating (or film) is generally between glazings in double-pane or triple-pane fenestration products.~~

M. **Mullion**. A frame member that is used to join two individual windows into one fenestration unit.

N. **Muntin**. See Dividers.

O. **National Fenestration Rating Council** is the entity recognized by the Energy Commission to supervise the rating and labeling of fenestration products. NFRC lists the Certified Product Directory, containing NFRC certified U-factors ~~and~~ SHGC values for thousands of residential fenestration products see http://www.nfrc.org

Fenestration product performance data used in compliance calculations must be provided through the NFRC rating program and must be labeled by the manufacturer with the rated U-factor and SHGC in accordance with §10-111 procedures.

~~The U-factor for the center of glazing area; The U value measured at the center of a glazing assembly is the U value of the glazing itself. Not accounting for the edge affect or the U-factor of the framing.~~

Estimating the rate of heat transfer through a fenestration product is complicated by the variety of frame configurations for operable ~~windows~~, the different combinations of materials used for sashes and frames, and the difference in sizes available in various applications. The NFRC rating system makes the differences uniform, so that an entire fenestration product line is assumed to have only one typical size. The NFRC rated U-factor may be obtained from a directory of certified fenestration products, directly from a manufacturer's listing in product literature, or from the product label.

P. **Nonmetal Frame**. Includes vinyl, wood, or fiberglass. Vinyl is a polyvinyl chloride (PVC) compound used for frame and divider elements with a significantly lower conductivity than metal and a similar conductivity to wood. Fiberglass has similar thermal characteristics. Non-metal frames may have metal strengthening bars entirely inside the frame extrusions or metal-cladding only on the surface.

Q. **Operable**. The fenestration product can be opened for ventilation.

R-value

R. ~~R-va.lue is a~~ A measure of a material's thermal resistance, expressed in ft²(hr)°F/Btu. R-value is the inverse of U-factor. A higher R-value and lower U-factor indicate higher energy efficiency.

The rated R-value of fiberglass (batt) insulation is based upon its fully expanded thickness and may be obtained from the Reference Joint Appendices JA4, Table 4.6.2 or from the manufacturer's literature. When the insulation is compressed, the R-value is reduced. The most common insulation compression occurs with R-19 and R-22 insulation batts installed in locations with a nominal 6-inch framing that is actually only 5.5 in. thick. To achieve its rated insulation value, an R-19 batt of insulation expands to a thickness of six and one quarter inches. If it is compressed into 2x6 framing with an actual depth of 5.5 inches, the insulation
R-Value is lowered to 17.8.

S. **Soft Coat**. A low-e coating applied through a sputter process. See separate glossary term for low-e coating.

Solar Heat Gain Coefficient (SHGC).

T. ~~Solar heat gain coefficient (SHGC) is a~~A measure of the relative amount of heat gain from sunlight that passes through a fenestration product. 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.

~~SHGCc is the SHGC for the center of glazing area;~~ SHGC or SHGCt is the SHGC for the total fenestration product and is the value used for compliance with the Standards.

U. **Spacer or Gap Space.** A material that separates multiple panes of glass in an insulating glass unit.

V. **Thermal Break Frame.** Includes metal frames that are not solid metal from the inside to the outside, but are separated in the middle by a material, usually vinyl or urethane, with a significantly lower conductivity.

W. **Tinted**. Darker gray, brown or green visible tint. ~~Also, low-e or IG unit with an SHGC less than 0.5.~~

U-factor. ~~**of Fenestration Products**~~

X. A ~~U-factor is a~~ measure of how much heat ~~passes~~ 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 ft² of window area per degree °F of temperature difference (Btu/hr-ft²-°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 ~~windows~~, the frame losses can be significant.

Y. **Visible Transmittance (~~-~~VT)** is~~. T~~ the ratio of visible light transmitted through the fenestration. The higher the VT rating, the more ~~light~~ is allowed through a window.

Z. **Window Films** are composed of a polyester substrate to which a special scratch resistant coating is applied on one side, with a mounting adhesive layer and protective release liner applied to the other side.

~~**Low-e Coatings**~~

~~Low-emissivity coatings are special coatings applied to the second or third surfaces in double-glazed windows or skylights. As the name implies the surface has a low emittance. This means that radiation from that surface to the surface it "looks at" is reduced. Since radiation transfer from the hot side of the window to the cool side of the window is a major component of heat transfer in glazing, low-e coatings are very effective in reducing the U-factor. They do nothing, however, to reduce losses through the frame.~~

~~In the residential market, there are two kinds of low-e coatings: low solar gain and high solar gain. Low-solar gain low-e coatings are formulated to reduce air conditioning loads. Fenestration products with low solar gain low-e coatings typically have an SHGC of 0.40 or less. Low-solar gain low-e coatings are sometimes called spectrally selective coatings because they filter much of the infrared and ultra-violet portions of the sun's radiation while allowing visible light to pass through. High solar gain low-e coatings, by contrast, are formulated to maximize solar gains. Such coatings would be preferable in passive solar applications or where is little air conditioning.~~

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~~National Fenestration Rating Council~~

~~The National Fenestration Rating Council (NFRC) is the entity recognized by the Energy Commission to supervise the rating and labeling of fenestration products. NFRC list the Certified Product Directory, containing NFRC certified U-factors and SHGC values for thousands of residential fenestration products see http://www.nfrc.org~~

~~Fenestration product performance data used in compliance calculations must be provided through the NFRC rating program and must be labeled by the manufacturer with the rated U-factor and SHGC in accordance with §10-111 procedures.~~

~~R-value~~

~~R-value is a measure of a material's thermal resistance, expressed in ft²(hr)°F/Btu. R-value is the inverse of U-factor. A higher R-value and lower U-factor indicate higher energy efficiency.~~

~~The rated R-value of fiberglass (batt) insulation is based upon its fully expanded thickness and may be obtained from the Reference Joint Appendices JA4, Table 4.6.2 or from the manufacturer's literature. When the insulation is compressed, the R-value is reduced. The most common insulation compression occurs with R-19 and R-22 insulation batts installed in locations with a nominal 6-inch framing that is actually only 5.5 in. thick. To achieve its rated insulation value, an R-19 batt of insulation expands to a thickness of six and one quarter inches. If it is compressed into 2x6 framing with an actual depth of 5.5 inches, the insulation R-Value is lowered to 17.8.~~

~~Solar Heat Gain Coefficient~~

~~Solar heat gain coefficient (SHGC) is a measure of the relative amount of heat gain from sunlight that passes through a fenestration product. 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.~~

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~~Divider (Muntin). An element that actually or visually divides different lites of glass. It may be a true divided lite, between the panes, and/or applied to the exterior or interior of the glazing.~~

~~**Dynamic Glazing:**~~

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~~**R-value**~~

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~~**North-Facing**- "North-facing is oriented to within 45 degrees of true north, including 45°0'0" east of north (NE), but excluding 45°0'0" west of north (NW)." [§100.1]~~

~~**South-Facing**- “South-facing is oriented to within 45 degrees of true south, including 45°0’0” west of south (SW), but excluding 45°0’0” east of south (SE).” [§100.1] The designation “South-Facing” is also used in production buildings using orientation restrictions (e.g., Shaded Areas: East-Facing).~~

~~**West-Facing**- "West-facing is oriented to within 45 degrees of true west, including 45°0'0" due north of west (NW) but excluding 45°0'0" south of west (SW)." [§100.1]. The designation “West-Facing” is also used in production buildings using orientation restrictions (e.g., Shaded Areas: West-Facing).~~

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Table of Contents

9. Additions, Alterations and Repairs

9.1 Introduction

This chapter covers key aspects of how the Standards apply to construction of residential additions, alterations to an existing residential building, or both. As explained further below, the Standards do not apply to repairs*.*

The chapter is organized as follows:

1. **Section 9.1, Introduction.** Highlights the applicable Standards definitions for additions, alterations and repairs; and provides several examples of each.
2. **Section 9.2, What's New in the 2016~~3~~ Standards.** Highlights of the requirements and compliance options which have changed or are entirely new in the 201~~3~~6 Standards as compared with the ~~2008~~ 2013 Standards.
3. **Section 9.3, Compliance Approaches.** An overview of all prescriptive and performance compliance options available to meet the Standards for additions only, for alterations only and for projects which include both additions and alterations.
4. **Section 9.4, Mandatory Requirements.** Mandatory requirements for additions and alterations as they apply to the envelope, fenestration, mechanical system, water heating system, indoor lighting, and outdoor lighting.
5. **Section 9.5, Additions.** Detailed information on prescriptive and performance compliance methods and related information for additions, with or without alterations.
6. **Section 9.6, Alterations.** Detailed information on prescriptive and performance compliance methods and related information for alterations, with or without an addition.
7. **Section 9.7 Performance Method.** An explanation of the Existing + Addition + Alteration Approach with examples.
8. ~~**Section 9.8 Online Registration.** Compliance Forms and Online Registration with a HERS Provider.~~

Whenever additions and alterations trigger mandatory measures - whether envelope, mechanical, water heating, indoor lighting or outdoor lighting - the Certificate of Compliance and the Mandatory Measures Summary must be submitted with the permit documentation and included in the building plans.

When additions and alterations include changes to the envelope, mechanical and/or water heating systems, a Certificate of Compliance must be completed prescriptively or generated by compliance software with the performance approach. The prescriptive Certificate of Compliance that should be used for additions and alterations in all climate zones is the CF1R-ADD or CF1R-ALT form. For HVAC-only change-outs and other mechanical system alterations, a climate zone specific CF1R-ALT-HVAC form for prescriptive compliance may be used. ~~Almost all~~In addition, note that most additions and alterations ~~under the 2013 Standards~~ that include changes in HVAC systems ~~also~~ will include one or more measures that require HERS Diagnostic Testing and Field Verification. When a HERS measure is specified, the Certificate of Compliance must be registered online with an approved HERS provider web site. Refer to Section 2.2.2 and to Residential Appendix RA2 for more information about document registration.

For copies of the appropriate compliance forms, refer to Appendix A.

9.1.1 Additions

An addition is any change to an existing building that increases conditioned floor area and conditioned volume. See §100.1.

Examples of projects considered as additions include:

1. Adding a conditioned sunroom or other rooms to an existing house;
2. Converting a garage or other existing unheated space into conditioned living space;
3. Enclosing and conditioning an existing patio area;
4. Obtaining a permit to legalize an existing, habitable and conditioned space that was added to a residence without a permit;
5. Adding a bay window that extends to the floor increasing both floor area and volume.

9.1.2 Alterations

~~9.1.3~~ An alteration is any change to a building's water-heating system, space-conditioning system, lighting system, or envelope that is not an addition. See §~~Section~~ 100.1.

Examples of projects considered alterations include:

1. Adding insulation to any existing exterior roof or ceiling, exterior wall, or raised floor over a crawl space, garage or unheated basement;
2. Replacing or installing a new top surface to an existing roofing assembly (re-roofing); replacing portions of or replacing the entire roof assembly;
3. Replacing existing fenestration or adding fenestration area (e.g., windows, bay windows, greenhouse/garden windows, dynamic glazing, clerestories or glass glazed doors) to existing walls;
4. Replacing an existing skylight or increasing the area of skylight to an existing roof;
5. Constructing an entirely new roof over an existing conditioned space;
6. Adding a loft within the existing conditioned volume of a residence;
7. Replacing an existing heating system or adding a heating system (e.g., furnace, wall heater, heat pump or radiant floor);
8. Replacing an existing cooling system or adding a cooling system (e,g., air conditioner or heat pump);
9. Extending or replacing an existing duct system, or adding an entirely new duct system;
10. Replacing the existing water heater or adding water heaters and/or hot water piping;
11. Replacing existing lighting or adding new hardwired lighting fixtures;
12. Adding window film, when complying under the Performance approach only.

~~9.1.4~~9.1.3 Repairs

A repair is "the reconstruction or renewal for the purpose of maintenance of any component, system, or equipment of an existing building. Repairs shall not increase the pre-existing energy consumption of the repaired component, system, or equipment. Replacement of any component, system, or equipment for which there are requirements in the Standards is considered an alteration and not a repair**."** See §100.1.

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

For example, when a component, system, or equipment of 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, it is decided to replace the component, system or equipment with a new or different one, the scope of work is considered an alteration and not a repair and requirements of the Standards pertaining the that measure must be met.

Examples of work considered repairs include:

1. Replacing a broken pane of glass but not replacing the entire window;
2. When fenestration and other envelope components are uninstalled for maintenance or repair purposes and the same fenestration or other envelope components are re-installed in the same location, this is considered a repair;
3. When any existing envelope component is moved to a new location (even when that location partially overlaps the item's previous location), the work is considered an alteration;
4. Replacing a failed fan motor or gas valve in a furnace but not replacing the entire furnace;
5. Replacing a heating element in a water heater but not replacing the entire water heater.

Note, replacement of some HVAC components for repairs purposes are defined by the Standards as alterations, therefore triggering requirements that must be met. §~~Section~~ 150.2(b)1E defines the following HVAC component replacements as an alteration that triggers the requirement for duct sealing: *"replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, or cooling or heating coil."* Similarly, if more than 40 ~~lineal~~ linear feet of new or replacement space conditioning ducts are installed then the entire duct system must be insulated, sealed, tested and verified for low duct leakage (see §150.2(b)1D).

Example 9-1

Question

A sunspace addition is designed with no mechanical heating or cooling and a glass sliding door separating it from all existing conditioned space. This design is approved by the enforcement agency as non-habitable or unimproved space. Under what conditions will the Energy Standards apply to this addition?

Unconditioned Sunspace

Answer

The mechanical and envelope requirements of the Energy Standards do not apply if the space is not considered habitable or improved and therefore can be unconditioned as defined in §100.1; however, per §100.0(c)2, the sunspace must still comply with the applicable lighting requirements of §150.0(k). The sunspace is unconditioned if:

▪ The new space is not provided with heating or cooling (or supply ducts)

▪ All openings between the new space and the existing house can be closed off with weather-stripped doors and windows

▪ The addition is not indirectly conditioned space (defined in §100.1 under CONDITIONED SPACE, INDIRECTLY)

A building official may require a sunspace to be conditioned if it appears to be habitable space, in which case the Energy Standards apply.

Example 9-2

Question

An existing duplex is remodeled, which includes only the installation of new faucets, and bathroom lighting. Do the Energy Standards apply?

Answer

This is an alteration since no new conditioned space is being created, the remodel must comply with applicable mandatory measures described in §110.1 for appliances and §150.0(k) for lighting.

Example 9-3

Question

An existing house is remodeled by adding additional floor area but not increasing the volume of the house. This was accomplished by adding a loft through an area in the house with a vaulted ceiling. As part of this remodel new ~~fenestration~~ windows are replacing existing ones, and two new windows are being added. Several exterior walls are being opened up to install new wiring. What requirements will apply?

Answer

Since floor area is being added but not conditioned volume, this is an alteration and not an addition. New and replacement ~~fenestration~~ windows must meet the maximum U-factor and SHGC prescriptive requirements of §150.2(b)1. Newly installed windows~~fenestration~~ must also comply with the mandatory measures for caulking/sealing around windows per~~of~~ §110.7. In alterations, ~~the Energy~~it is ~~Commission~~ recommended~~s~~ to install~~ing~~ insulation in the exposed~~to~~ walls ~~being exposed~~ if no insulation was found when the walls were opened; for ~~a~~ 2x4 wood framing ~~use~~ install R-13 and for 2x6 wood framing install~~use~~ R-19.

Alternatively, the performance approach may be used to demonstrate compliance for overall building (the entire house) even if individual windows fail to meet the prescriptive requirements, as long as the building meets all applicable mandatory requirements. At this time, since the exterior walls are exposed or open, this allows the opportunity to insulate the walls and contribute the ability to meet energy compliance; otherwise it would be difficult to comply with overall building compliance.

9.2 What's New in the ~~2013~~ 2016 Energy Standards

The ~~2013~~ 2016 Energy Standards includes new mandatory measures and different compliance requirements for additions and alterations. This section highlights the key changes from the ~~2008~~ 2013 Standards.

~~1.5.1~~
~~2.5.1~~
~~3.5.1~~
~~4.5.1~~
~~5.5.1~~
~~6.5.1~~
~~7.5.1~~

~~8.5.1~~

~~9.5.1~~9.2.1 Mandatory Measures in Additions and Alterations

~~9.2.1~~ 9.2.1.1 Envelope

A. Ceiling and Rafter Roof: Insulation shall be insulated between wood-framing members with insulation R-value of R-22 or a weighted average U-factor not exceeding U-0.043. Depending on the attic ventilation, insulation shall be installed either:

1. At the ceiling level for a ventilated attic.
2. At either the ceiling or roof level for an unvented attic.

B. Additions of roofs and ceilings that are 700 ft² ~~square feet~~ or less shall meet the mandatory insulation requirement of §150.0(a)

~~9.2.2~~ 9.2.1.2 ~~Wall Insulation:~~

~~1. **Walls: exterior walls built with 2x6 or greater framing must have a minimum of R-19 cavity insulation or achieve a U-factor = 0.074. See §150.0(c);**~~

~~2. **Raised-floor insulation: raised floors must have a minimum of R-19 insulation between framing members or achieve the equivalent U-factor as specified in §150.0(d);**~~

~~3. **Fenestration: the area-weighted average U-factor of all new and replacement fenestration must have a maximum value of 0.58; §150.0(q); Exception: up to 10 square feet or 0.5% of the conditioned floor area, whichever is greater, is exempt from the maximum fenestration U-factor requirement.**~~

~~9.2.3~~ HVAC and Water Heating

~~New piping insulation requirements per Table 120.3A include:~~

~~1. All piping with a ¾ inch (19 mm) or larger diameter must be insulated as specified in §150.0(j);~~

~~All hot water pipes from the heating source to the kitchen fixtures must be insulated as specified in §150.0(j); Exceptions: piping in walls which meet Quality Insulation Installation (QII) criteria; and inaccessible existing piping.~~ Liquid line filter driers are required for new HVAC systems or replaced condensers when provided by the manufacturer ~~.~~ of the system.

~~2.~~

~~9.2.4~~ 9.2.1.3 Ducts and Air Distribution Systems

Installation of all new (or full replacement) duct systems:

1. Higher duct insulation levels for ducts located in unconditioned space resulting in either R-6 or R-8 dependent on climate zone §150.2(b)1D.
2. New target leakage level of 5% for entirely new or complete replacement duct systems §150.2(b)1D.

~~1. **Duct system sealing and leakage testing and field verified per RA3.1.4.3; online registration of the CF1R form with a HERS provider as specified in**~~ RA2 ~~**§150.0(m);**~~

~~2. **Zonally controlled central forced air systems must deliver greater than 350 CFM/ton of nominal cooling and have a fan efficacy less than 0.58 W/CFM; accordance to the procedures as specified in Residential Reference Appendix RA3.3 with online registration of the CF1R form with a HERS provider as specified in**~~ RA2 ~~**§150.0(m);**~~

~~3. **Additions must meet the mechanical ventilation requirements in ASHRAE Standard 62.2 (*not a new requirement*);**~~ and ~~**the whole building ventilation airflow must be in accordance to the procedures as specified in Residential Reference Appendix RA3.7 with online registration of the Certificate of Compliance with a HERS provider as specified in**~~ RA2 ~~**§150.0(o).**~~

~~9.2.5~~ 9.2.1.4 Lighting

~~1. Simplified requirements for classifying "high efficacy" luminaires (lighting fixtures) per Tables 150.0-A and 150.0-B as specified in §150.0(k);~~

~~2. An Energy Management Control System (EMCS) or multi-scene programmable controller may be used to comply with dimmer requirements if specific listed requirements are met. See §150.0(k);~~

~~3. An Energy Management Control System (EMCS) may be used to comply with vacancy sensor requirements if specific listed conditions are met See §150.0(k);~~

~~4. A minimum of one high efficacy luminaire shall be installed in each bathroom, and all other bathroom lighting shall be high efficacy or controlled by vacancy sensors. See §150.0(k).~~

The 2016 Energy Standards have simplified the residential lighting requirements with the following important changes:

1. All installed luminaires ~~have to~~ must be high efficacy light sources as specified in Table 150.0-A of the Energy Standards. This change eliminates the previously required kitchen wattage calculation.
2. The definition of high efficacy lighting has been expanded to include luminaires (including screw based luminaires) that are installed with light sources or lamps that meet the requirements of ~~Reference Joint Appendix~~ JA8. This allows for installation of efficient lamps to be used for compliance ~~considered as complying~~ with §150.0(k).
3. The only place screw based luminaires cannot be used is for ~~R~~recessed downlights ~~luminaires~~ in ceilings. R~~r~~ecessed downlights are required to contain JA8 compliant light sources that also meet elevated temperature requirements. ~~Recessed downlights with screw based sockets are no longer permitted to be installed under the 2016 Energy Standards.~~

More details of the 2016 Energy Standards residential lighting requirements can be found in Chapter 6.

~~1.3.2~~

~~2.3.2~~

~~3.3.2~~

~~4.3.2~~

~~5.3.2~~

~~6.3.2~~

~~7.3.2~~

~~8.3.2~~

~~9.2.6~~9.2.2 Prescriptive Additions

1. All new size (conditioned floor area) categories and new special requirements for prescriptive additions as outlined in this section and Tables 9-~~-~~3A through 9-3E.

2. Extensions of existing wood-framed walls may retain the dimensions of the wall being extended. For example, continuous insulation would not be required for an extension if the existing wall did not already have continuous insulation. Wall extensions shall be insulated with cavity insulation of R-15 in 2x4 framing and R-19 in 2x6 framing.

~~1. Additions ≤ 400 ft2 are allowed a Total Glazing Area up to 75 ft2 or 30% of Conditioned Floor Area, whichever is greater; and have up to 60 ft2 West-Facing Glazing Area. See §150.2(a)1B;~~

~~2. Additions > 400 ft2 and ≤ 700 ft2 are allowed a Total Glazing Area up to 120 ft2 or 25% of Conditioned Floor Area, whichever is greater; and have up to 60 ft2 West-Facing Glazing Area, see §150.2(a)1B;~~

~~3. Additions > 700 ft2 are allowed a Total Glazing Area up to 175 ft2 or 20% of Conditioned Floor Area, whichever is greater; and have West-facing Glazing Area up to 70 ft2 or 0.5% of Conditioned Floor Area, whichever is greater. See §150.2(a)1.A;~~

~~4. Additions > 1,000 ft^2 must meet Package A whole house fan requirements, while Additions ≤ 1,000 ft^2 are exempt. See §150.2(a), EXCEPTION 6 to §150.1(c)12.~~

~~Note: None of the above options allows credit for glazing when removed to make way for the addition.~~

~~9.2.7~~9.2.3 Prescriptive Alterations

~~1. The total fenestration area and west-facing area limitations include vertical glazing and skylights;~~

~~Up to 75 square feet of vertical fenestration is exempt from the total area and west-facing area limitations.~~

~~2.~~ New requirements for duct insulation apply when the new ducts are located in unconditioned spaces.

~~9.2.8~~9.2.4 Performance Approach - Existing + Addition + Alterations (E+A+A)

1. Performance compliance may not be used for tradeoffs unless there are at least two or more altered components listed in §Table 150.2-~~B~~C;
2. Existing roofs/ceilings removed as part of an addition or alteration -- and all existing skylights being removed as part of the removed roofs/ceilings - are excluded (not modeled) in the Existing + Addition + Alterations (E+A+A) performance calculations;
3. Existing exterior walls removed as part of an addition or alterations -- and all existing vertical fenestration (windows, clerestories, glazed doors) being removed as part of the removed walls -- are excluded (not modeled) in the ~~Existing + Addition + Alterations~~E+A+A performance calculations;
4. Only "Existing", "Altered" and "New" building components and/or systems are included and modeled in the ~~Existing + Addition + Alterations~~E+A+A performance calculations;
5. Existing fenestration not being removed as part of an alteration can now be improved with Window Films and can be modeled in the ~~Existing + Addition + Alterations~~E+A+A performance calculations;
6. Without Third Party Verification of the building's existing (i.e., pre-alteration) conditions, the E+A+A approach no longer provides energy credits based on altered components which upgrade (improve) the existing conditions. See §150.2(b)2B and Table 150.2-~~B~~C of the Energy Standards;
7. With Third Party Verification of the building's existing (i.e., pre-alteration) conditions, the E+A+A approach still provides energy credits based on altered components which upgrade (improve) the existing conditions. See §150.2(b)2B and Table 150.2-~~B~~C of the Energy Standards.

See Table 9-4 in this chapter for a summary of how the compliance software sets the Standard Design (energy budget) for alterations.

~~For further discussion on how Energy Commission-approved 2013 compliance software programs have changed from the 2008 compliance software, see Chapter 8.~~

9.3 Compliance Approaches

Apart from meeting all applicable mandatory requirements as outlined in Section 9.4, an addition or alteration must also demonstrate energy compliance using a prescriptive or performance method.

There are number of different compliance alternatives or compliance paths to demonstrate that an addition or alteration meets the Energy Standards. Compliance alternatives depend on whether the scope of permitted work is:

1. **Addition ~~Only~~ only** where no changes are being made to the existing building except removal of roofs, exterior walls and floors required as a result of the addition; and

removal of any fenestration in those same removed roofs and exterior walls to make way for the addition; or

2. **Alterations ~~Only~~ only** where there is no addition (i.e., no increase in conditioned floor area and volume); or
3. **Addition and Alterations** where there are both additions and alterations to the existing building.

For each of these permit scenarios, Table 9-1 summarizes the available compliance approaches for low-rise residential additions and alterations.

Table 9-1: Compliance Alternatives for Residential Additions and Alterations

Project Scope	Prescriptive Approach	Performance Approach[1, 2]
1. Addition Only:	Additions ≤400 ft²~~2~~; or	Addition Alone
	Additions >400 ft²~~2~~ and ≤700 ft²~~2~~	
	Additions >700 ft²~~2~~; or	
2. Alteration Only:	Meet All Applicable Requirements for Prescriptive Alterations	Existing + Alterations Without Third Party Verification of Existing Conditions; or
		Existing + Alterations With Third Party Verification of Existing Conditions; or
		Existing + Alterations as All New Construction
3. Addition and Alteration Combined:	Meet All Applicable Requirements for Prescriptive Alterations and a Prescriptive Addition Approach (see Additions Only above)	Existing + Addition + Alterations Without Third Party Verification of Existing Conditions; or
		Existing + Addition + Alterations With Third Party Verification of Existing Conditions; or
		Existing + Addition + Alterations as All New Construction

1) In the performance method, the building must be modeled with Energy Commission-approved compliance software as explained in Chapter 8 of this Manual.

2) The Existing + Alterations performance approach with or without third party verification may be used only if there are at least two types of altered components in the existing building. This requirement does not apply to the Existing + Addition + Alterations compliance method.

_

9.3.1 ~~ADDITIONS ONLY~~ Additions Only

9.3.1.1 Prescriptive

The prescriptive standard requirements for new addition construction are listed in §150.2(a)1; however, prescriptive additions have some alternative requirements as summarized:

1. **Additions of < 300 ft^2:** ~~or less~~ ~~D~~do not require a cool roof to be installed;
2. **Additions ≤ 400 ft^2**: -Total glazing area up to 75 ft^2 or 30% of the conditioned floor area, whichever is greater; and up to 60 ft^2 of West-facing glazing area; wall insulation of R-13 is acceptable;
3. **Additions > 400 ft^2 and ≤ 700 ft^2**: Total glazing area up to 120 ft^2 or 25% of the conditioned floor area, whichever is greater; up to 60 ft^2 of West-facing glazing area; and need not exceed R-13 insulation in exterior walls;
4. **Additions > 700 ft^2**: Total glazing area up to 175 ft^2 or 20% of the conditioned floor area, whichever is greater; and up to 70 ft^2 of West-facing Glazing area.

Note that every applicable prescriptive requirement for additions must be met when using the prescriptive approach. Otherwise, the building as a whole must comply using a performance approach.

For prescriptive additions, a Certificate of Compliance (CF1R-ADD) form must be completed and submitted for permit. If any mandatory or prescriptive measures require HERS verification and/or testing, the Certificate of Compliance for the project must be registered online with a HERS provider before submittal to the enforcement agency. Refer to Section 2.5, HERS Field Verification and Diagnostic Testing and Section 2.2.2, Permit Application.

9.3.1.2 Performance

Additions may comply using the performance approach by meeting the requirements in §150.2(a)2 ~~of the Standards~~ and explained further in Section 9.5.2. The performance options are:

A. **Addition Alone**: Only the addition is modeled for compliance, and not the existing building;

B. **Existing + Addition as New Construction** Demonstrating compliance by combining existing plus addition as all new construction is another approach. This approach is used when the addition does not comply on its own. Compliance can be hard to achieve because all existing features would have to be brought up to current code.

~~B.~~ **~~.. Demonstrating compliance as a whole new building, combining existing plus the addition as all new construction, this approach is usually difficult to achieve, but still an option. Typically this approach is when the addition cannot comply on its own; it would require the existing building to help the addition to comply. Depending on the age of the existing building, the older the building the more revisions or alterations will be required to bring-in the existing and addition into compliance as a whole.~~**

~~C.~~9.3.2 A~~LTERATIONS ONLY~~lterations Only

9.3.2.1 Prescriptive

Alterations may comply prescriptively by meeting all applicable requirements in §150.2(b) ~~of the Standards~~ which are explained further in Section 9.5.1 ~~of this manual~~ and summarized in Tables 9-5A and 9-5B. Several prescriptive alteration requirements are specific to the building site climate zone. There are also a number of exceptions to the prescriptive requirements based on either climate zone or other conditions listed in the Energy Standards.

Note: Every applicable prescriptive alteration requirement must be met to use the prescriptive approach; otherwise, the building must comply using a performance approach.

Under the prescriptive alteration approach, the appropriate Certificate of Compliance (e.g., CF1R-ALT or CF1R-ALT-HVAC) form must be completed and submitted for permit. If any mandatory or prescriptive measures require HERS verification or testing (see Section 2.5, HERS Field Verification and Diagnostic Testing of this manual), the Certificate of Compliance for the project must be registered online with a HERS provider (see Section 2.3, Energy Standards Compliance Documentation of this manual) before submittal to the enforcement agency.

~~ALTERATIONS ONLY~~

9.3.2.2 Performance

Alterations may comply using the performance approach by meeting the requirements in §150.2(b)2. ~~of the Standards~~This is explained in Section 9.6.2, and summarized in Table 9-1. The main options are:

1. **Existing + Alterations:** When two or more types of components or systems are being altered in the existing building, then the Existing + Alterations performance approach may be used~~.~~;
2. **Compliance Without Third Party Verification** allows for compliance of the alterations without the need for third party inspection to verify existing conditions being altered;
3. **Compliance With Third Party Verification** allows for compliance of the alterations only with third party inspection to verify existing conditions being altered;
4. **Existing + Alterations** as new construction: Demonstrating alterations compliance as a whole new building is usually difficult to achieve, but still an option. Typically this approach is used ~~is~~ when prescriptive alterations cannot meet the prescriptive requirements in Table 150.1-A in the Energy Standards.

Note: Every applicable prescriptive alteration requirement must be met to use the prescriptive approach; otherwise, the building must comply using a performance approach.

~~A.~~

~~9.3.2~~9.3.3 ~~ADDITIONS and ALTERATIONS COMBINED~~ dditions and Alterations Combined

9.3.3.1 Prescriptive

When a low-rise residential project includes both an addition and any alterations, the prescriptive requirements for each separate condition must be met. ~~for the prescriptive approach to be used.~~ The addition may comply with any of the prescriptive addition options explained above and documented with~~by~~ the appropriate compliance forms (~~e.g~~e.g., CF1R-ADD). ~~However, t~~The alterations must also meet all prescriptive requirements, and be documented with the specific compliance forms for alterations (e.g., CF1R-ALT, CF1R-ALT-HVAC).

9.3.3.2 Performance

The performance path that includes both additions and alterations is the "**Existing + Addition + Alterations**" approach. As explained above in ~~(under Alterations Only – Performance~~Section 9.3.2.2~~)~~, there are two ways to analyze the building using this method: compliance with third party verification of all existing conditions ~~to be~~ altered; ~~and~~or compliance without third party verification. ~~See Section 9.5.2.~~

9.4 Mandatory Requirements

The mandatory measures apply to all newly added or altered envelope components ~~as they do to new construction,~~ regardless of whether the prescriptive or performance compliance method is used. This section describes the mandatory requirements for low-rise residential buildings as they apply to additions and alterations. More information on the mandatory measures ~~is~~can be found in Chapters 3, 4, 5 and 6.

9.4.1 Envelope Measures

Envelope mandatory measures are listed below, including the relevant reference in the Energy Standards and the section number in this manual. The following measures include fenestration products, ~~and~~ exterior doors, insulation, roofing products and radiant barriers. See Sections 3.2 – 3.8 ~~, 3.3, 3.4, 3.5, 3.6, 3.7, and 3.8~~ and the Energy Standards for more information.

~~1.~~A. Manufactured fenestration products and exterior doors air leakage infiltration rates, see §110.6(a)1, Section 3.5.~~2~~3.1;
B. Fenestration U-factor, SHGC, VT ratings, see §10-111, §110.6(a)2, 3 & 4, Section 3.5.3.2;
~~2.~~
~~1.~~C. Fenestration temporary and permanent labels, see §110.6(a)5, Section 3.5.3.3;
~~2.~~D. Fenestration maximum weighted average U-factor = 0.58, see §150.0(q), Section 3.5.3.4;
~~3.~~E. Installation of field-fabricated fenestration and exterior doors, see §110.6(b), Section 3.5.3;
~~4.~~F. Sealing joints and other openings, see §110.7, Section 3.6.1.1;
~~5.~~G. Certification of insulating materials, see §110.8(a), Section 3.6.1.2;
~~6.~~H. Restrictions on use of urea formaldehyde foam insulation, see §110.8(b), Section 3.6.1.3;
~~7.~~I. Flame spread insulation ratings, see §110.8(c), Section 3.6.1.4;
~~8.~~J. Insulation placement on roof/ceilings, see §150.0(a)~~110.8(e)~~, Section 3.6.1.9;
~~9.~~K. Minimum roof/ceiling insulation, see §150.0(a), Section 3.6.1.9;
~~10.~~L. Minimum roof/ceiling insulation in an existing attic, see §110.8(d)1 and §150.0(a), Section 3.6.1.9;
M. Roofing products (cool roofs) solar reflectance and thermal emittance rating and labeling, see §10-113 and §110.8(i), Section 3.6.1.7;
~~11.~~N. Radiant Barrier, see §110.8(j), Section 3.6.1.8;
~~12.~~O. Loose-fill insulation, see §150.0(b), see Section 3.6.1.10;
~~13.~~P. Minimum wall insulation, see §150.0(c), see Section 3.6.1.11;
~~14.~~Q. Minimum floor insulation, see §150.0(d), see Section 3.6.1.12;
~~15.~~R. Slab edge insulation moisture resistance and physical protection, see §150.0(~~l~~f), Section 3.6.2.3;
~~16.~~S. Insulation requirement for heated slab floors, see §110.8(g), Section 3.6.1.14;
~~17.~~T. Vapor retarder §150.0(g), see Section 3.6.1.15.

~~9.4.2~~9.4.1.1 Ceiling/Roof and Wall Insulation

~~**18.**~~ When insulation is installed in the attics of existing buildings, at least R-~~30~~ 22 shall be installed in all climate zones. When ceilings without attics are altered, at least R-19 shall be installed between wood-framing members; or enough insulation shall be installed to achieve the equivalent of R-19 insulation between wood framing members. When the space between framing members becomes accessible as a part of a ceiling/roof modification, the ceiling/roof is considered altered and the insulation measure applies.

However, if the roofing surface material is replaced but the roof sheathing is not being removed, there is no insulation requirement.

~~19.~~ Existing buildings that already have R-11 insulation installed in framed walls are exempt from the mandatory minimum R-13 or R-19 wall insulation required by §150.0(c) if the building can demonstrate performance method compliance with the walls modeled as R-11.

~~9.4.3~~9.4.1.2 Roofing Products: (Cool Roof)

~~9.4.4~~ Roofing products installed ~~either~~ to meet prescriptive requirements or to take performance compliance credit for reflectance and emittance are referred to as "cool roofs". These roofing products must be certified by the Cool Roof Rating Council (www.coolroofs.org) per §10-113 and §110.8(i).

To be considered a cool roof, the roofing products manufacturer must have its roofing product tested for solar reflectance and thermal emittance, and be listed in the Cool Roof Rating Councils (CRRC) Rated Product Directory. Figure 9-1 provides an example of an approved CRRC product label.

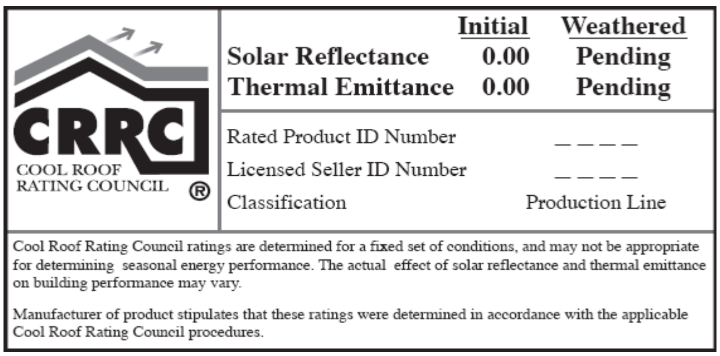


Figure 9-1 CRRC Product label and information

If the aged value for the reflectance is not available in the CRRC's Rated Product Directory then the equation below can be used until the aged rated value for the reflectance is posted in the directory.

Equation 9-1: Aged Reflectance

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

Where:

$\rho_{initial}$ = Initial Reflectance listed in the CRRC Rated Product Directory~~.~~
β = soiling resistance value ~~which is~~ listed in Table 9-2

Table 9-2 –Soiling Resistance Value β, By Product Type

PRODUCT TYPE	β
Field-applied coating	0.65
Other	0.70

~~9.4.5~~9.4.1.3 Fenestration

~~9.4.6~~ ~~Fenestration which is n~~New or replacement (altered) glazing, ~~–~~including skylights, ~~–~~must meet the maximum U-factor requirement in one of three ways:

1. ~~Every~~All fenestration products (glazed opening) must meet~~s~~ the mandatory maximum U-factor of 0.58; or
2. ~~All~~ all new or replacement fenestration combined must meet the mandatory maximum of 0.58 U-factor using an area weighted average calculation; or
3. the area of new and replacement fenestration up to 10 ft^2 or 0.5% of the conditioned floor area (CFA), whichever is greater, is exempt from the maximum U-factor requirement per Exception to §150.0(q).

Example: an existing 2,500 ft^2 house undergoes an alteration with all the existing windows being replaced. The owner may install up to 12.5 ft^2 of new glazing (i.e., up to 0.5% of 2,500 ft^2) without meeting the maximum U-factor of 0.58, ~~. I~~if the overall alterations meet the Energy Standards with the prescriptive or performance approach (see Sections 9.6).

Consistent with Exception 1 to §150.1(c)3A: For each dwelling unit, up to 3 ft^2 ~~square feet~~ of new glazing area installed in doors and up to 3 ft^2~~square feet~~ of new tubular skylight area with dual-pane diffusers shall not be required to meet or be included in the area-weighted average fenestration calculation to meet the mandatory requirement of §150.0(q).

~~9.4.7~~9.4.1.4 Greenhouse Windows

Greenhouse or garden windows are special windows that project from the façade of the building~~,~~. It ~~and are typically~~is typically ~~create~~ a five sided structure. ~~An~~ NFRC-rated U-factors for greenhouse windows ~~is~~ are ~~typically quite~~comparatively high and may not meet the mandatory U-factor requirements of 0.58.~~s for the fenestration U-factor of 0.58.~~

For new buildings, §150.0(q) includes an exception from the U-factor requirement for dual-glazed greenhouse or garden windows that total up to 30 ft^2~~square feet~~ of fenestration area.

For ~~larger greenhouse windows and~~ greenhouse and garden windows included in additions, the area-weighted average for all new and replacement fenestration must be used to show that the combined average U-factor complies with the U-factor requirement.

For alterations, dual-glazed greenhouse or garden windows are deemed to comply with U-factor requirements.

~~The three~~ two ~~ways to meet this mandatory measure for greenhouse windows are:~~

~~Must have a maximum U-factor of 0.58 or better; or~~

~~Use the area-weighted average for all new and replacement fenestration with a combined mandatory maximum of 0.58 U-factor as per §150.0(q)2; or~~

~~The Exception to §150.0(q)1 for up to 10 ft^2 or 0.5% of CFA, whichever is greater; or~~

~~When using the performance approach, Exception 1 to s. 150.2(b) states that any dual-glazed greenhouse or garden window installed as part of an alteration complies automatically with the U-factor requirements of s. 150.1(c)3. However, these windows are not exempt from the SHGC requirements of s. 150.1(c)3.~~

~~9.4.8~~9.4.2 Mechanical (HVAC) and Water Heating Measures

Mechanical (HVAC) system and water heating mandatory measures are listed below for additions and alterations. They include measures applicable to space conditioning equipment, controls and systems; water heaters, controls and systems, pool and spa equipment, controls and systems; outdoor air ventilation; pipe insulation; air ducts and plenums; and fireplaces. See Energy Standards and manual ~~S~~sections~~s~~ references below:

1. Appliance efficiencies and verification, see §110.1, Section 4.1.~~6~~4;
2. Space conditioning equipment efficiencies, see §110.2(a), Sections 4.2.1 & 4.3.1;
3. Heat pump controls, see §110.2(b), Sections 4.2.1.2;
4. Setback thermostats (in most cases), see §110.2(c), Section 4.5.1;
5. No continuously burning gas pilot lights, see §110.5, Sections 4.2.1.5; ~~& 5.2;~~
6. Heating and cooling load calculations, see §150.0(h), Sections 4.2.1.3 & 4.3.1.4;
7. Pipe insulation and refrigerant line insulation, see §150.0(j), Section~~-~~ 5.3.5.1 & 4.3.1.2~~5.2~~;
8. Duct insulation and protection of insulation, see §150.0(m), Section 4.4.1;
9. Dampers to prevent air leakage, see §150.0(m), Section 4.4.1.8;
10. Flexible duct labeling, see §150.0(m), Section 4.4.1.7;
11. Duct connections and closures, see §150.0(m), Section 4.4.1.2;
12. Duct system sealing and leakage testing, see §150.0(m)11, Section 4.4.1.12;
13. Zonally controlled central forced air systems, see §150.0(m)~~15~~13, Section 4.4.1.17;
14. Mechanical ventilation for indoor air quality, see §150.0(o), Section 4.6;
15. Fireplaces, decorative gas appliances, gas logs, see §150.0(e), Section ~~4.2.1~~3.6.1.13;
16. Water Heating Systems, see §150.0(n), Chapter 5;
17. Solar water heating, see §150.0(n)3, Section 5.5;
18. Pool systems and equipment installation, see §150.0(p), Section 5.6.

~~9.4.9~~9.4.3 Mechanical Ventilation

The whole building ventilation airflow requirement in ASHRAE 62.2 is required only in new buildings and in buildings with additions greater than 1,000 ft^2. However, all other mechanical ventilation requirements in §150(o), including local exhaust, must be met, as applicable, in all additions and alterations.

When whole-building ventilation airflow is required for compliance, field verification and diagnostic testing of airflow performance is required in accordance with the procedures in Residential Appendix RA3.7. In that case, a Certificate of Compliance CF1R form must be registered online with a HERS provider (see Section 2.5 and Appendix A).

~~9.4.10~~9.4.4 Lighting Measures

~~1.~~ Highlights of the ~~Indoor and outdoor~~residential lighting ~~mandatory~~ measures are listed below. All residential indoor and outdoor lighting measures are mandatory. Details of the 2016 Energy Standards residential lighting requirements can be found in Chapter 6~~See Chapter 6 for more information~~.

~~2.~~1. Luminaire (light~~Lighting~~ fixture) ~~(luminaire)~~ requirements, see §150.0(k)1, Section ~~6.3~~6.2;

~~3.~~2. ~~Switching devices and~~Indoor lighting controls, see §150.0(k)2, Section ~~6.5~~6.3;

~~4. Lighting in kitchens, see §150.0(k)3, Section 6.6.1;~~

~~5. Lighting internal to cabinets, see §150.0(k)4, Section 6.6.1;~~

~~6. Lighting in bathrooms, see §150.0(k)5, Section 6.6.2;~~

~~7.~~3. Lighting in bathrooms, garages, laundry rooms, and utility rooms~~garages, laundry and utility rooms~~, see §150.0(k)2J~~6~~, Section ~~6.6.3~~6.3.3;

~~8. Lighting in other rooms such as living rooms, dining rooms, bedrooms, family rooms and closets), see §150.0(k)7, Section 6.6.4;~~

~~9.~~4. Recessed ~~ceiling~~ downlight fixtures, see §150.0(k)~~8~~1C, Section ~~6.3.12~~6.2.32;

~~10.~~5. Outdoor lighting, see §150.0(k)~~9~~3, Section ~~6.7~~6.5;

~~11.~~6. Internally illuminated address signs, see §150.0(k)~~10~~4, Section ~~6.7.4~~6.5.4;

~~12.~~7. Residential g~~G~~arages for eight (8) or more vehicles, see §150.0(k)~~11~~5, Section ~~6.7.7~~6.6;

~~13.~~8. Interior common areas of low-rise multi-family buildings, see §150.0(k)~~12~~6, Section ~~6.8~~6.4.

Altered lighting and any newly installed lighting equipment ~~is~~ are required to comply with the residential lighting Standards, which apply to permanently installed lighting ~~(Section 6.3.1)~~ and associated lighting controls.

Only the lighting equipment that is altered needs to comply with the Energy Standards. Existing lighting equipment is not required to be replaced to comply with the Energy Standards.

~~If a residential kitchen has eight existing luminaires, and only two of them are altered, then only the two altered luminaires need to comply with the Standards. This means, however, that low efficacy lighting cannot be added to an altered kitchen until at least 50% of the lighting in the~~

~~finished kitchen becomes high efficacy. The newly installed lighting is also required to comply with the switching requirement.~~

Example 9-4

Question

I am doing minor renovations to my kitchen that has six recessed incandescent cans and I am adding a new luminaire over the sink. Does this luminaire have to be a high efficacy luminaire?

Answer

Yes, in kitchens all new luminaires must be high efficacy~~ until at least 50 percent of the total lighting wattage in the finished kitchen comes from high efficacy luminaires, see §150.0(k)3. The high efficacy luminaires also have to be controlled by a separate switch from the low efficacy luminaire, see §150.0(k)2~~.

~~An alternative approach to adding an extra switch and wiring is to retrofit all the pre-existing incandescent cans to high efficacy. This can be done with a California Energy Commission certified LED retrofit kit that does not have a screw base. The database of Energy Commission certified LED sources http://www.appliances.energy.ca.gov/QuickSearch.aspx. These kits require the removal of the screw (Edison) base from the luminaire and replacement with another form of electrical connection (such as GU-24 socket and base or quick-connect connectors) Exception to §150.2(b)1I. See sections 6.2.3; 6.3.5; 6.4.6; and 6.9 of the 2013 2016 Residential Compliance Manual for additional information.~~

Example 9-5

Question

In the kitchen above I am replacing one of the recessed downlight luminaires. Must the new downlight luminaire be high efficacy?

Answer

Yes, newly installed ~~the new~~ luminaires ~~is the altered component and~~ must ~~be high efficacy. In fact, all luminaire replacements must be high efficacy until at least 50 percent of the total lighting wattage in the finished kitchen comes from high efficacy luminaires~~ must be high efficacy and meet the requirements in §150.0(k). Note that screw-based sockets are not permitted for newly installed recessed downlight luminaires in ceilings.

Example 9-6

Question

I am completely remodeling my kitchen and putting in an entirely new lighting system. How do the Energy Standards apply to this case?

Answer

When an entirely new lighting system is installed, it is treated like new construction. The new lighting system must comply with all of the mandatory ~~kitchen~~ lighting requirements in §150.0(k)~~3~~1 and (k)2. ~~This includes the following:~~

~~At least half the lighting watts must be high efficacy luminaires (lighting internal to cabinets is not included in this calculation);~~

~~If all the lighting in the kitchen is controlled by vacancy sensors or dimmers in addition to high efficacy and low efficacy lighting being separately switched, an added 50 W of low efficacy lighting is allowed for dwelling units ≤ 2,500 sf and an added 100 W of low efficacy lighting allowed for dwelling units > 2,500 sf;~~

~~High efficacy and low efficacy lighting have to be controlled by separate switches as specified in §150.0(k)2.~~

~~Permanently installed lighting internal to cabinets is limited to no more than 20 watts of power per linear foot of illuminated cabinet as specified in §150.0(k)4. The linear foot of cabinet is defined as follows:~~

~~A. The horizontal length of the illuminated cabinet; or~~

~~B. One vertical length, per illuminated cabinet section, or~~

~~C. No more than one vertical length per every 40 horizontal inches of illuminated cabinet.~~

See Section ~~6.6.1~~6.2 and 6.3 of the ~~2013~~ 2016 Residential Compliance Manual for additional information.

Example 9-7

Question

I am replacing my incandescent bath bar in the bathroom. Must the new luminaire meet the Energy Standards requirements?

Answer

The new luminaire is the altered component and must meet requirements in ~~Section~~ §150.0(k) including the high efficacy luminaire and lighting control requirements. T~~Note that t~~he 2016 Energy Standards now allow the installation of JA-8 compliant lamps in screw-based fixtures as a way to comply with the high efficacy lighting requirements. See Section 6.2 and 6.3 of the 2016 Residential Compliance Manual for details. ~~It depends if there is already another luminaire in the bathroom that qualifies as high efficacy. If there are no high efficacy luminaires in the bathroom, the bath bar is the altered component and must meet the Standards requirements of §150.0(k)5, which requires at least one high efficacy luminaire in each bathroom. The alternative would be to use a low efficacy bath bar in conjunction with a vacancy sensor and have at least one other luminaire in the bathroom which is high efficacy.~~

~~Note that a luminaire with a screw-in lamp, is not considered high efficacy, even if the lamp is LED (light emitting diode) or CFL (compact fluorescent lamp).~~

~~Example 9-8~~

~~**Question**~~

~~Are there ever situations with a kitchen lighting alteration where I can end up with more than 50 percent low efficacy wattage after the alteration?~~

~~**Answer**~~

~~Yes, there is a tradeoff option which allows an additional 50W of low efficacy lighting for houses ≤ 2,500 sf and 100 W for houses > 2,500 sf if vacancy sensors or dimmers are installed to control all of the lighting in the kitchen as specified in Exception to §150.0(k)3. These controls are required in addition to low efficacy lighting being switched separately for high efficacy lighting. See Section 6.6.1 of the 2013 2016 Residential Compliance Manual for more information about the kitchen low efficacy tradeoff option.~~

9.5 Additions

For a definition of an addition in the Energy Standards, and several useful examples of additions, see the Introduction, Section 9.1 of this chapter.

For a summary of compliance alternatives for additions, see ~~see Compliance Approaches,~~ Section 9.~~2~~ 3 of this chapter.

Beyond the outline provided in Section 9.2, this section provides more specific information, descriptions and guidelines on how to meet the Energy Standards using each of the available compliance paths. Copies of compliance forms referenced here are included in the Compliance Forms Summary, Appendix A of this manual.

9.5.1 Prescriptive Requirements

In general, the prescriptive requirements apply to additions in the same way they apply to entirely new buildings and must be documented on the CF1R-ADD Form. However, there are a few exceptions as noted below and summarized in Table 9-3A.

There are three prescriptive paths available for additions based on the total conditioned floor area (CFA) of the addition. The total CFA of the addition may include floor areas representing several physically separate additions to the building under the same permit.

Table 9-3A summarizes the key features of the prescriptive envelope requirements for the three prescriptive addition options in §150.2(a)1 ~~of the Standards~~. Envelope requirements unique to that type of prescriptive addition are shown in bold face on white background. Table 9-~~3B~~ 3DE shows that all prescriptive additions have the same mechanical system and water heating system requirements as the Package A prescriptive measures for new construction listed in §150.1(c) and explained in Chapters 4 and 5. For more details on the residential envelope requirements and compliance options, refer to Chapter 3.

~~I.~~ A. Additions ≤ 400 ft²

All prescriptive Package A requirements must be met except:

1. Total glazing area may be up to 75 ft² or 30% of conditioned floor area, whichever is greater;
2. West-facing glazing area may be up to 60 ft²;
3. Required exterior wall insulation:
   a. In 2x4 wood frame walls, insulation shall be R-13 or an overall construction assembly U-factor ≤ 0.102, for wood or metal frame walls;

b. In 2x6 or greater wood frame walls, insulation shall be R-19 or an overall construction assembly U-factor ≤ 0.074, for wood or metal frame walls;

4. No requirement for a whole house fan (WHF) to provide ventilation cooling;

~~4.~~5. Roof and ceiling insulation requirements.

~~5.~~6. For additions ≤ 300 ft^2 cool roof compliance is not required.

~~J.~~B. Additions > 400 ft2 and ≤ 700 ft2 :

All prescriptive Package A requirements must be met except:

1. Total glazing area may be up to 120 ft^2 or 25% of conditioned floor area, whichever is greater;
2. West-facing glazing area may be up to 60 ft^2;
3. Required exterior wall insulation:
   a. In 2x4 wood frame walls, insulation shall be R-13 or an overall construction assembly U-factor ≤ 0.102, for wood or metal frame walls;
   b. In 2x6 or greater wood frame walls, insulation shall be R-19 or an overall construction assembly U-factor ≤ 0.074, for wood or metal frame walls;

4. No requirement for a whole house fan (WHF) to provide ventilation cooling.

~~4.~~5. Roof and ceiling insulation requirements.

~~K.~~C. Additions > 700 ft2

All prescriptive Package A requirements must be met except:

1. Total glazing area may be up to 175 ft^2 or 20% of conditioned floor area, whichever is greater;
2. West-facing glazing area may be up to 70 ft^2 or 5% of conditioned floor area, whichever is greater;
3. If the addition is ≤ 1,000 ft^2, there is no requirement for a whole house fan (WHF) to provide ventilation cooling;
4. Additions > 1,000 ft^2 must include provide ventilation cooling with a WHF as indicated in §150.1(c)12;
5. If the Total Proposed fenestration area exceeds the Standard Maximum Glazing Area of 20% then the performance compliance approach must be used. Likewise, if the Proposed West-Facing fenestration area in climate zones 2, 4, and 6-16 exceeds 5% of the conditioned floor area, then the performance compliance approach must be used;
6. If the addition has a floor area >700 ft^2 and < 1,000 ft^2, all requirements of Package A apply except the West-Facing Glazing Area may be allow up to 70 ft^2 for additions up to 1,400 ft^2 (since 70 ft^2 is 5% of 1,400 ft^2). See §150.2(a)1A.

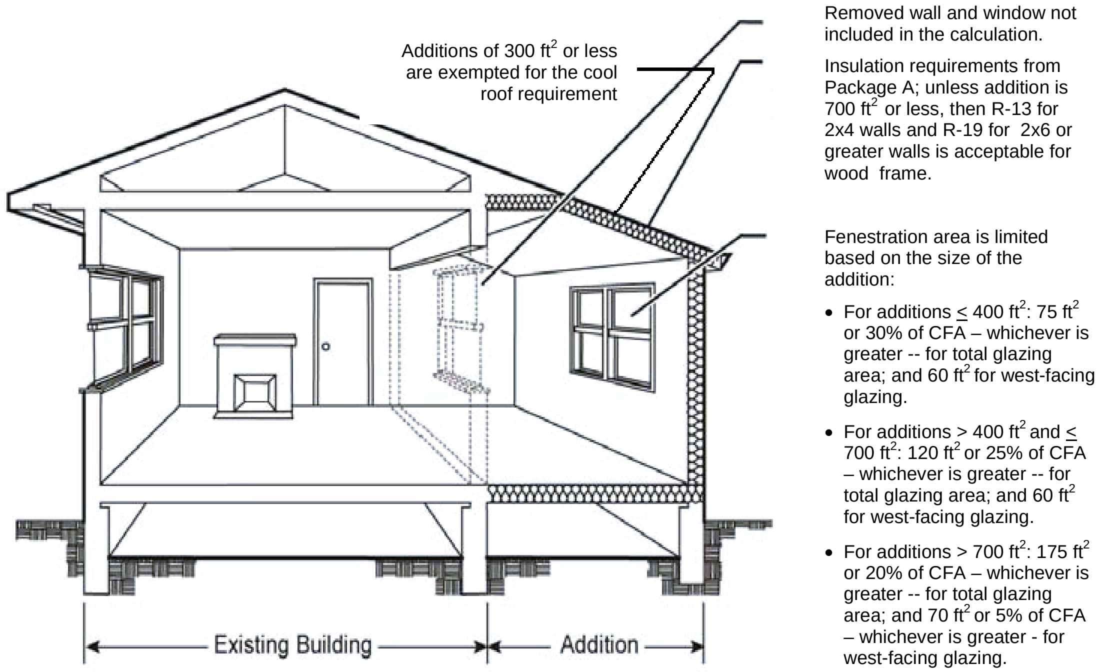


Figure 9-2 – Prescriptive Addition Envelope Requirements

9.5.2 Compliance Forms for Prescriptive Additions

The permit applicant must submit a completed version of the Certificate of Compliance, CF1R-ADD form, for prescriptive additions when less than 100 ~~ft^2~~-ft^2.~~.~~

Important note: All projects which require third party diagnostic testing and/or field verification by a HERS rater *must also have the CF1R-ADD form uploaded and registered online with a HERS provider (*see Chapter 2).

Use the CF1R-ADD form to document fenestration by orientation. The total percentage of fenestration should be no greater than the amount summarized above and in Table 9-3A. West facing area includes skylights tilted to the west or tilted in any direction when the pitch is less than 1:12 (9.5 degrees from the horizontal), and must not exceed 5 percent of the conditioned floor area (CFA) in climate zones 2, 4, and 6-16.

Note: Plan checkers will verify on the CF1R-ADD form that the Total Proposed Glazing Area is less than or equal to the Standard Maximum Glazing Area; and that the Proposed West-Facing Glazing Area is less than or equal to the Standard West-Facing Glazing Area.

~~9.5.3~~

~~9.5.4~~9.5.3 Fenestration Exceptions

New fenestration in prescriptive additions must meet the area-weighted average U-factor and SHGC requirements in §150.1(c)3A with the following exceptions particularly relevant to additions:

1. EXCEPTION 1: For each dwelling unit, up to 3 ft^2 of new glazing in doors and up to 3 ft^2 of tubular skylights with dual pane diffusers are exempt;

2. EXCEPTION 2: For each dwelling unit, up to 16 ft^2 of skylights with a maximum U-factor of 0.55 and a maximum SHGC of 0.30 is exempt.

See Section 3.5 for further information on fenestration which meets or is exempt from §150.1(c)3A in new construction.

Other Prescriptive Addition Envelope Measures

For further information on prescriptive envelope measures which are not specific to additions and not mentioned~~highlighted~~ above, see Chapter 3.

Prescriptive Mechanical Measures

For a summary and discussion of prescriptive mechanical requirements when installing new or replacement space conditioning equipment and/or ducts, see Section 9.6.1.

Example 9-8

Question

When using the performance approach for the addition alone, do the refrigerant charge requirements in §150.1(c)7A, and fan airflow and watt draw measurements in §150.0(m)13 need to be met for existing central split system air conditioners serving an addition?

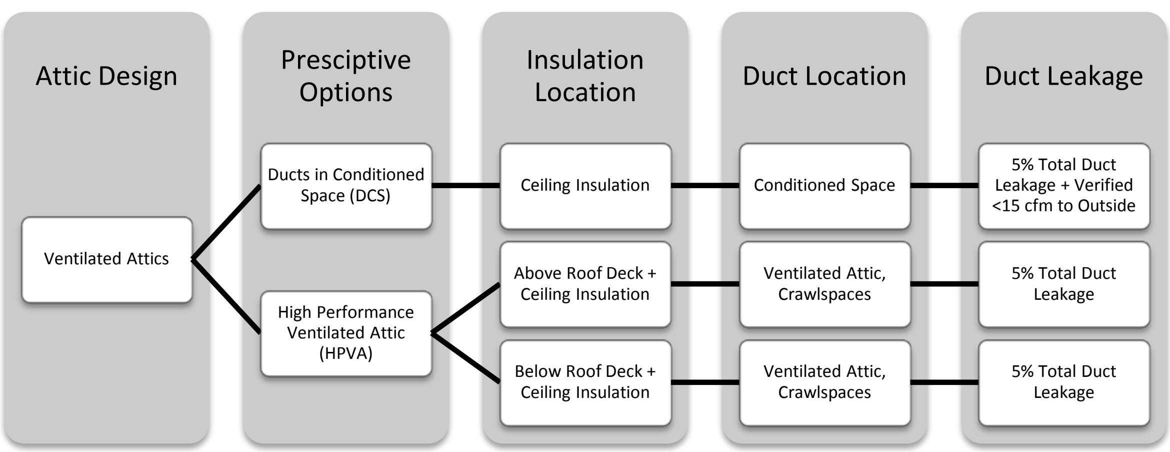
Answer

If existing equipment is used to serve the addition, the refrigerant charge, airflow and watt draw requirements do not need to be met as specified by Exception 5 to §150.2(a). However, if added ducts to serve the addition are more than 40 linear feet and they are in unconditioned space, then the ducts must be tested and verified by a HERS rater as described in §150.2(b)1D. All installed ducts regardless of their length and location shall be sealed and meet insulation levels as described in §150.0(m) items 1 through 6.

If a new central split system is installed to serve the addition, it must meet all of the requirements for air conditioners in a new residence.

Table 9-3A: Envelope Roof/Ceiling Requirements for Prescriptive Additions

Component	**Requirements of Additions ≤ 400 ft²**	**Requirements of Additions > 400 ft² and ≤ 700 ft²**	**Requirements of Additions > 700 ft²**
Roof/Ceiling Insulation:	~~Package A:~~ ~~CZ1, 11-16: R-38 / U=0.025;~~ ~~CZ2-10: R-30 / U=0.031~~<u>No requirements</u>	~~Package A:~~ ~~CZ1, 11-16: R-38 / U=0.025;~~ ~~CZ2-10: R-30 / U=0.031~~<u>No requirements</u>	<u>Package A:</u> CZ1~~, 11-16~~: R-38 / U=0.025; CZ2<u>3, 5-7</u>~~-10~~: R-30 / U=0.031 <u>CZ 4, 8-16: Option A, B, or C (see below).</u>
Roof Products (Cool Roof):	<u>Package A:</u> <u>Steep-Sloped (> 2:12)</u>: CZ10-15: Reflect.=0.20 and Emittance=0.75; or SRI=16	<u>Package A:</u> <u>Steep-Sloped (> 2:12)</u>: CZ10-15: Reflect.=0.20 and Emittance=0.75; or SRI=16	<u>Package A:</u> <u>Steep-Sloped (> 2:12)</u>: CZ10-15: Reflect.=0.20 and Emittance=0.75; or SRI=16
	<u>Package A:</u> <u>Low-Sloped (< 2:12)</u>: CZ13 & 15: Reflect.=0.63 and Emittance=0.75; or SRI=75	<u>Package A:</u> <u>Low-Sloped (< 2:12)</u>: CZ13 & 15: Reflect.=0.63 and Emittance=0.75; or SRI=75	<u>Package A:</u> <u>Low-Sloped (< 2:12)</u>: CZ13 & 15: Reflect.=0.63 and Emittance=0.75; or SRI=75
	<u>Exception</u>: Additions < 300 ft² exempt from all cool roof requirements.		
Radiant Barrier Above Attic:	<u>Package A</u>: CZ2-15: Radiant Barrier above Attic Spaces	<u>Package A</u>: CZ2-15: Radiant Barrier above Attic Spaces	<u>Package A</u>: CZ2-15: Radiant Barrier above Attic Spaces<u>, except when complying with Option B from §150.1(c)</u>



<u>Figure 9-3 Ventilated Attic Prescriptive Compliance Choices for Additions >700ft2</u>

Table 9-3B: ~~Envelope Glazing~~Roof and Ceiling Requirements for Prescriptive Additions

	Option A (CZ 4, 8-16)	*Option B (CZ 4, 8-16)*	*Option C (CZ 4, 8-16)*
Roof Deck Insulation1,2	*Above deck continuous insulation: R6 (with air space), R8 (no air space)*	*Below deck insulation: R13 (with air space), R18 (no air space)*	*None required*
Ceiling Insulation	*R38*	*R38*	*CZ 4, 8-10: R30* *CZ 11-16: R38*

1. Roof deck insulation should be installed flush with the roof deck. Above deck insulation is applied as continuous insulation. Below deck insulation is installed in the cavities between trusses.

2. A designed air space may exist between the roof deck and the finishing roofing material, triggering lower required insulation values.

Table 9-3C: Envelope Glazing Requirements for Prescriptive Additions

Component	**Requirements of Additions ≤ 400 ft^2**	**Requirements of Additions > 400 ft^2 and ≤ 700 ft^2**	**Requirements of Additions > 700 ft^2**
Total Glazing Area:	Up to 75 ft^2 or 30% of Conditioned Floor Area, whichever is greater	Up to 120 ft^2 or 25% of Conditioned Floor Area, whichever is greater	Up to 175 ft^2 or 20% of Conditioned Floor Area, whichever is greater
West-Facing Glazing Area: In Climate Zone 2, 4, 6-16	Up to 60 ft^2	Up to 60 ft^2	Up to 70 ft^2 or 5% of Conditioned Floor Area, whichever is greater
Glazing U-Factor & SHGC[1]:	Package A: All CZs: U = 0.32 CZ 2, 4 & 6-16: SHGC = 0.25	Package A: All CZs: U = 0.32 CZ 2, 4 & 6-16: SHGC = 0.25	Package A: All CZs: U = 0.32 CZ 2, 4 & 6-16: SHGC = 0.25
1. See §150.0(q) and §150.1(c)3 for new and replaced window and skylight exceptions .			

Table 9-3D~~C~~: Envelope Insulation Requirements for Prescriptive Additions

Component	**Requirements of Additions ≤ 400 ft^2**	**Requirements of Additions > 400 ft^2 and ≤ 700 ft^2**	**Requirements of Additions > 700 ft^2**
Exterior Wall[1] Insulation:	In 2x4 Framing: R-13, U=0.102 In 2x6 Framing: R-19, U=0.074	In 2x4 Framing: R-13, U=0.102 In 2x6 Framing: R-19, U=0.074	Package A: All CZs: U=0.065
Raised Floor[1] Insulation:	Package A: All CZs: R-19 or equivalent U-factor	Package A: All CZs: R-19 or equivalent U-factor	Package A: All CZs: R-19 or equivalent U-factor

Slab Floor[1] Insulation:	Package A: CZ1-15: No Requirement; CZ 16: R-7.0 or U=0.58	Package A: CZ1-15: No Requirement; CZ 16: R-7.0 or U=0.58	Package A: CZ1-15: No Requirement; CZ 16: R-7.0 or U=0.58
1. R-values refer to wood framing and U-factors refer to metal framing.			

Table 9-3E:~~D~~ HVAC and Water Heating Requirements for Prescriptive Additions

Component	Requirements of Additions < 400 ft2	Requirements of Additions > 400 ft2 and < 700 ft2	Requirements of Additions > 700 ft2
Ventilation Cooling1 (Whole House Fan)	No Requirement.	No Requirement.	Additions < 1,000 ft2: No requirement Additions > 1,000 ft2: Package A Whole House Fan, §150.1(c)12
Adding New Space Conditioning System(s)	All Package A requirements.	All Package A requirements.	All Package A requirements ~~including~~except requirements for Ducts in Conditioned Space[2] ~~where appropriate as explained in Section 3.2.6.~~
Replacing Existing Space Conditioning System(s)	All Package A requirements.	All Package A requirements.	All Package A requirements except requirements for Ducts in Conditioned Space[2] ~~where appropriate as explained in Section 3.2.6.~~
Adding All New Complete Duct System(s)	All Package A requirements.	All Package A requirements.	All Package A requirements ~~including~~except requirements for Ducts in Conditioned Space[2] ~~where appropriate as explained in Section 3.2.6.~~
Extending Existing Duct System(s) by > 40 Feet	All Package A duct insulation requirements; duct system sealing and HERS Verified	All Package A duct insulation requirements; duct system sealing and HERS Verified	All Package A duct insulation requirements; duct system sealing and HERS Verified. Except requirements for Ducts in Conditioned Space[2] .
1. (Note: also mandatory mechanical ventilation per ASHRAE 62.2 with HERS verification for additions > 1,000 ft^2) ~~1.~~2. For more information about ducts in conditioned space see Section 3.2.6			

~~9.5.10~~9.5.4 Prescriptive Water Heating System

If an addition increases the number of water heaters serving a dwelling unit, ~~then~~ the addition can comply prescriptively if any one of the following conditions contained in §150.2(a)1D.i, ii and iii are met:

~~9.5.11~~1. The additional water heater is a 50 gallon or less, gas storage or gas instantaneous, non-recirculating water heater with an EF (Energy Factor) equal to or greater than the federal minimum standards as defined in Section 5.4; or

~~1.~~2. The building does not have natural gas or propane available; and the additional water heater is a 50 gallon or less electric storage tank water heater, or electric instantaneous with an EF equal to or greater than the federal minimum standards; or

~~2.~~3. A water-heating system determined by the Executive Director of the Energy Commission to use no more energy than the one specified in item 1 above; or if no natural gas is connected to the building, a water-heating system determined by the Executive Director to use no more energy than the one specified in item 2 above.

If none of these conditions can be met when adding a water heater to an existing dwelling unit, then the prescriptive addition compliance path cannot be used. In that case, the Existing + Addition + Alterations compliance approach must be used to demonstrate overall compliance with whatever combination of existing and new water heaters serve the dwelling unit. This is summarized in §150.2(a)1D.iv and discussed as part of the overall performance method in Section 9.5.2.

For other alterations to the water heating system that occur as part of an addition, see Section 9.6.

Example 9-9

Question

A small addition of 75 ft² is being planned for a house located in climate zone 7. An existing porch off the master bedroom is being enclosed. The existing heating and air conditioning system will serve the new conditioned space including an extension of less than 40 linear feet of new ducts. The contractor wants to follow the prescriptive requirements. What requirements apply?

Answer

Since the addition is smaller than 400 ft², the total fenestration area is limited to a maximum of 75 ft² and west-facing fenestration area is limited to 60 ft². The fenestration must meet the U-factor and SHGC requirements of Package A. For climate zone 7, these fenestration requirements are a maximum U-factor of 0.32 and a maximum SHGC of 0.25. For an addition of this size, insulation only must meet the mandatory requirements of R-30 ceiling insulation; R-13 wall insulation and R-19 floor insulation. Since the addition is also less than 300 ft^2, there is no cool roof requirement.

Since the existing heating and cooling equipment is being used for the addition, that equipment does not have to meet the mandatory equipment efficiency requirements. Mandatory duct insulation requirements of §150.0(m) apply (including R-6.0 minimum in unconditioned space). All other mandatory requirements in §150.0 must be met.

Example 9-10

Question

If I remove a window from the existing house and re-use this window in an addition to that house, does the relocated window have to meet the prescriptive requirements of Package A?

Answer

Yes, if using prescriptive compliance, in which case the relocated window must be treated as a new window and must meet the U-factor and SHGC requirements of Package A, §150.1(c)3. If you use this existing window in the addition, you must use the actual or default U-factor and SHGC of the window in showing compliance. Therefore, meeting the prescriptive requirements may not be possible, and performance compliance may be the only option. Window certification and labeling requirements of §110.6(a) do not apply to existing used windows.

Relocated windows must also meet the maximum area-weighted average U-factor in §150.0(q) with the EXCEPTION of up to 10 ft² ~~square feet~~ or 0.5% of conditioned floor area, whichever is greater.

Example 9-11

Question

I am doing an alteration in Climate Zone 12 in which I am moving an existing 25 ft^2 window to another location within the same existing wall; and am not increasing total glazing area. Does the re-located window need to meet any prescriptive requirements?

Answer

Removing an area of glazing in an existing wall, and re-inserting up to the same area of glazing in a different opening, is considered replacement fenestration as defined in §150.2(b)1B. Exception 1 to §150.2(b)1B states that up to 75 ft^2 of vertical replacement fenestration in Climate Zone 12 must meet a prescriptive U-factor = 0.40 and an SHGC = 0.35.

Example 9-12

Question

For additions and alterations that include a greenhouse window (also known as garden window), what are the U factor and SHGC requirements? What is the area used for calculations for greenhouse windows?

Answer

For greenhouse windows in alterations, they must also meet the prescriptive U-factor and SHGC requirements of Package A; however, not many greenhouses can meet the new efficiency prescriptive requirements. In the performance approach, any dual-glazed greenhouse or garden window installed as part of an alteration complies with the U-factor requirements, §150.1(b)1B.

Alternatively, Greenhouse windows can also meet the prescriptive maximum area-weighted average U-factor in §150.0(q) with the Exception of up to 10 ft² ~~square feet~~ or 0.5% of conditioned floor area, whichever is greater is allowed. Note For greenhouse windows, the window area is the rough opening.

However, the SHGC for greenhouse windows must meet the requirements shown in the prescriptive Package A, or must meet the SHGC used to show compliance in the performance approach. To meet the SHGC for greenhouse windows, the proposed fenestration may use the NFRC rated SHGC or the default SHGC from Energy Standards §Table 110.6-B, if the area weighted average SHGC of the greenhouse window plus other fenestration in the proposed design meets the values used for compliance is also allowed.

For skylights, Exception to §150.1(c)3A, exempts up to two square foot of tubular skylights from the U-factor requirements, provided that the ceiling diffusers are dual-paned; and any additional skylights must meet the U-factor requirements. Skylights may use one of three methods for determining the proposed SHGC:

1) NFRC rated SHGC; or

2) Default SHGC from §Table 110.6-B; or

3) If site-built greenhouses then $SHGC_{fen}$ can be calculated from the manufacturer's center of glass SHGC (SHGCc) and using the following equation: $SHGC_{fen} = 0.08 + 0.86 \times SHGC_c$.

~~9.5.12~~9.5.5 Performance Method: Addition Alone and Existing + Addition + Alterations Approach

Additions may comply using the performance approach with one of the following compliance paths summarized in Section 9.2, Table 9-1:

1. Addition Alone;
2. E + A + A Without Third Party Verification;
3. E + A + A With Third Party Verification;
4. E + A + A as New Construction.

Energy Commission-approved compliance software is used to model the building as explained in Chapter 8. Whichever compliance path is selected, the Certificate of Compliance (CF1R) generated by the compliance software must be submitted for permit. If the CF1R includes energy measures that require HERS testing or verification, the CF1R must also be registered online with a HERS provider. See Section 2.2.2.

To learn more about what kinds of alterations are assigned energy credit using the Existing + Addition + Alterations performance approach, see Section 9.5.2.

9.5.51 Addition Alone

In this compliance scenario, the addition alone is modeled using the compliance software and the existing building is not modeled at all. This approach may work well when the existing building is not undergoing alterations, and the permitted work scope covers only the addition.

1. **Advantages**: Data for the existing building is not needed except for the total existing conditioned floor area which is used to calculate the fractional "number of dwelling units" for the addition. The existing building is not modeled and not analyzed for altered components or systems. This typically saves a large amount of time performing the analysis.
2. **Disadvantages**: If the addition includes a large area of glazing or is otherwise deficient in comparison with the prescriptive requirements, it may be difficult to demonstrate compliance under this approach. Alterations to the existing conditions

which improve the energy performance of the existing building cannot be used in this approach as “trade-offs” with the addition.

9.5.5.2 Existing + Addition + Alterations Without Third Party Verification

The existing building with all alterations is modeled together with the addition; and existing conditions are not verified by a third party HERS Rater. The Standard Design that sets the energy budget for this approach is automatically based only on the type of each altered component and not on the existing conditions. Under this performance path the building is modeled as follows:

1. Addition: All new components at the addition and all new systems serving the addition are modeled including roof/ceilings and skylights, exterior walls and glazing (fenestration), raised floors and slab floors, HVAC equipment, ducts and water heating. All these elements are tagged within the compliance software as “New”; or

2. Existing Components to Remain Unchanged: Existing components and systems to remain as is (untouched) are modeled and tagged within the compliance software as “Existing”; or

3. Existing Components to be Altered or Replaced, "Altered”: Each altered component (i.e. a new component which replaces an existing component) is modeled and tagged within the performance compliance program as "altered". Each component or system which remains is modeled and tagged within the compliance software as “Altered” such as, a new water heater that replaces an existing water heater would be labeled "altered”; a new water heater that is added to supplement an existing water heater would be labeled "new". Also, new mechanical equipment that does not replace existing mechanical equipment would be tagged as "new". No verification of existing conditions is required in this compliance path; therefore, no “Existing” (pre-alteration) conditions are specified.

Note: Portions of new fenestration including skylights that will occur in the existing opening of fenestration to be replaced are tagged "altered". Portions of new fenestration that will occur where there is no existing fenestration opening are labeled as "new".

9.5.5.3 Existing to be Removed:

Existing roof/ceilings to be removed as part of the permitted work, plus any skylights within those removed roof/ceilings, are excluded from the model (i.e., they are completely omitted from the calculations); exterior walls to be removed, and all fenestration areas in those removed walls, are not modeled; and raised floors and slab-on-grade floors to be removed are also omitted.

~~*Note: This is an important change in the E+A+A modeling rules from the 2008 Standards as discussed in Section 9.6.*~~

Advantages: Energy improvements to the existing building that go beyond the Standard Design levels are an energy credit that can be effectively “traded” against features of the addition that are less energy efficient than required by the prescriptive levels that set the Standard Design for the addition alone. For example, an addition with a large glazing area may comply by replacing the existing HVAC system with high-efficiency equipment.

Disadvantages: Detailed plans and other information on the existing building may be difficult to document and obtain. The E+A+A analysis may be relatively complex and time-consuming.

Refer to Table 9-4 for a summary of E+A+A modeling rules.

9.5.5.4 Existing + Addition + Alterations With Third Party Verification

The existing building with alterations is modeled together with the addition(s); and existing conditions of the components being altered must be verified by a third party HERS ~~R~~rater before any construction work begins. The Standard Design that sets the energy budget may, depending on the energy efficiency of the altered component or system, be based on the pre-altered existing conditions. In those instances, energy credit is calculated as a function of the difference between pre-altered existing conditions and post-alteration energy measures. Under this approach the building is modeled as follows:

1. **Addition**: All new components for the addition and all new systems serving the addition are modeled including roof/ceilings and skylights, exterior walls and glazing (fenestration), raised floors and slab floors, HVAC equipment, ducts and water heating. All these elements are tagged within the compliance software as “New”; or
2. **Existing Components to Remain Unchanged:** Existing components and systems to remain as is (untouched) are modeled and tagged within the compliance software as “Existing”; or
3. **Existing Components to be Altered or Replaced:** "Existing to be Altered: Each altered component (i.e. a new component which replaces an existing component) is modeled and tagged within the performance compliance program as "altered". Each component or system which remains is modeled and tagged within the compliance software as “Altered” such as, a new water heater that replaces an existing water heater would be labeled "altered”; a new water heater that is added to supplement an existing water heater would be labeled "new". Also, new mechanical equipment that does not replace existing mechanical equipment would be tagged as "new". No verification of existing conditions is required in this compliance path; therefore, the “Existing” (pre-alteration) conditions must be specified.

   Note: Removing an area of fenestration in an existing wall or roof, and re-inserting up to the same total area of glazing in different openings, is considered replacement or “altered” fenestration as defined in §150.2(b)1B. Any net glazing area added to the total existing fenestration in an existing wall or existing roof is considered “new” fenestration.

~~*4.*~~ **Removed Surfaces:** Existing roof/ceilings to be removed as part of the permitted work, plus any skylights within those removed roof/ceilings, are excluded from the model (i.e., they are completely omitted from the calculations). Exterior walls to be removed, and all fenestration areas to be removed in those walls, are not modeled; and raised floors and slab-on-grade floors to be removed are also omitted.

4. ~~*Note: This is an important change in the E+A+A modeling rules from the 2008 Standards summarized in Section 9.6.*~~
5. **Advantages**: Energy improvements meeting certain threshold values are credited based on the difference between existing conditions and the altered component or system. These energy credits can be effectively “traded” against features of the addition that are less energy efficient than required by the prescriptive levels that set the Standard Design for the addition alone. For example, an addition with a large glazing area may comply by upgrading insulation levels in the existing house.
6. **Disadvantages**: Detailed plans and other information on the existing building may be difficult to document and obtain. The E+A+A analysis may be relatively complex and

time-consuming. ~~And a~~A third party verification must be conducted of all existing conditions prior to construction, and ~~that~~ verification must be registered online with a HERS provider prior to permit submittal.

Refer to Table 9-4 for a summary of E+A+A modeling rules.

9.5.5.5 Existing + Addition + Alterations as New Construction

A compliance approach rarely used, but available within the Energy Standards, is to model Existing + Addition + Alterations as all "New" components and systems and the compliance software sets the energy budget as if the project were an entirely new building.

1. **Advantages:** Modeling the existing building with alterations and additions as all new makes the performance analysis relatively simple and less time-consuming. This method will provide the owner and designer with an energy efficiency compliance relative to requirements for new construction. Any owner who wants to bring their building up to new construction energy efficiency levels should have their project modeled as "new".
2. **Disadvantages:** The energy budget with this approach is very stringent. Unless a building is going through a complete retrofit of all its envelope components, as well as replacing all mechanical and water heating systems, it is unlikely that the building will meet the Energy Standards with this approach.

9.5.5.6 Summary of Modeling Rules

Table 9-4 summarizes the basic rules for compliance software users analyzing a residential addition or alteration using the Existing + Addition + Alterations approach. For further information, see the specific compliance software user's manual for details on how to input data correctly.

Table 9-4: Modeling Rules for Existing + Addition + Alterations

~~Table summarizes b~~Basic rules for a low-rise residential building using the Existing + Addition + Alterations performance approach. Note for further details reference the Residential ACM Reference Manual.		
Type of Component or System Modeled	**Standard Design Without Third Party Verification of Existing Conditions**	**Standard Design With Third Party Verification of Existing Conditions**
"EXISTING" -- Components or Systems That Remain Unchanged	Model each component or system as "Existing"	Model each component or system as "Existing"
"ALTERED" -- Components or Systems Being Changed/Replaced	Model each altered component or system as "Altered" but do not model the "Pre-Altered Existing" conditions	Model each component or system as "Altered" and also model the "Pre-Altered Existing" conditions
"NEW" -- Components or Systems Being Added	Model each component or system as "New"	Model each component or system as "New"
"REMOVED" -- Components or Systems Being Removed and Not Replaced	These components and systems are omitted entirely from the model ~~(Note: this is a change from 2008 Standards rules)~~	These components and systems are omitted entirely from the model ~~(Note: this is a change from 2008 Standards rules)~~

9.6 Alterations

This section provides a road map and a few relevant summaries that identify the Energy Standards requirements which are unique to alterations. Envelope, mechanical and water heating system alterations must meet all applicable mandatory measures as discussed in Section 9.3; and also must comply with the Energy Standards using the prescriptive or performance approach. If a building does not meet all applicable prescriptive measures, see Section 9.5.1), then the performance method using of approved compliance software is the alternative, see Section 9.5.2.

Residential lighting alterations need to meet applicable mandatory measures discussed in Section 9.3.3 since there are no prescriptive lighting requirements in residential buildings.

9.6.1 Prescriptive Requirements

Although alterations must meet many of the same prescriptive requirements for new construction and additions, there are several exceptions or special allowances for certain types of alterations. Table 9-5~~A~~ provides a detailed outline of envelope requirements for alterations; and Table 9-~~5B~~ 9 provides a similar outline for HVAC and water heating alterations. For each type of alteration, the tables list:

1. The highlights of the mandatory measures applicable to that kind of alteration; and
2. A summary of the relevant prescriptive measures; and
3. Key exceptions, exemptions or special allowances to the prescriptive measures; and

4. The list of prescriptive compliance forms that must be submitted for permit.

9.6.2 Prescriptive Envelope Alterations

Table 9-5~~A~~ summarizes requirements for the following types of residential envelope alterations:

1. Adding ceiling or roof insulation to an existing roof; or constructing a new roof on an existing building;
2. Replacing the roof sheathing of an existing roof;
3. Replacing part or all of the roof surface of ~~the~~an existing building;
4. Replacing or adding skylights;
5. Adding exterior wall insulation; or constructing new walls in an existing building;
6. Adding raised floor insulation over unconditioned space;
7. Replacing vertical fenestration: windows, clerestories and glazed doors;
8. Adding vertical fenestration: windows, clerestories and glazed doors.

Table 9-5~~A~~: For Residential Alterations, Summary of Mandatory and Prescriptive Measures

Type of Envelope Alteration	Highlight(s) of Applicable Mandatory Measures[1]	Summary of Relevant Prescriptive Measure(s)[2]	Exception(s) to the Prescriptive Measures	Prescriptive Compliance Form(s)
Adding Ceiling or Roof Insulation to an Existing Roof; or a New Roof on an Existing Building	Ceiling w/ Attic: R-~~3022~~19, U=0.~~031~~054 §150.0(a)	~~CZ 1, 11-16: R-38, U=0.025~~	N/A	CF1R-ALT
	Roof Rafters: R-19, U=0.056 §150.0(a)	~~0.031~~		
Adding Exterior Framed Wall Insulation3 or a New Wall in an Existing Building	In2x4 Framing: R-13, U=0.102 In 2x6 Framing: R-19, U=0.074 Exception: Walls already insulated to R-11 §150.1(c)	In 2x4 Framing: R-13, U=0.102 In 2x6 Framing: R-19, U=0.074 (same as Mandatory)	N/A	CF1R-ALT
Replacing Roof Sheathing	§110.8(j)	CZ 2 - 15: Radiant Barrier above Attic Spaces	(a) No requirement in CZ1 and CZ16; (b) Not required when installing below roof deck insulation	CF1R-ALT
Replacing > 50% of the Existing Roof Surface	§110.8(i)	Steep Sloped (≥ 2:12): CZ 10 - 15: Reflect.=0.20 and Emittance=0.75; or SRI=16	(a) Air space of 1.0" between roof deck and bottom of roofing product; or, (b) Profile ratio of rise to width of 1:5 for >50% width of roofing product; or, (c) Existing ducts in attic insulated and sealed per §150.1(c)9; or, (d) Roof has ≥ R-38 ceiling insulation; or, (e) Roof has a radiant barrier	CF1R-ALT

			per §150.1(c)2; or, (f) There are no ducts in the attic; or, (g) In CZ10-15, >R-4.0 insulation above the roof deck.	
		Low Sloped< 2:12: CZ13 & 15: Reflect.=0.63 and Emittance=0.75; or SRI=75	(a) There are no ducts in the attic; or, (b) Reflectance and Roof Deck Insulation R-value in Table 150.2-A are met.	CF1R-ALT
Replacing Entire Roof, including sheathing	§150.0(a) Ceilings and rafter roofs achieve R19 or weighted U=0.054	CZ 4, 8-16: Roof deck, ceiling insulation, and radiant barrier according to §150.1(c)1A using Option A~~,~~ or B.	N/A	CF1R-ALT
Adding or Replacing Skylight[3]	Weighted average U-factor = or < 0.58 Exemption: Up to 10 ft² or 0.5% of Conditioned Floor Area, whichever is greater, is exempt from the U-factor requirement §150.1(q)	Must not exceed the 20% Total or 5% West Fenestration Area with a U-factor = 0.32 (all CZs); in CZ2, 4 & 6-16: SHGC = 0.25 §150.2(b)1.A.	Added fenestration up to 75 ft² need not meet Total or West-facing fenestration area ~~as~~ per §150.2(b)1A Exception 1. Replacement skylights ~~up to 16 ft²~~ with a U=0.55 and SHGC=0.30 and not meet the total fenestration and West-facing area requirements ~~as~~ per §150.2(b)1 ~~A~~ Exception 2.	CF1R-ALT
~~**Adding Exterior Framed Wall Insulation[3] or a New Wall in an Existing Building**~~	~~In 2x4 Framing: R-13, U=0.102~~ ~~In 2x6 Framing: R-19, U=0.074~~ ~~Exception: Walls already insulated to R-11 §150.1(c)~~	~~In 2x4 Framing: R-13, U=0.102~~ ~~In 2x6 Framing: R-19, U=0.074~~ ~~(same as Mandatory)~~	~~N/A~~	~~CF1R-ALT~~

Table 9-5~~A~~: Residential Alterations, Summary of Mandatory and Prescriptive Measures (continued)

Type of Envelope Alteration	Highlight(s) of Applicable Mandatory Measures[1]	Summary of Relevant Prescriptive Measure(s)[2]	Exception(s) to the Prescriptive Measures	Prescriptive Compliance Form(s)
Adding Raised Floor Insulation	R-19 or equivalent U-factor Exception: Floors over controlled ventilation or	R-19 or equivalent U-factor (same as Mandatory)	N/A	CF1R-ALT

	unvented crawlspaces per §150.1(d)			
Replacing Vertical Fenestration[4] (Altered Glazing)	Weighted average U-factor = or < 0.58 <u>Exemption</u>: Up to 10 ft^2 or 0.5% of Conditioned Floor Area, whichever is greater, is exempt from the U-factor requirement §150.0(q)	All CZs: U-factor = 0.32 CZ 2, 4 & 6-16: SHGC = 0.25 §150.2(b)1.B.	Replacement of vertical fenestration up to 75 ft^2: U=0.40 (in all CZs) and SHGC=0.35 in CZs 2, 4 & 6-16 as per §150.2(b)1B Exception 1 .	CF1R-ALT
Adding Vertical Fenestration[4] (New Glazing) and Greenhouse	Weighted average U-factor = or < 0.58 <u>Exemption</u>: Up to 10 ft^2 or 0.5% of Conditioned Floor Area, whichever is greater, is exempt from the U-factor requirement §150.0(q)	Must not exceed the 20% Total or 5% West Fenestration Area U-factor = 0.32 (in all CZs); In CZ2, 4 & 6-16: SHGC = 0.25 §150.2(b)1.A.	Added fenestration up to 75 ft^2 need not meet total or west-facing fenestration area requirements as per §150.2(b)1A Exception 1 . Added Greenhouse must either meet the maximum U-factor of 0.58 or weighted average U-factor of 0.58 or up to 10ft^2 or 0.5% of CFA whichever is greater as per §150.0(q)1.	CF1R-AL
1: Alterations must comply with all applicable mandatory measures in §110.0 and §150.0 of the <u>Energy</u> Standards as explained in Chapters 3, 4, 5 and 6 of this Manual.				
2: Several prescriptive measures are Climate Zone (CZ) specific.				
3: There are no mandatory measures or prescriptive requirements when altering below-grade or exterior mass walls.				
4: Replacement fenestration is new fenestration that is located in the same existing wall or roof in which the same or larger area of existing fenestration is being removed. It labeled as "altered. Any new fenestration area that increases the total net area of fenestration in any existing wall or roof is labeled as "new".				

9.6.2.1 -Greenhouse Windows

Greenhouse or garden windows are special windows that project from the façade of the building and are typically five sided structure. An NFRC-rated U-factor for greenhouse windows is typically quite high and may not meet the mandatory requirements for the fenestration U-factor of 0.58.

The ways to meet this mandatory measure for greenhouse windows are:

Must have a maximum U-factor of 0.58 or better; or

Use the area-weighted average for all new and replacement fenestration with a combined mandatory maximum of 0.58 U-factor as per §150.0(q)2; or

The Exception to §150.0(q)1 for up to 10 ft^2 or 0.5% of CFA, whichever is greater; or

When using the performance approach Exception 1 as per §150.2(b) - Any dual-glazed greenhouse or garden window installed as part of an alteration complies automatically with the U-factor and meets the requirements as per §150.1(c)3.

~~9.6.3~~ 9.6.2.2 Adding Insulation to Existing Roof/Ceilings, Walls and Raised Floors

The prescriptive requirement for alterations is to add the equivalent of the specified level of ~~batt~~ insulation that fits within the cavity of wood framed assemblies:

1. R-~~38~~ 19 or greater in between wood-framing members or a weighted average U-factor equal to or less than 0.054 for insulation installed at ceilings and rafter roofs. ~~in attic spaces in climate zones 1 and 11 through 16; and R-30 in attics in climate zones 2 through 10; or~~and
2. R-13 in 2x4 exterior walls, and R-19 in 2x6 or greater exterior walls, with no exterior rigid insulation required; or
3. R-19 in raised floors over crawl spaces, over open outdoor areas and over unheated basements and garages.

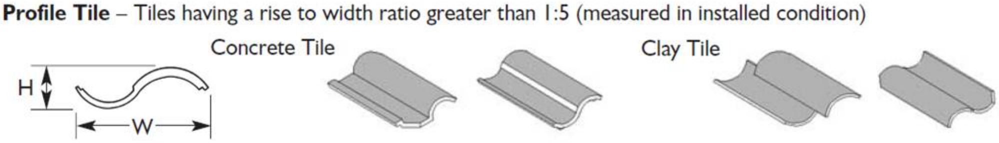
~~9.6.4~~ 9.6.2.3 Replacing the Roof Surface or Roof Sheathing (partial or entire replacement)

A. STEEP-SLOPED ROOFS (> 2:12)

In ~~c~~Climate ~~z~~Zones 10 through 15: if 50% or more of the existing building's roof surface is being replaced, the minimum cool roof requirement for the replaced steep-sloped roofing area shall have an~~is~~ aged solar reflectance of~~=~~ 0.20, thermal emittance of~~=~~ 0.75 or a minimum SRI of~~=~~ 16. These~~se~~ requirements above apply unless one~~any~~ of the following below is present which are considered equivalent to the cool roof requirements in §150.2(b)1Hi:

1. Air space of 1.0" (25mm) between the roof deck and the bottom of the roofing product; or
2. Roofing product profile ratio of rise to width is at least 1:5 for >50% width of roofing product; or

High Profile Tile – Tiles having a rise to width ratio greater than 1:5 (measured in installed condition)



3. Existing ducts in attic insulated and sealed according to §150.1(c)9; or
4. Building has at least R-38 roof/ceiling insulation; or
5. Roof of attic spaces has a radiant barrier according to §150.1(c)2; or
6. There are no ducts in the~~any~~ attic space; or
7. In Climate Zones10 through 15 ~~only~~: greater than R-2.0~~4.0~~ insulation above the roof deck.

B. LOW-SLOPED ROOFS (< 2:12)

In ~~c~~Climate ~~z~~Zones 13 and 15: if 50% or more of the existing building's roof surface is being replaced, the minimum cool roof requirements for low-sloped roofs shall have an~~are~~ aged solar reflectance of~~=~~ 0.63, thermal emittance of~~=~~ 0.75 or a minimum SRI of~~=~~ 75 per §150.2(b)1Hii. These apply unless one of the ~~any of the~~ following is present which are considered equivalent to the cool roof requirements in §150.2(b)1Hii:

1. There are no ducts in any attic space; or

2. The aged solar reflectance can be traded off with additional insulation being added at the roof deck as specified in Table 150.2-A of the Energy Standards.

Table 9-6 Aged Solar Reflectance Insulation Trade Off Table

Aged Solar Reflectance	Roof Deck Insulation R-value	Aged Solar Reflectance	Roof Deck Insulation R-value
0.62 – 0.60	2	0.44 – 0.40	12
0.59 -0.55	4	0.39 – 0.35	16
0.54 - 0.50	6	0.34 – 0.30	20
0.49 – 0.45	8	0.29 – 0.25	24

C. ROOF SHEATHING

In ~~c~~Climate ~~z~~Zones 2 through 15: if roof sheathing over an attic space with a continuous radiant barrier is being replaced, a continuous radiant barrier must be re-installed.

In Climate Zones 4, 8-16: if the entire roof sheathing over a ventilated attic space is being replaced, roof and ceiling insulation must be installed to meet the following prescriptive requirements (as specified in §150.1(c)1A):

Option A: R-8 or R-6 above roof deck insulation (see detailed explanation on required R-value in Compliance Manual Section 3) AND R-38 ceiling insulation

Option B: R-18 or R-13 below roof deck insulation (see detailed explanation on required R-value in Compliance Manual Section 3) AND R-38 ceiling insulation

Option C: Verified ducts in conditioned space AND R-30 or R-38 ceiling insulation

Example 9-13

Question

There is a Victorian building that has been converted to an office building and needs to have a shake roof replacement. This building has a vented unconditioned attic with the insulation on the ceiling. Would I need to meet §150.2(b)Hi?

Answer

No, this section does not apply. The occupancy type has been changed to nonresidential. Since the Victorian building has a shake roof and is considered a steep sloped roof, §141.0(b)2Bib for nonresidential buildings would apply.

~~9.6.5~~ 9.6.2.4 Replacement Fenestration

If any fenestration (i.e. windows, skylights, clerestories, and glazed doors) that is being removed and replaced in an exterior wall or roof, it is considered “replacement fenestration”.

Example 9-14

~~Example 9-14~~

Question

An existing building, 50 ft^2 of total 85 ft^2 vertical glazing is being removed from an existing south wall and new glazing will be replaced as part of the alteration in the same opening. What requirements apply?

Answer

Since~~,~~ 50 ft^2 is treated as "replacement" fenestration and 35 ft^2 is considered existing, ~~then~~ ~~the replace~~the replaced~~ment of~~ fenestration must comply with the requirements~~measures~~ in §150.2(b)1B; or for this example Exception 1 to §150.2(b)1B can used. Vertical fenestration not greater than 75 ft^2 can meet the requirements~~measures~~ by installing fenestration no greater than a U-factor of 0.40 in Climate Zones 1-16 and SHGC of 0.35 in Climate Zones 2, 4, and 6-16.

Replacement fenestration is an area of new fenestration which replaces an equal or greater 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 exact openings as the glazing being removed as long as it is being installed in the same existing wall or roof surface which remains a part of the existing building. Any added fenestration area that is larger than the total altered glazing area) is labeled as "new".

~~9.6.6~~ 9.6.2.5 New Fenestration in Alterations

The ~~2013~~ ~~2016~~ Energy Standards have relaxed some of the prescriptive restrictions on new vertical fenestration for alterations in existing dwellings. When new vertical fenestration is added in existing dwellings, up to 75 ft²~~square feet~~ are not required to meet the overall total fenestrations limit (20 %~~percent~~ of the CFA) and the west-facing area limit (5 %~~percent~~ of the CFA). This provides for additional flexibility to meet the Energy Standards requirements using the prescriptive approach, without having to resort to the performance approach. However, this additional fenestration must meet the prescriptive U-factor and SHGC requirements of Package A or meet the U-factor and SHGC requirements of Exceptions 1 and 2 to ~~Section~~ §150.2(b)1B.

Example 9-15

Question

An existing house in ~~c~~Climate ~~z~~Zone 12 has all single-pane windows. All of the windows will be replaced within existing openings, except a pair of 40 ft^2 French doors to replace an existing 30 ft^2 window. What requirements apply?

Answer

For prescriptive compliance, replacement fenestration (equal to or less than the area of existing windows in each wall being altered) and new additional fenestration area must both meet the U-factor (0.32) and SHGC (0.25) in Package A. The post-alteration total glazing area must be no greater than 20% of conditioned floor area, and all installed fenestration also must meet applicable mandatory measures.

In order to use the performance approach, at two or more energy measure must be used as a trade-off within the house per §150.2(b)2. For example, if the homeowner is replacing the 1) water heater along with 2) window replacements, then the Existing + Alterations calculation is available as a compliance alternative. In that case:

(a) In the Existing + Alterations approach *without* third party verification, replacement fenestration that achieves the fenestration values in Table 150.2-B of the Energy Standards is compared to those same values in the Standard Design. Replacement fenestration that does not reach these values is penalized; or,

(b) In the Existing + Alterations approach *with* third party verification, replacement fenestration that achieves the fenestration values in Table 150.2-B of the Energy Standards is compared to §Tables 110.6-A and 110.6-B default values for the existing fenestration condition. Replacement fenestration that does not reach these values is penalized:

(c) ~~New for the 2013~~ 2016 ~~is t~~The use of window films in lieu of fenestration replacement. ~~Window films~~ are considered as an alteration option to existing fenestration for energy compliance. Similar to fenestration replacement the window film must also meet the Standard Design for altered component *with* or *without* third party verification as indicated in Table 150.2-B of the Energy Standards. Also, see window film installation protocols in ~~Reference Appendices~~ RA4.2.3.

Example 9-166

Question

An existing building has all single-pane, metal-frame windows. A proposed remodel will replace all the windows; no other work is being done as part of the remodel. What applies?

Answer

Since only the windows are being replaced, ~~Because two or more altered components are required to use the performance method per §150.2(b)2, only the prescriptive path is available to meet the Standards. As a result, the area-weighted average of~~ all replacement windows must meet the requirements of Package A, and new fenestration must also meet applicable mandatory measures of §110.6, §117.0 and §150.0.

Example 9-17

Question

An existing building has all single-pane, wood-frame windows. Two double-pane, metal-frame greenhouse windows will be added as part of a remodel. How should the greenhouse windows be treated?

Answer

Since greenhouse windows add conditioned volume, but do not add conditioned floor area, this remodel is considered an alteration rather than an addition. For the purposes of alterations, any dual-glazed greenhouse windows installed as part of an alteration may use §150.0(q) to meet the U-factor and Package A to meet SHGC requirement.

If two or more types of altered energy measures are in the existing building, the Existing + Alterations performance method may be used. ~~as explained above in the answer to Example 9-15.~~ All applicable mandatory measures must be met.

Example 9-18

Question

Why are ~~the~~ low-sloped roofing products requirement only listed for Climate Zones 13 and 15?

Answer

These two climate zones are the only climate zones which show energy cost-effectiveness for having a low-slope roofing product (cool roof) requirement.

Example 9-19

Question

Why are there so many exceptions to the addition and alterations section that can be considered equivalents to Roofing Products?

Answer

There are several energy features that are~~have a roughly~~ equivalent or having greater impact on energy savings than the Roofing Products.~~cool roof requirements~~. For example: ~~There are o~~Older ~~vintage structures~~homes ~~that~~ often have ducts under the house rather than in the attics; and newer homes may have materials just slightly below current requirements or equal to one of the items considered to be equivalent. If the ducts are insulated and air leakage controlled to meet current requirements, energy savings are expected to be at least equal the benefit of reflective roof coverings.

~~Often changing one performance measure in a system can have an impact, sometimes reducing or negating the positive benefit of another. In warm months the main concern is heat gain in the attic negatively impacting ducts, or, by conduction, heating the occupied area ceilings. For example,~~

~~If the ducts are insulated and air leakage controlled to meet current requirements, energy savings are expected to at least equal the benefit of reflective roof coverings.~~

Example 9-~~19~~20

Question

What happens if I have a low-slope roof on most of the house but steep-sloped roof on another portion? Do I have to meet two different criteria for the roofing products?

Answer

Yes. If your house is in ~~c~~Climate ~~z~~Zones 13 or 15, you will need to meet the low-slope criteria for the areas with low-slope. The areas with steep-slope roof will need to meet the other cool roof criteria.

Example 9-~~1819~~21

Question

I am replacing my existing wood shake roof with asphalt shingles. Would this be considered a repair?

Answer

No. A repair is defined as a reconstruction or renewal for the purpose of maintenance of any component, system or equipment of an existing building. A replacement of any component (i.e. roof top), system, or equipment for which there are requirements in the Energy Standards is considered an alteration and not a repair.

Example 9-~~21~~22

Question

Where do radiant barriers need to be installed when using the prescriptive Package A or meeting the performance standards where credit is taken for retrofitting a radiant barrier in the existing house?

Answer

The radiant barrier only needs to be installed on the underside of an attic roof assembly and the gable wall ends associated with an addition. The prescriptive requirement is the same for entirely new buildings.

Example 9-~~22~~23

Question

I am considering doing a reroofing on my house. Under what conditions will I be required to put on a cool roof?

Answer

Cool roof requirements are triggered when 50 %~~percent~~ or more of the roof area is being replaced. Prescriptive requirements are waived if one of the Exceptions to §150.2(b)1H below applies:

Prescriptive Exceptions for Steep-Sloped Roofs

1. Air-Space of 1.0 inch (25 mm) is provided between the top of the roof deck to the bottom of the roofing product; or

2. The installed roofing product has a profile ratio of rise to width of 1 to 5 for 50%~~ percent~~ or greater of the width of the roofing product; or

3. If existing ducts in the attic are insulated and sealed according to §-150.1(c)9 ; or

4. Buildings with at least R-38 ceiling insulation; or

5. If the building has an attic radiant barrier meeting the requirements of §150.1(c)2 ; or

6. Buildings with no ducts in the attic; or

7. If in ~~c~~Climate Zones 10-15, R-2~~4~~ or greater insulation above the roof deck.

Prescriptive Exceptions for Low-Sloped Roofs

1. Buildings with no ducts in the attic; or

2. Aged Solar Reflectance and roof deck insulation R-value in §Table 150.2-A are met.

Alternatively, the building may show compliance using the performance approach.

Example 9-~~23~~24

Question

I am building a 450 ft² addition on my house. Do I have to meet cool roof requirements in the prescriptive package?

Answer

Yes. If using prescriptive compliance, the roof must meet the cool roof requirements of Package A for the type of roof slope and density. To avoid the cool roof requirements, you may use the performance approach and tradeoff against other energy efficiency features of the addition alone or the existing building by using the Existing + Addition + Alterations approach.

~~9.6.7~~9.6.3 Prescriptive HVAC System and Water Heating Alterations

The Energy Standards apply to alterations of the heating and cooling system whether or not the alterations correspond to an addition to the building. This section describes the conditions where compliance is necessary and describes the corresponding prescriptive requirements.

If the heating and cooling system is left unchanged as part of an addition or alteration, then compliance with the requirements for altered HVAC systems is not necessary. Extension ~~of an existing heating and cooling system, such as extension~~ of a duct is not considered a change to the existing heating and cooling equipment. ~~therefore the existing heating and cooling system components are unchanged (except the ducts) and do not need to meet the Standards requirements.~~ However, the new ducts~~extensions of the duct systems~~ must meet mandatory requirements described in Section 9.4.2; and prescriptive requirements described below.

Example 9-~~24~~25

Question

An existing 1,500 ft² single family residence is getting a 500 ft² addition. A new 50 gallon gas water heater will replace the existing water heating system. How do the water heating requirements apply?

Answer

Since this is an alteration to an existing water heating system, no water heating calculations are required for compliance of the addition alone. However, applicable mandatory measures apply. The water heater must have an Energy Factor equal to or greater than the federal minimum standards, or R-12 insulation wrap. The first 5 ft. of hot and cold pipes must be insulated. If building energy compliance is achieved with the Existing + Addition + Alterations calculation, the EF and other energy features of the water heating system are modeled in the performance method.

Example 9-~~25~~26

Question

An existing 2,000 ft² single family residence has one 50 gallon gas water heater, and a 600 ft² addition with a new instantaneous gas water heater is proposed. How does this comply?

Answer

When there is an increase in the number of water heaters with an addition, the Energy ~~s~~Standards allow addition alone compliance in certain circumstances. Since this is an instantaneous gas water heater, it may be installed if it can be demonstrated that it uses no more energy than a 50 gallon gas non-recirculating storage tank (see Prescriptive Water Heating Alterations above). Since §150.1(c)8A~~B~~ declares a single instantaneous gas water heater to be equivalent to a standard 50 gallon storage water heater, then no water heating calculations are required. The ~~M~~mandatory measures still apply.

The ~~O~~other alternative~~s~~ ~~are~~ to show compliance is by using the~~with~~ existing-plus-addition or whole building compliance.

Example 9-~~26~~27

Question

An existing single family residence with one electric water heater has a 500 ft² addition with a 30 gallon electric water heater proposed. Does this comply?

Answer

When there is an increase in the number of water heaters with an addition, the Energy Standards allow addition alone compliance in certain circumstances.

If this residence does not have natural gas connected to the building and the new water heater has an EF equal to or greater than the federal minimum standards, the system automatically complies. No water heating calculations are submitted.

If it does have natural gas connected, then the new water heater must be natural gas, or calculations are required to show the proposed water heater would use no more TDV energy than a 50 gallon natural gas water heater with an EF equal to the federal minimum standards.

~~9.6.8~~ 9.6.3.1 HVAC "Changeouts"

The Energy Standards make a distinction between two types of HVAC "changeout" situations:

1. Entirely New or Complete Replacement Space Conditioning Systems;
2. Altered Space Conditioning Systems.

The differences in the requirements for these two types of HVAC changeout situations are discussed in the following sections.

~~9.6.9~~A. *Entirely New or Complete Replacement Space Conditioning Systems*

~~9.6.10~~ When an *Entirely New or Complete Replacement Space Conditioning Systems* is installed, the system must meet all applicable mandatory measures, including:

~~9.6.11~~ §150.0(h) – Space conditioning equipment loads, design, installation, etc.;

§150.0(i) – Thermostat requirements;

§150.0(j)2 – Refrigerant line insulation thickness;

§150.0(j)3 – Refrigerant line insulation protection;

§150.0(m)1 – California Mechanical Code(CMC) compliance;

§150.0(m)2 – Factory fabricated duct system UL requirements;

§150.0(m)3 – Field fabricated duct system UL requirements;

§150.0(m)4 – Duct R-value minimum ratings;

§150.0(m)5 – Duct insulation thickness and R-value;

§150.0(m)6 – Duct labeling requirements;

§150.0(m)7 – Backdraft damper requirements on vent systems;

§150.0(m)8 – Gravity ventilation system dampers;

§150.0(m)9 – Protection of insulation;

§150.0(m)10 – Prohibition of using porous inner core;

§150.0(m)11 – Duct system sealing and leakage testing for new systems;

§150.0(m)12 – Air filtration requirements;

§150.0(m)13A – HSPP/PSPP, mandatory return duct sizing (or diagnostically tested airflow and fan efficacy);

§150.0(m)~~15~~ 13B-C – Requirements for zonally controlled systems;

These systems must also meet the prescriptive requirements found in:

§150.1(c)6 – Allowed heating system types;

§150.1(c)7 – Space heating and cooling system minimum efficiencies and refrigerant charge verification in ~~c~~Climate ~~z~~Zones 2, 8 through 15.

§150.1(c)9 - Duct insulation requirements;

§150.1(c)10 – Central fan integrate systems added or required as part of an addition or alteration must meet the 0.58 watts per cfm requirement.

These requirements are discussed in detail in Chapter 4, HVAC Requirements.

Note: Completely New or Replacement Duct Systems in *multifamily* dwelling units shall meet the 12% (total leakage protocol), or ~~6~~5% (leakage to outside protocol) criteria used for newly constructed systems (may also use the smoke test protocol if the system does not meet these criteria). Otherwise, altered duct systems in multifamily dwelling units shall meet the 15% (total leakage protocol), or 10% (leakage to outside protocol), or smoke test criteria given in §150.2(b)1Dii~~(b)~~.

A system installed in an existing dwelling shall be considered an *Entirely New or Complete Replacement Space Conditioning System* when:

1. the air handler and all of the system heating/cooling equipment (e.g. outdoor condensing unit and indoor cooling or heating coil for split systems; or complete replacement of a package unit),are new, and
2. the duct system meets the definition of an *Entirely New or Complete Replacement Duct System (including systems less than 40 ft~~ee~~t in length).*

An altered duct system installed in an existing home shall be considered an Entirely New or Complete Replacement Duct System when:

1. at least 75 %~~percent~~ of the duct material is new, and
2. any remaining components from the previous system are accessible and can be sealed.

Altered duct systems that do not meet the definition of Entirely New or Complete Replacement Duct Systems shall be considered an Extension of an Existing System.

Space conditioning systems that do not meet the definition of Entirely New or Complete Replacement Space Conditioning Systems shall be considered Altered Space Conditioning Systems.

~~9.6.12~~*B.* ***Altered Duct Systems – Duct Insulation and Sealing Requirements***

When more than 40 linear feet of ducts are installed in an unconditioned space, it must be insulated to an installed minimum R-value as described in Table 9-7below:

Table 9-7 Duct Minimum R-Value

Climate Zone	*1 -10, 12 & 13*	*11, 14 -16*
Duct R-value	*R-6*	*R-8*

When ~~M~~more than 40 linear feet of ducts are installed in conditioned space, the ducts must be insulated to the minimum mandatory insulation level of R-4.2 and be verified to be in conditioned space by both visual verification and diagnostic testing in accordance to RA3.1.4.3.8.

Entirely New or Complete Replacement Duct Systems must meet the mandatory requirements of:

~~9.6.13~~1. §150.0(m)12 – Air filtration requirements, and

~~9.6.14~~2. §150.0(m)13 – HSPP/PSPP, mandatory return duct sizing (or diagnostically tested airflow and fan efficacy).

These requirements are discussed in detail in Chapter 4.

Entirely New or Complete Replacement Duct Systems must also be sealed to the criteria for “new duct systems” found in Table RA3.1-2, discussed below.

~~Because~~*An* *Entirely New or Complete Replacement Duct Systems* may~~can~~ also include the original air handler, which may leak substantially more than the new equipment. Therefore, ~~A~~an attempt should be made to seal the duct system and the air handler to meet the ~~6~~ 5 %~~percent~~ (of nominal system central fan airflow) leakage rate criteria. If the ~~6~~ 5 %~~percent~~ leakage rate criteria cannot be met, a smoke test should be performed to verify that the excess leakage is ~~coming only from~~ non-accessible ~~the furnace cabinet (air handler cabinet)~~, and not from other *accessible* portions of the duct system. Note that the protocol for Smoke Test ~~of~~for Accessible-duct Sealing given in ~~Reference Residential Appendix~~ RA3.1.4.3.7. ~~makes an exception for the furnace cabinet (air handler cabinet).~~

Note that this will satisfy the sealing requirement and does not cause the system to no longer meet the definition of an *Entirely New or Complete Replacement Duct Systems.*

Altered duct systems that do not meet the definition of *Entirely New or Complete Replacement Duct Systems* shall be considered an *Extension of an Existing System.* These duct systems are required to meet one of the leakage criteria for “altered existing systems” cases in Table RA3.1-2.

~~Because d~~Duct sealing is a mandatory measure~~,~~ therefore alterations to an existing duct system, such as adding or replacing sections of duct, will trigger duct sealing. However, cost-effectiveness must also be taken into account. Having to seal an entire system because one foot of duct is being removed may not be cost effective all by itself. The Energy ~~s~~Standards set the length of 40 ft~~eet~~ of duct as a criterion to trigger this requirement.

If 40 ft~~eet~~ of duct are being added or replaced, this work alone can trigger the requirement for duct sealing and field verification. The system would have to meet one of the leakage criteria for “altered existing systems” cases in Table RA3.1-2.

In addition to the duct sealing requirements, the added or replaced ducts must also meet the air distribution requirements of §150.0(m) and the duct insulation requirements of §150.1(c)9. Note that the air distribution and duct insulation requirements must be complied with in all climate zones; however, these requirements apply to only new or replaced ducts, the existing and unaltered ducts do no need to comply with these requirements.

Installing 40 ft~~eet~~ or less of new or replacement ducts alone will not trigger the sealing requirements described above; however, the new ducts and connections must still meet the air distribution and duct insulation requirements of §150.0(m) and §150.1(c)9.

~~9.6.15~~*C.* ***Altered Space-Conditioning Systems - Duct Sealing ~~and Insulation~~***

Existing duct systems must be sealed and verified by a HERS rater when portions of the heating and cooling system are altered. The requirement applies in all climate zones.

~~9.6.16~~ **An air handler is installed or replaced.**

Ducts must be sealed (as described below) under any of the following circumstances:

1. An outdoor condensing unit of a split system air conditioner or heat pump is installed or replaced;
2. A cooling or heating coil is installed or replaced;
3. More than 40 ft~~eet~~ of new or replacement ducts are installed~~ in unconditioned space~~

~~The requirements apply to the duct system that is affected by any one of the alterations listed above.~~If a residence has more than one duct system, only the ducts connected to the altered equipment need to be sealed and verified.

There are three options for showing compliance for existing duct systems listed below. The HERS rater or installing contractor must at least attempt compliance with the first option (15 %~~percent~~ leakage); then any of the other options can be utilized:

a. Total leakage is less than 15 %~~percent~~ of nominal system fan airflow (RA3.1.4.3.1);
b. Leakage to the outside is less than 10 %~~percent~~ of system fan airflow (RA3.1.4.3.4);
c. If the first option (15 %~~percent~~) leakage target cannot be met, then compliance can be achieved by sealing all accessible leaks verified by a HERS rater inspection. When using this option sampling is not allowed (RA3.1.4.3.5-7).
d. HERS field verification is required for all options listed above. For options 1, and 2, verification can be accomplished through sampling as described in *Sampling for Additions or Alterations* below. For option 3, sampling is not allowed; a certified HERS rater must do the visual inspection and the smoke test on every house that chooses option 3.
e. Since test equipment must be set up for the first three options, it may be most efficient to test and record the results for the existing system and then attempt to meet each option sequentially until compliance is achieved.
f. There are a few cases where duct sealing and duct leakage verification are not required. These exceptions include the following:

   - ~~9.6.17~~ Ducts that have already been sealed, tested, and certified by a HERS rater;
   - Duct systems with less than 40 ft of duct~~ in unconditioned spaces~~;
   - Duct systems that are insulated or sealed with asbestos.

~~9.6.18~~ **Accessible Ducts**

Several code sections and protocols require a smoke test to demonstrate that all accessible leaks have been sealed.

Accessible is defined in ~~Joint Appendix~~ JA1 as "having access thereto, but which first may require removal or opening of access panels, doors, or similar obstructions."

Ducts located in an attic or crawlspaces are generally considered accessible because code requires access to those spaces. Access is usually gained by opening a door, hatch, or other moveable panel. If this can be done without causing damage that would need to be repaired, this is considered accessible. It is not expected that drywall sections have to be cut or damaged to gain access.~~,~~

Some judgment is required in determining if ducts are accessible or not. The local code enforcement agency will have the final say when it is not immediately obvious.

~~9.6.19~~ ***For example:***

If a boot is buried in insulation, then the boot would be considered accessible since the insulation could be moved or the register could be taken off to gain access so that it can be sealed.

When an air handler is replaced, the removal of the air handler would give the installer access to the attached plenums and ducts. These newly accessible areas of the duct work shall be sealed since they may be source of air leakage. Special attention should be given to where wall cavities are used as plenums and ducts.

If the ducts are buried under insulation, and gaining access to the leaks in these ducts would require ~~substantially~~moving ~~disturbing the~~ insulation, this would also be ~~is probably not~~ considered accessible;

If a leak in the duct system is in too small a space between framing members for an average size person to be able to reach the joint to seal it, then this is probably not considered accessible;

If ducts are suspended far above the ground and reaching them would require scaffolding or special equipment other than normal ladders, then these are probably not considered accessible;

If sheet metal ducts are wrapped with insulation and a smoke test indicates multiple small leaks along the lengthwise seams in the ducts in many locations, it is probably not cost effective to remove the insulation to find and seal these leaks. However, if one or more location shows a very obvious and substantial leak, it ~~should~~ must be sealed.

All other portions of the duct system for which a smoke test identifies the presence of leakage must be sealed in order to comply. The exemption for inaccessible portions of the duct system is applicable only if the other criteria for duct leakage compliance cannot be met.

The installing contractor may perform a smoke test to locate and seal accessible leaks, or assess whether or not the duct leaks are accessible. However, compliance by smoke test and sealing all accessible leaks must be determined by a smoke test that has been conducted by a HERS rater.

~~9.6.20~~ Refrigerant Charge Verification

In climate zones 2, and 8-15, when a refrigerant containing component of an air conditioner or heat pump is replaced or installed in an existing building, §150.2(b)1F requires systems that do not have a ~~CID~~fault indicator display (FID) installed to have refrigerant charge field verified in accordance with all applicable procedures specified in ~~Reference Residential Appendix~~ ~~Sections~~ RA3.2.2, or ~~Reference Residential Appendix~~ RA1.

The RCV procedures in RA3.2 are not intended to replace the equipment manufacturer's charging procedures and specifications. The installer must first charge the system according to the manufacturer's instructions and specifications. It is important to know that the procedures in RA3.2 are not procedures for charging a system; rather, they are procedures for verifying proper *charge. HERS ~~R~~raters are not allowed to adjust the refrigerant charge in systems that they are verifying. Raters are also prohibited from performing the weigh-in charge verification procedures. However, when specified by the Energy Standards, a ~~R~~rater may observe the installer while the installer performs the weigh-in procedure to verify compliance as specified in ~~Section~~ RA3.2.3.2 (described below).*

In both cases the HERS ~~R~~rater must also confirm minimum system airflow. ~~This should be done before testing the refrigerant charge.~~

~~**Charge Indicator Display**~~**Fault indicator display**. As an alternative to RCV the installer may install a special device called a ~~charge indicator display~~fault indicator display (~~CID~~FID). When this alternative is used by the installer, a HERS rater must still field verify the installation and operation of the FID as well as confirm minimum system airflow.

A.

~~A.~~ This device provides real-time monitoring of the air conditioning system and will show a warning visible to the home's occupants when the system is either over or undercharged, or if the system airflow rate does not meet the minimum requirement. The display unit must be located within one foot of the thermostat. §~~150.1(c)7Aib states:~~

(When applicable, systems shall) be equipped with a ~~charge indicator display~~fault indicator display (~~CID~~FID) device that provides a clearly visible indication to the occupant when the air conditioner fails to meet the required system operating parameters specified in the applicable section ~~of Reference Joint Appendix~~ JA6 for the installed ~~CID~~FID technology. The ~~CID~~FID indication display shall be constantly visible and within one foot of the air conditioners thermostat. ~~CID~~FID installations shall be confirmed by field verification and diagnostic testing utilizing the procedures specified in ~~Reference Residential Appendix~~ RA3.4.2.

Minimum Airflow. When refrigerant charge verification (RCV) is required for compliance, the system must also comply with the minimum airflow ~~requirement specified in RA3.2.2.7~~of 300 cfm/ton according to the procedures specified in~~if the airflow verification protocol in~~ RA3.3. ~~can be applied to the system.~~

~~Altered HVAC systems must meet the minimum 300 cfm/ton airflow rate compliance criterion; example include but not limited to replacing the outdoor condensing unit, replacing the furnace or air handler, and entire replacement of the duct system.~~

Entirely New or Complete Replacement Space Conditioning Systems, as specified in §150.2(b)1C, must meet the minimum 350 cfm/ton airflow rate compliance criterion or the duct design alternative specified in §150.0(m)13.

Alternative to Refrigerant Charge and Verification requiring at least 300 cfm per ton of airflow. If the altered HVAC that requires RC&V is not able to comply with the 300 cfm per ton of airflow ~~required under subsection Reference Residential Appendix~~

~~RA3.2.2.7.2~~, the HVAC installer may choose the alternative procedure outlined in ~~Reference Residential Appendix~~ ~~RA3.2.2.7.3~~RA3.3.3.1.5, *Alternative to Compliance with Minimum System Airflow Requirements for Altered Systems*, provided that the system thermostat is an Occupant Controlled Smart Thermostat (OCST) which conforms to the requirements of ~~Reference Joint Appendix~~ JA5.

Under ~~RA3.2.2.7.3~~RA3.3.3.1.5, the installer must take a series of remedial steps, including but not limited to cleaning filters, removing obstructions from registers and dampers, replacing crushed or blocked ducts, cleaning the evaporator coil, making sure that the air handler is set to high speed and conforms to manufacturer specifications, and enlarging/adding the return duct and the return grill. These steps must be ~~HERS~~ verified by a HERS rater. Again, as mentioned above, when the installer chooses this option, the system thermostat must be an OCST.

B. **Applicability of the protocols**. The refrigerant charge verification (RCV) protocols in RA3.2 and RA1 are applicable only to air-cooled air conditioners and air-source heat pumps. Equipment types such as ground source, water source, and absorption air conditioners and heat pumps cannot be verified using the protocols in RA3.2 and RA1. When a system other than an air-cooled air conditioner or air-source heat pump is installed, the requirements in ~~Standards~~ §110.1 may provide further direction for compliance.

If an aspect of the RA3.2.2 or RA1 verification protocol is not applicable to the system, alternative requirements may be specified by applicable ~~subsections of~~ §150.2(b)1F, however the procedures in RA3.2.2 or RA1 that *are applicable to the system* shall be performed.

For example, if a system does not have both a high side and low side refrigerant access port, thus cannot conform to the subcooling or superheat refrigerant charge verification procedure, but is a ducted system that can conform to the airflow measurement protocol; the system must comply with the minimum airflow requirement specified in RA3.2.2.7. Similarly, if the outdoor temperature is below 55°F which precludes use of the RA3.2.2 protocol for verification of the charge, and if the RA1 protocol cannot be used, then the weigh-in charging procedure in ~~Reference Residential Appendix Section~~ RA3.2.3.1 shall be used, and the minimum system airflow rate shall be verified ~~as required~~using the protocols in ~~by~~ RA3.~~2.2.7~~3.

The installer must determine which procedures are applicable to a system and verify compliance accordingly.

~~C.~~ **Thermostats**. When an existing system has a refrigerant containing component added or replaced, the thermostat must be upgraded to a digital setback type that meets §110.2(c)

C.

D. **Package Units**. Package units are typically pre-charged at the factory prior to shipment. When a new package unit is being installed or is replacing an older unit, it may not require RCV if the installer ~~can document that the manufacturer certified~~certifies that the package unit came factory charged and the installation did not alter the system in any way that would affect the refrigerant. ~~correct refrigerant charge at the factory~~. The installer must submit a certificate of installation documenting this and third party verification of refrigerant charge by a HERS rater is not required. This only applies to new equipment shipped from the manufacturer. Any modification to existing equipment that adds or replaces refrigerant containing components voids ~~the manufacturer's certification~~ this exception. It is also important to note that this does not relieve the contractor from the requirement to verify that the system meets the minimum 300 cfm per ton airflow rate requirement.

~~D.~~E. **Mini-Splits and Other System Types.** Some air-cooled air conditioning systems and air-source heat pumps cannot use the standard charge verification procedure, as specified in RA3.2.2, due to the design or construction of the system components. These include certain types of "mini-split" systems and variable speed condenser systems. In these cases, the installer must use the weigh-in charge procedures, as specified in RA3.2.3.1, and these systems must be HERS verified using the, as specified in RA3.2.3.2 procedure for HERS Rater observation of the weigh in charge procedure. These systems must also be equipped with an Occupant Controlled Smart Thermostat (OCST) which conforms to the requirements of ~~Reference Joint Appendix~~ JA5.

It is therefore important that the installation of these types of systems be coordinated with the third party verification. When these systems are ducted, they are still subject to the minimum system airflow requirements.

1. **Winter Refrigerant Charge Verification**. Most systems will normally be verified using the RA3.2.2 standard charge verification procedure to demonstrate compliance. However, when the outdoor temperature is less than 55°F, and the ~~S~~standard ~~C~~charge verification procedure or an RA1 protocol cannot be used, the installer may elect to use the weigh-in charge method to demonstrate compliance. Compliance with HERS verification when the outdoor temperatures are less than 55°F can be demonstrated using one of two alternatives:

   A. The installer may use the weigh-in charging procedure, but elect to have the system verified by a HERS rater using the RA3.2.2 ~~S~~standard ~~C~~charge ~~V~~verification procedure at a later time when the temperature is warmer; however, this option can delay the project~~;~~. In this case, the installer must include the signatures of the homeowner and HERS Rater on the CF2R - MCH25c form for the local enforcement agency, as part of an agreement that he or she will return to correct refrigerant charge if a HERS Rater determines it is needed at a later time, RA 2.4.4. The installer must also provide written notice to the homeowner that the charge has not yet been verified (RA2.4.4).~~or~~Or;

   B. The EXCEPTION 1 to ~~Section~~ §150.2(b)1Fiib~~i~~ provides for an alternative HERS verification procedure if the weigh-in method is used. This exception allows the installer to elect to utilize the HERS Rater verification procedure in ~~Reference Residential Appendix Section~~ RA3.2.3.2 in which the ~~R~~rater observes the installer while the installer performs the weigh-in charging procedure. However, when the HVAC installer elects this procedure for verification, as specified in RA3.2.3.2, the system thermostat must be an Occupant Controlled Smart Thermostat (OCST) which conforms to the requirements of ~~Reference Joint Appendix~~ JA5.

~~C.~~2. **Weigh-in Procedure During Warm Weather**. The installer may also opt to use the weigh-in procedure when the outdoor temperature is at or above 55°F, but in this case the rater must use the standard charge verification procedure.

~~D.~~3. **Weigh-in Procedure Description**. The weigh-in procedure involves charging the system by determining the appropriate weight of refrigerant based on the size of the equipment and refrigerant lines rather than by actual performance of the system. Systems utilizing the weigh-in procedure by the installer for any reason may not be third party verified by using sample groups.

There are two basic variations of the weigh-in procedures. One involves the adjustment to the amount of refrigerant in a system by adding or removing a fraction of the refrigerant as specified by the manufacturer (weigh-in charge adjustment). The other involves evacuating the entire system and recharging it with the correct total amount of refrigerant, by weight (weigh-in total charge).

The weigh-in charge adjustment procedure may only be used when a new factory-charged condenser is being installed and the manufacturer provides adjustment specifications based on evaporator coil size and refrigerant line size and length.

The weigh-in total charge may be used for any weigh-in procedure but still requires manufacturer's adjustment specifications.

~~E.~~4. **Standard Charge Procedure Description**. The standard charge verification procedure also has two basic variations. One is for systems that have a fixed orifice and the other is for systems that have a variable metering device such as a thermostatic expansion valve (TXV) or electronic expansion valve (EXV).

Both procedures, whether performed by the installer or the rater require that adequate airflow be confirmed prior to verifying charge. If the airflow is less than the minimum requirement of 300 cfm per ton, the system is not operating near its designed capacity or efficiency and the standard charge verification procedure is not valid.

The standard charge verification procedures involve taking refrigerant line temperatures and pressures, calculating equipment performance parameters and comparing those to targets either provided by the manufacturer or obtained from standard tables. All temperature and pressure measurements must be taken using calibrated digital meters. Analog gauges are no longer allowed for refrigerant charge verification procedures due to a lack of accuracy and precision.

In systems that have metering devices, the proper installation and performance can be verified by similar measurements and is an important part of the standard charge verification procedure for systems that have metering devices.

~~F.~~5. **Verifying Minimum System Airflow**. The procedures for measuring total system airflow are found in RA3.3. They include plenum pressure matching using a fan flow meter, a flow grid, a powered flow hood and the traditional (non-powered flow hood). The airflow verification procedures for refrigerant charge verification no longer include the temperature split method.

If a system does not meet the minimum airflow requirements, remedial steps may be required to bring the airflow up. More airflow is generally better for systems with air conditioning. Not only does this allow proper refrigerant charge to be verified, but it also improves the overall performance of the system. When able to be performed on a system, regardless of the refrigerant charge verification procedure, minimum system airflow must always be verified. Note that §150.2(b)1F states that systems must be installed with "all applicable procedures". This includes the minimum system airflow requirements.

In some cases, improving airflow may be cost prohibitive and there is a process for documenting this in ~~RA3.2.2.7.3~~RA3.3.3.1.5. When this option is used, verification by sample groups is not allowed.

~~G.~~6. **Temperature Measurements**. To properly perform the standard refrigerant charge verification procedure, a means of taking an accurate return air dry-bulb temperature must be provided by the installer. In most systems, this is accomplished by drilling a 5/16" measurement access hole (MAH) in the return side of the air handler or return plenum as shown in Figure RA3.2-1. In some cases the correct location for these holes may not be accessible and an alternative location may be provided as long as an accurate return air temperature measurement of the air as it enters the return side of the equipment can be made.

In other cases, taking the return air dry-bulb temperature at the return grill may be appropriate. This is true when the return is located entirely within conditioned space and not subject to leakage or conduction that may change the temperature of the air after it passes through the return grill and before it enters the evaporator coil. This may also apply to equipment where the return grill is an integral part of the air handler, such as enclosed soffit-mounted air handlers (aka, "pancake units").

~~E.~~F. **Maintaining 70°F Return Air Temperature**. During the data collection portion of the standard charge verification procedures, the return air dry bulb temperature, as measured at the MAH, must remain at or above 70°~~o~~F. This is to ensure proper refrigerant charge conditions, including but not limited to preventing the moisture on the coil from freezing. This requirement may be problematic during cooler outdoor conditions (above 55°~~o~~F but below 70°~~o~~F). The return air temperature can be maintained above 70°F by utilizing the home's heating system or supplemental heaters is permissible. ~~<refer to Blueprint language on this topic>~~. Note that the weigh-in method is always an option for the installer in these cases.

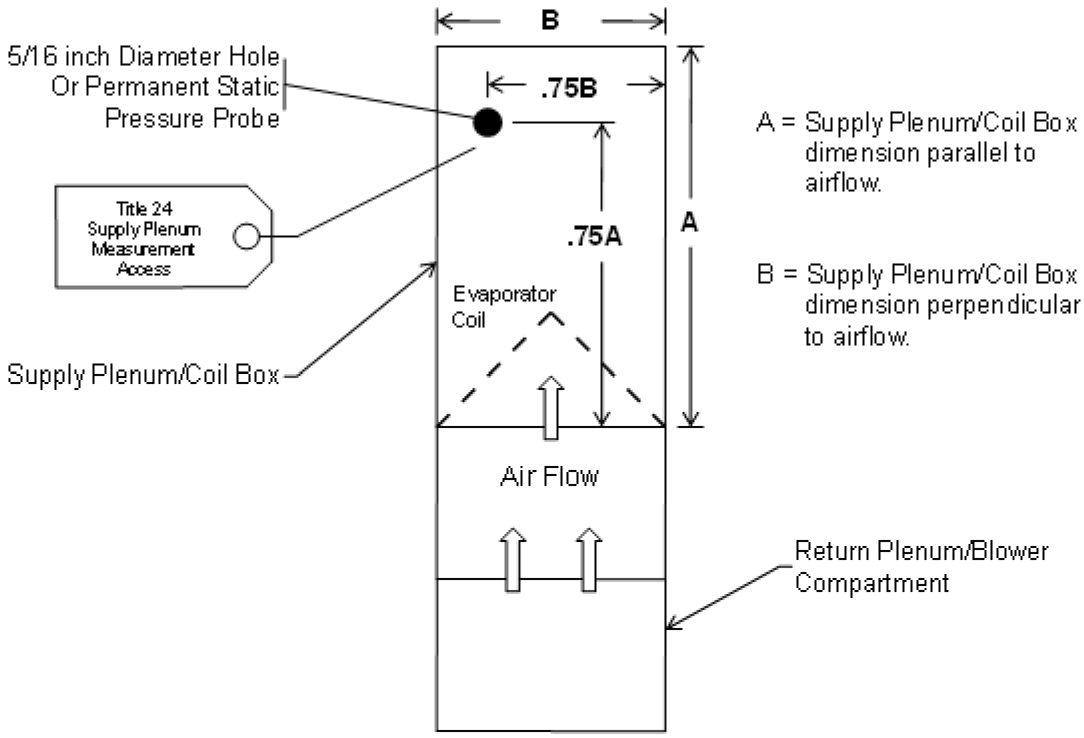
~~F.~~G. **Airflow and Fan Efficacy**

In all climate zones when an entirely new or replacement duct system (refer to section 9.6.9, above) is installed, the central forced air fan of all ducted air conditioners and heat pumps must simultaneously, in every zonal control mode, demonstrate an airflow of greater than 350 CFM/ton of nominal cooling, and a fan watt draw of less than 0.58 W/CFM in accordance with the procedures in ~~Reference Residential Appendix~~ RA3.3.

As an alternative to the field verified air flow and fan efficacy requirements, the system's return ducts can be sized according to §Tables 150.0-C or 150.0-D.

In addition to either the airflow/fan efficacy or return duct sizing alternative, the system installer must provide in the supply plenum, a hole for the placement of a static pressure probe (HSPP) or a permanently installed static pressure probe (PSPP), downstream of the evaporator coil that meets the specifications of ~~Residential Reference Appendix~~ RA3.3.1.

<Insert Diagram>



These requirements are mandatory measures and cannot be traded off by using the performance approach.

These requirements are discussed in more detail in Chapter 4 of this manual.

Heating-only space-conditioning systems are not required to meet the prescriptive cooling coil airflow and fan watt draw requirements.

~~G.~~H. **Sampling for Alterations**

When compliance for an alteration requires field verification and diagnostic testing, the building owners or their agents may choose to have testing and field verification completed for the dwelling unit alone, or as part of a closed sample group of dwelling units for which the same installing company has completed work that requires testing and field verification for compliance.

Registration of the compliance documentation is required and the procedures for registration of compliance documentation must be followed as described in Chapter 2 of this Residential Compliance Manual, and in ~~Residential Reference Appendix~~ RA2.

Notes regarding sampling for alterations:

1. The sample group shall be no larger than seven;
2. The installing company may request a smaller group for sampling;
3. Homes in a sample group must all have the same set of features to be verified (duct testing, airflow/fan efficacy, refrigerant charge, etc.);
4. Homes with systems utilizing the weigh in method for refrigerant charge verification by the installer cannot be sampled;
5. Whenever the HERS rater for the group is changed, a new group will be established;

6. Field verification and diagnostic testing shall be completed by the HERS rater for at least one randomly selected dwelling unit in each group;
7. Re-sampling, full testing and corrective action shall be completed if necessary, as specified in~~by the Residential Reference Appendix~~ RA2.6.3;
8. The installing contractor must self- test and register certificates of installation for all features to be tested prior to the rater choosing a home for verification by sampling.

~~H.~~ **Third Party Quality Control Program.**

I. An approved Third Party Quality Control Program may serve some of the functions of HERS raters for field verification and diagnostic testing purposes but does not have authority to sign the Certificate of ~~Field~~ Verification ~~and Diagnostic Testing~~ (CF-~~4~~3R) as a HERS rater, as specified in ~~Residential Reference Appendix~~ RA2.7.

When a Third Party Quality Control Program is used, the HERS rater must still submit completed, signed, registered copies of the CF3R-~~4R~~ to the enforcement agency, the installing contractor, and the builder or building owner for all dwellings that must demonstrate compliance.

~~I.~~ **Setback Thermostat.**

J. When a split system air conditioner or heat pump is altered by the installation or replacement of any refrigerant containing component and the existing thermostat is not a setback thermostat, then a new setback thermostat must be installed as described in Chapter 4 of this manual and as specified in §150.2(b)1Fi.

~~J.~~ **Fuel Switching.**

K. For prescriptive compliance, new electric resistance heating systems are prohibited in alterations unless the system being replaced is an electric resistance heating system. If the existing system is gas, propane, or LPG, then new electric resistance systems are not permitted. However, changing from a gas, propane, or LPG space heating system to an electric heat pump is allowed as long as the heat pump efficiency meets minimum efficiency standards, and the heat pump installed size is shown to result in no more TDV energy use than the standard design heat pump using the performance method as specified in §150.2(b)1C.

Table 9-7 – Acceptable Replacement Heating System Fuel Source(s)

Existing Heating System Fuel Source	**Acceptable Replacement Heating System Fuel Source(s)**
Electric	Electric, natural gas, or equipment with efficiency equal to or better than existing system*****
Natural gas	Natural gas, or equipment with efficiency equal to or better than existing system* or a heat pump with equal or lower TDV energy use than a standard design system.
LPG	Liquefied petroleum gas, natural gas, or equipment/ system with efficiency equal to or better than existing system* or a heat pump with equal or lower TDV energy use than a standard design system.
***** Proof that equipment has an efficiency that is equal to or better than the existing system can be demonstrated by an approved compliance program or other approved alternative calculation method to compare the TDV energy use of the existing system to the proposed system.	

Table 9-5A~~B~~ summarizes requirements for the following types of residential mechanical and water heating system alterations:

1. New or complete replacement space conditioning system: all new equipment and all new ducts with more than 40 linear feet of duct;~~s in unconditioned or indirectly conditioned space;~~
2. Altered space conditioning system with forced air ducts;
3. Altered mechanical cooling system;
4. Altered duct systems: when more than 40 linear feet of new or replacement ducts ~~are installed in unconditioned or indirectly conditioned space~~;
5. Installed a zonally controlled central forced air system;
6. Replacing water heaters and altering hot water pipes.

Since there are some overlaps in Table 9-5A~~B~~ between a few mandatory and prescriptive measures depending on the kind of alteration, it is important to accurately identify the type(s) of alteration within the permitted scope of work. For example, duct sealing and HERS testing is a mandatory measure when there is a new or complete replacement space conditioning system and greater than 40 linear feet of duct.~~s in unconditioned space.~~ However, when only new or replacement ducts are being installed, and there is no new space conditioning equipment involved, duct sealing and HERS testing is a prescriptive measure. A key to using Table 9-5A~~B~~ effectively is to have a good understanding of the scope of the proposed alterations.

Example 9-~~27~~ 28

Question

Do I have to seal my ducts if I replace my outdoor units in my existing house without changing the indoor unit?

Answer

Yes, replacing the outdoor unit (or indoor unit) by itself will trigger the duct sealing and verification requirement (§150.2(b)1E). However, there are two exceptions that might apply:

1. If the ducts have been previously sealed and verified as sealed, the ducts do not have to be sealed again and re-verified.

2. Less than 40 linear feet of the duct ~~system is located in unconditioned spaces such as attics or crawl spaces~~.

Example 9-~~28~~ 29

Question

I have an existing electric furnace and I'm adding a new bedroom. Can I extend the existing ducts to the new room and use the existing furnace?

Answer

Yes. If ducts are extended from an existing space conditioning system §150.2(b)1D allows the existing system but requires duct sealing if more than 40 linear feet of the new duct work is installed ~~system is located in unconditioned or indirectly conditioned space such as in an attic or crawl space~~. . The existing furnace must have adequate heating capacity to meet California Building Code requirements for the additional space.

Example 9-~~29~~ 30

Question

I am adding a bedroom to an existing house which uses a central forced air natural gas furnace. I would like to heat the room with an electric resistance baseboard heater rather than extend the existing ductwork to reach the new space. Is this allowed?

Answer

No. If using prescriptive compliance and since the existing system is gas, the addition cannot use an electric heating system. Options for heating the space include:

Extending the existing natural gas furnace system as long as there is adequate capacity to meet the California Building Code requirement;

Heating the added bedroom with an electric resistance heater is allowed if the performance approach is taken and the relatively high TDV energy consumption of the electric resistance heater is made up by TDV energy reductions from energy efficiency measures in the addition or in an accompanying alteration.

Note: If there are more than 40 linear feet of added ducts ~~being located in unconditioned or indirectly conditioned space,~~ , then the ducts must be sealed, tested and the ducts must be verified as sealed by a HERS rater.

Example 9-~~30~~ 31

Question

My central gas furnace stopped working. Since it is about 30 years old I decided to get a new more efficient unit rather than repair the existing one. What are the requirements?

Answer

Mandatory requirements apply to the components being replaced. The furnace, of course, must meet minimum efficiency requirements, but all systems sold in California should already meet the minimum efficiency requirements. If the existing thermostat is not a setback thermostat, it must be replaced with a setback thermostat, as specified in §150.2(b)1Fi that meets the requirements described earlier in this chapter.

All new ducts must meet insulation and construction requirements. ~~In climate zones 2, 9-16, a~~All existing and new ducts must be sealed and HERS verified, as specified §150.2(b)1E.

Prescriptively, the new heating unit must also be a natural gas unit.

The performance approach could be applied but only if the alteration includes *"tradeoffs between two or more altered components that are listed in §Table 150.2-B"* (insulation, fenestration, space conditioning equipment, air distribution systems, water heating system, roofing and other measures). Thus if other alterations are also being done one could specify other heating equipment such as heat pumps, electric resistance etc as long as the overall project has a lower TDV energy consumption than the "standard design" efficiency. When using the performance approach one can decide to either use the default standard design efficiencies that the alteration is compared against. Alternately one can hire a HERS rater to document the existing efficiencies and these existing efficiencies can be used in the standard design of performance calculation.

Example 9-~~31~~ 32

Question

As part of an upgrade in an existing house, one of the ducts is being replaced because of deterioration of the insulation and jacket. What requirements apply to the replacement duct?

Answer

This is an alteration to the space conditioning system; therefore ~~since no new conditioned space is being added. T~~the mandatory measures for ducts apply. If more than 40 ft of the ducts are altered ~~ducts are installed is in unconditioned or indirectly conditioned space~~, then the requirements of §150.2(b)1D would trigger~~require~~ diagnostic testing and HERS verification of the whole duct system.

Example 9-~~32~~ 33

Question

An up-flow air-handling unit with a furnace and air conditioning coil is located on a platform in the garage of an existing house. The platform is used as a return air plenum. The air-handling unit is being replaced and the platform is being repositioned to the corner of the garage (3 feet away from the current location). What requirements apply to this alteration?

Answer

The mandatory requirements apply to this alteration. In particular, §150.0(m) prohibits raised platforms or building cavities from being used to convey conditioned air (including return air and supply air). When the platform is relocated, it is being altered, and the mandatory requirement applies. Ducts made from sheet metal, duct board or flexible ducts must be installed to carry the return air to the replaced air handler. This requirement would not apply if the platform were not being altered.

In addition since the air handler is being replaced the prescriptive duct sealing requirements apply per §150.2(b)1E , unless the ducts have been previously sealed and confirmed through verification or there is less than 40 linear feet of duct.~~s in unconditioned spaces.~~

Example 9-~~33~~34

Question:

What is meant by the term "air handler"?

Answer:

The term "air handler" is used to identify the system component that provides the central system forced air movement for the ducted heating or cooling space-conditioning system. The term "air handler" may be properly used to identify various types of central system forced air-moving components that must meet the functional requirements for different types of space-conditioning systems. For instance: A "gas furnace" air handler includes a gas combustion heat exchanger, and the central system fan, but does not include a DX cooling coil; An "electric furnace" air handler has electric heating coils, and the central system fan, but does not include a DX cooling coil; A "fan-coil unit" air handler for a split system heat pump has a DX cooling/heating coil and the central system fan; A hydronic heat pump air handler includes the air-side DX coil, compressor, water-cooled condenser, and the central system fan. There are other air handler configuration variations as well.

Example 9-~~34~~35

Question

I have a residential building that was constructed in the 1920's. It has a freestanding gas furnace and I want to change it to an electric wall heater. Is this permitted?

Answer

No. §150.2(b)1Cii states that the new space-conditioning system be limited to natural gas, liquefied petroleum gas, or the existing fuel type unless it can be demonstrated that the TDV energy use of the new system is more efficient than the existing system. For your situation you would have to use gas or a heat pump for compliance.

Example 9-~~35~~ 36

Reserved

Table 9-~~8~~9 Summary of Prescriptive HVAC & Water Heating Alterations

Type of Mechanical System Alteration	Highlight(s) of Applicable Mandatory Measures (1)	Summary of Relevant Prescriptive Measure(s)	Exception(s) to the Prescriptive Measures	Prescriptive Compliance Form(s)
New or Complete Replacement Space Conditioning System (New Equipment and All New Ducts > 40 ft. in Unconditioned or Indirectly Conditioned Space)	New equipment must meet all minimum efficiency and other requirements in Sections 150.0(h), 150.0(i), 150.0(j)2, 150.0(j)3, 150.0(m)1 thru 11: duct sealing & HERS testing with forced air duct systems	All requirements of Section 150.1(c)6,7,9 & 10; and heating system limited to natural gas, LPG or existing fuel type	Exemption from fuel type requirement if new system can be shown to use less TDV energy than the existing system.	CF-1R-ALT or CF-1R-ALT-HVAC; MF-1R *(CF-1R must be registered w/ a HERS Provider)*
Altered Space Conditioning System with Forced Air Ducts	New equipment must meet all the minimum efficiency and other requirements in Sections 150.0(h), 150.0(i), 150.0(j)2, 150.0(j)3, 150.0(m)1 thru 11	Duct sealing & HERS testing per Section 150.2(b)1.E	(1) Duct systems documented as previously sealed and HERS tested; or, (2) Duct systems with < 40 lineal feet in unconditioned spaces; or, (3) Existing duct system constructed, insulated or sealed with asbestos	CF-1R-ALT or CF-1R-ALT-HVAC; MF-1R *(CF-1R must be registered w/ a HERS Provider)*
Altered(5) Mechanical Cooling (Refrigerant-Containing) System	New equipment must meet all the minimum efficiency and other requirements in Sections 110.2(c), 150.0(h), 150.0(i), 150.0(j)2, 150.0(j)3, 150.0(m)1 thru 11	In CZ2, 8-15: refrigerant charge per RA3.2.2 and & HERS testing per Section 150.2(b)1.F.i.a.; or refrigerant weigh-in charging per RA3.2.3.1 & HERS testing	(1) Packaged systems w/ correct, verified and documented refrigerant charge by manufacturer do not require HERS testing (2) When outdoor temperature < 55° F. and refrigerant weigh-in charging used and HERS test RA3.2.3.2 used, system thermostat must be Demand Response.	CF-1R-ALT or CF-1R-ALT-HVAC; MF-1R *(CF-1R must be registered w/ a HERS Provider)*
Altered Duct Systems: When > 40 ft. of New or Replacement Ducts are Installed in Unconditioned or Indirectly Conditioned Space	New ducts must meet applicable portions of Sections 150.0(m)1 thru 11 including duct insulation in Table 150.1-A. Entirely new and complete replacement duct systems must meet additional requirements in Sections 150.0(m)12 & 13.	*New or Replacement Duct System*: duct sealing & HERS testing per Section 150.2(b)1.D.ii.a. *Extension of Existing Ducts By > 40 ft*: HERS testing of existing duct system per Section 150.2(b)D.ii.b.	*Exception to 150.2(b)D.ii.b. Duct Sealing:* when existing duct system is constructed, insulated or sealed with asbestos.	CF-1R-ALT or CF-1R-ALT-HVAC; MF-1R *(CF-1R must be registered w/ a HERS Provider)*

Note 1: Alterations must comply with all applicable mandatory measures in Sections 110 and 150 of the Standards as explained in Chapters 3, 4, 5 and 6 of this Manual.
Note 5: Non-setback thermostats must be replaced with setback thermostats per Section 110.2(c) when alterations include intallation or replacement of the compressor, condensing coil, evaporator coil, refrigerant metering device or refrigerant piping.

Table 9-~~8~~ 9 Summary of Prescriptive HVAC & Water Heating Alterations (cont.)

Type of Mechanical System or Water Heating Alteration	Highlight(s) of Applicable Mandatory Measures [1]	Summary of Relevant Prescriptive Measure(s)	Exception(s) to the Prescriptive Measures	Prescriptive Compliance Form(s)
Installing Zonally Controlled Central Forced Air System	Airflow > 350 CFM/Ton cooling, Fan < 0.58 W/CFM: HERS testing *Section 150.1(m)15*	Bypass ducts that deliver conditioned supply air directly to the return duct airflow may not be used. *Section 150.1(c)13*	N/A	CF-1R-ALT or CZ-Specific CF-1R-ALT-HVAC; MF-1R *(CF-1R must be registered w/ a HERS Provider)*
Replacement Water Heaters and Altered Piping	New equipment must meet minimum efficiency and other requirements in Sections 110.1, 110.3 and 150.0(j)2 Exception to 150.0(j)2: Inaccessible piping requires no insulation	(1) A natural gas or propane water heater that meets the requirements of Section 150.1(c)8 with no recirculation system; or, (2) If no natural gas is connected to the building: an electric water heater with an Energy Factor = or > that required by the Appliance Efficiency Regulations and a storage tank < or = 60 gal and no recirculation system	According to a calculation method approved by the CEC: Any water heating system that uses no more TDV energy than the prescriptive natural gas/propane water heater; or. when no natural gas is connected to the building, any water heating system that uses no more TDV energy than the prescriptive electric water heater.	CF-1R-ALT; or CF-1R-ALT-HVAC; MF-1R

Note 1: Alterations must comply with all applicable mandatory measures in Sections 110 and 150 of the Standards as explained in Chapters 3, 4, 5 and 6 of this Manual.

Table 9-~~9~~10: Residential Alteration, Summary of Mandatory and Prescriptive Measures

Type of Mechanical System Alteration	Highlight(s) of Applicable Mandatory Measures[1]	Summary of Relevant Prescriptive Measure(s)	Exception(s) to the Prescriptive Measures	Prescriptive Compliance Form(s)
New or Complete Replacement Space Conditioning System **(New Equipment and All New Ducts > 40 ft. ~~in Unconditioned or Indirectly Conditioned Space~~)**	New equipment must meet all minimum efficiency and other requirements in §150.0(h), 150.0(i), 150.0(j)2, 150.0(j)3, 150.0(m)1 thru 11: duct sealing & HERS testing with forced air duct systems	All requirements of §150.1(c)6,7,9 & 10~~;~~, 150.2(b)1D; and heating system limited to natural gas, LPG or existing fuel type	Exemption from fuel type requirement if new system can be shown to use less TDV energy than the existing system.	CF1R-ALT or CF1R-ALT-HVAC; (CF1R must be registered w/ a HERS Provider)
Altered Space Conditioning System with Forced Air Ducts	New equipment must meet all the minimum efficiency and other requirements in §150.0(h), §150.0(i), §150.0(j)2, §150.0(j)3, §150.0(m)1 thru 11	Duct sealing & HERS testing per §150.2(b)1.E	(1) Duct systems documented as previously sealed and HERS tested; or, (2) Duct systems with < 40 ~~lineal feet in unconditioned spaces~~; or, (3) Existing duct system constructed, insulated or sealed with asbestos	CF1R-ALT or CF1R-ALT-HVAC; (CF1R must be registered w/ a HERS Provider)
Altered[(5)] Mechanical Cooling (Refrigerant-Containing) System	New equipment must meet all the minimum efficiency and other requirements in §110.2(c), §150.0(h), §150.0(i), §150.0(j)2, §150.0(j)3, §150.0(m)1 thru 11	In CZ2, 8-15: refrigerant charge per RA3.2.2 and & HERS testing per §150.2(b)1.F.i.~~a~~ b.; ~~or refrigerant weigh-in charging per RA3.2.3.1 & HERS testing~~ Minimum system airflow per §150.2(b)1Fia	(1) Packaged systems w/ correct, verified and documented refrigerant charge ~~by manufacturer~~ do not require HERS testing (2) When outdoor temperature < 55o F. and refrigerant weigh-in charging used and HERS test RA3.2.3.2 used, system thermostat must be Demand Response.	CF1R-ALT or CF1R-ALT-HVAC; (CF1R must be registered w/ a HERS Provider)

Altered Duct Systems: When > 40 ft. of New or Replacement Ducts are Installed ~~in Unconditioned or Indirectly Conditioned Space~~	New ducts must meet applicable portions of §150.0(m)1 thru 11 including duct insulation in Table 150.1-A. Entirely new and complete replacement duct systems must meet additional requirements in §150.0(m)12 & 13.	New or Replacement Duct System: duct insulation per §150.2(b)1i., sealing & HERS testing per §150.2(b)1.D.ii.a. Extension of Existing Ducts By > 40 ft: HERS testing of existing duct system per §150.2(b)D.ii.b.	Exception to 150.2(b)D.ii.b. Duct Sealing: when existing duct system is constructed, insulated or sealed with asbestos.	CF1R-ALT or CF1R-ALT-HVAC; (CF1R must be registered w/ a HERS Provider)

9.7 Performance Method:

9.7.1 Existing + Additions + Alterations

Alterations may meet the Energy Standards using the performance approach with any one of the following compliance paths summarized in Section 9.2, Table 9-1:

1. *Existing + Addition + Alterations Without Third Party Verification*
2. *Existing + Addition + Alterations With Third Party Verification*
3. *Existing + Addition + Alterations as New Construction*

For a detailed explanation of each of these compliance alternatives, refer to Section 9.5.2. When there is no addition, the performance calculations model the existing building, all altered components to remain and any new components (see Section 9.5.2 and Table 9-4).

When there is no addition and only alterations to an existing building, this compliance path is allowed only when there are two or more types of altered components as stated in §150.2(b)2.

Energy Commission-approved compliance software is used to model the building as explained in Chapter 8 of this manual. Whichever compliance path is selected, the Certificate of Compliance (CF1R) generated by the compliance software must be submitted for permit. If the CF1R includes energy measures that require HERS testing or verification, the CF1R must also be registered online with a HERS provider (see Section 2.2.2).

Example 9-~~36~~ 37

Question

A 1,600 ft² house built in 1980 in climate zone 12 is being renovated as follows:

1. A 500 ft² room will be added, including 120 ft² of new windows;
2. A 200 ft² wall and 100 ft² of old window will be removed;
3. Attic insulation in the existing house will be upgraded to R-38; and
4. The addition will be connected to the existing HVAC and duct system.

If the performance approach is used to demonstrate compliance, how does the compliance software establish the standard and proposed designs?

Answer

Table 9-4 summarizes the Modeling Rules for Existing + Addition + Alterations which must be followed to have the compliance software accurately set the standard design and model the proposed design. Under the ~~2013~~ 2016 Standards performance rules, the 200 ft² wall removed and the 100 ft² of old window within it are not included in the energy model and will have no impact on the standard design. The standard design for the addition portion is set using the prescriptive requirements of §150.1(c). If the existing duct system is extended by 40 linear feet or more, the standard design assumes the duct alterations requirements summarized in Table 9-5A~~B~~.

The standard design assumptions for the existing house follow the rules summarized in §150.2(b)2 and §Table 150.2-B based on whether there is a third party verification of the existing conditions. Without third party verification, upgraded energy components in the existing house are modeled as fixed assumptions in the standard design that represent levels of efficiency reasonably expected for each altered component. If the energy analyst using the compliance software selects third party verification of energy components in the existing house to be upgraded (see Section 9.5.2), the standard design assumes the existing conditions for those components to be as part of the alterations.

If the proposed design including Existing + Addition + Alterations does not pass, other energy components of the existing building and/or the addition may have to achieve compliance. For example, the water heater or the HVAC equipment in the existing portion of the house may be upgraded to achieve additional credits towards compliance. In the addition, higher performing windows and higher levels of roof and wall insulation may also be used to achieve compliance.

Example 9-~~37~~38

Question

For the 1980 house in the examples above, an operable single pane metal window is replaced with a 0.55 U-factor window. Does this alteration result in a compliance credit? How about the case where the existing window is replaced with a window that has a U-factor of 0.35?

Answer

As explained in Example 9-36, altered components that receive compliance credit must exceed the requirements of §Table 150.2-B. Windows in the addition must have a U-factor of < 0.32 and SHGC < 0.25 to receive credit. Replacement windows in the existing house must have a U-factor of < 0.40 and SHGC < 0.35 to receive credit.

A window replacement with a 0.55 U-factor will receive a penalty as compared with a 0.40 U-factor standard design assumption for that window. Without third party verification of existing conditions, a 0.35 U-factor window replacement will receive a credit as compared with a 0.40 U-factor standard design assumption for that window. With third party verification of existing conditions, a 0.35 U-factor window replacement will receive a credit as compared with a 1.28 U-factor standard design assumption for an operable single pane metal existing window.

Although this example describes a window alteration, the same principles apply to other building systems, such as other building envelope components as well as HVAC and water heating equipment.

Example 9-~~38~~39

Question

An addition of 590 ft² is being added to an existing 2,389 ft² single family house. How do you demonstrate compliance using the Existing + Addition + Alterations method?

Answer

The first step is to determine whether alterations to the existing building include at least two different types of energy components (e.g. upgrading attic insulation and replacing the water heater.) If so, use the E+A+A approach. If not, you're not allowed to use the performance approach.

Assuming the E+A+A calculation is permissible, the process requires the following next steps:

1. Collect accurate envelope and mechanical information about the existing building from scaled drawings (plans, sections and elevations); and what components, including HVAC, ducts and water heating, are being altered as part of the permitted scope of work.

2. Enter the information about the addition and the existing building into the compliance program, identifying each modeled feature as "Existing", "Altered" or "New" as summarized in Table 9-4. Proper tagging of each of these inputs is critical to correctly and accurately determining compliance.

3. Run the compliance software to determine if the proposed building TDV energy is equal or less than the standard design TDV energy.

4. If not, modify the energy features of the addition and/or the existing building until compliance is achieved; and print out the appropriate compliance report for permit submittal.

5. All projects that include energy measures requiring HERS field verification and diagnostic testing – which represent almost all buildings under the ~~2013~~ 2016 Standards – must be registered online with a HERS provider as explained in Section 2.3.

Example 9-~~39~~40

Question

When using the existing-plus-addition performance approach, do the refrigerant charge, access holes (MAH and STMS) or ~~CID~~FID, see §150.1(c)7, airflow, watt draw measurement, and static pressure probe (HSPP), or a permanently installed static pressure probe (PSPP) as specified in §150.0(m)13 and need to be met for central split system air conditioners serving an addition?

Answer

If existing equipment is extended to serve the addition, these space conditioning requirements do not need to be met as specified by Exception 4 to §150.2(a). However, Exception 5 to §150.2(a) indicates that the duct system that is going to be extended must be sealed tested and HERS verified according to §150.2(b)1D.

For performance compliance in climate zones that require a refrigerant charge and airflow measurement in Package A, a hypothetical standard design SEER split system with this credit would be modeled in both the standard and the proposed designs (for example, values from the vintage table, or minimally complying equipment), resulting in neither credit nor penalty related to this feature.

If a new central split system is installed to serve the addition, it must meet the requirements of §150.2(b)1C where installation of a new air conditioner to serve both the existing house and the addition is considered an alteration, and must meet the requirements for diagnostically tested refrigerant charge measurement fan airflow, watt draw and other requirements described. The duct sealing, testing and verification requirements of §150.2(b)1E must also be met.

Example 9-~~40~~ 41

Question

When using the E+A+A performance method, can compliance credit be gained by sealing the existing ducts when it was not required for prescriptive compliance?

Answer

Yes. Credit can be obtained from sealing, testing and HERS verification of duct sealing.

However as shown in §Table 150.2-B "Standard Design for an Altered Component," the base case duct leakage will be the requirements in §150.2(b)1D (i.e. with 15% duct leakage or 10% leakage to the outside). Sealing below 15% can be difficult if the ducts are not readily accessible and large holes are present in the ducts. An alternative approach is to replace the ducted system with a ductless system such as a mini-split.

Example 9-~~41~~ 42

Question

When using the existing plus addition performance compliance method, can credit be gained by installing a radiant barrier in the existing house attic? If so, where does the radiant barrier need to be installed?

Answer

Yes, installing a radiant barrier in the existing building will result in a credit relative to the standard design for existing buildings permitted (or constructed) prior to June 1, 2001. The radiant barrier must be installed over the entire attic/roof area including gable walls. If there are roof/ceiling assemblies where it is not possible to reach the underside of the roof, such as roof/ceiling assemblies using enclosed rafters which are not proposed to be exposed as part of the project, the radiant barrier cannot be properly installed and compliance credit is not possible.

Example 9-~~42~~43

Question

I am adding a room to and altering an existing building in climate zone 12. I am upgrading a single-pane clear glass window with a U-factor of 1.2 and SHGC of 1.0 to a dual-pane window with a U-factor of 0.50 and SHGC of 0.45. Do I receive credit toward the addition compliance for installing this window?

Answer

No. There will be a penalty toward achieving compliance since the window is not as efficient as required by §Table 150.2-B for climate zone 12 which requires a U-factor of 0.40 and an SHGC of 0.35. The penalty for the U-factor is based on the difference between 0.40 and 0.50 and for the SHGC is based on the difference between 0.35 and 0.45. If fenestration is installed which exceeds the performance of the values in §Table 150.2-B, then credit is available.

Example 9-~~43~~44

Question

I am planning on installing R-25 insulation in the attic of an existing house built in 1970. Can I use this added insulation as a credit for trading with the energy features of an addition?

Answer

No. When insulation is added to an attic, it must comply with §150.0(a) which sets a mandatory minimum for attic insulation of R-30. No credit is allowed until the mandatory minimum R-30 is reached. However, if you install R-30 or greater in the existing attic, you are allowed to take credit for the difference between the proposed attic insulation R-value and the standard design assumption:

1. Without third party verification of existing conditions, the energy credit is the difference between the default construction assembly U-factor for R-30 and the lower U-factor for attic insulation greater than R-30.
2. With third party verification of existing conditions, the energy credit is the difference between the default construction assembly U-factor for R-30 and U-factor of the site-verified existing attic conditions.

Example 9-~~44~~45

Question

I am planning on installing R-25 insulation in an un-insulated vaulted ceiling without an attic space in an existing house built in 1970. Can I use this added insulation as a credit for trading with the energy features of an addition?

Answer

Yes. Since there is no attic space, the requirements of §150.0(a) require only R-19 or the equivalent between roof rafters. When you install R-25 you are allowed to take credit for the difference between R-25 and R-19 without third party verification of existing conditions. With third party site verification of the existing un-insulated vaulted ceiling prior to construction, you may take credit for the difference between the R-25 and R-0 (no insulation) in the vaulted ceiling.

CERTIFICATE OF COMPLIANCE	CF1R-ADD-01-E
Prescriptive Residential Additions 1,000 ft^2 or Less	(Page 1 of 6)
Project Name:	Date Prepared:

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) (Addition):	
11	Building Type:		12	Slab Area (ft^2):	
13	Project Scope:		14	Exceptions to Fenestration U-factor and SHGC 150.1(c)3A:	

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

01	02	03	04	05	06	07	08	09	10	11
					Proposed				Required	
								Appendix JA4 Reference		
Tag/ID	Assembly Type	Frame Type	Frame Depth (inches)	Frame Spacing (inches)	Cavity R-value	Continuous Insulation R-value	U-Factor	Table	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(c)1)

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

CERTIFICATE OF COMPLIANCE	CF1R-ADD-01-E
Prescriptive Residential Additions 1,000 ft^2 or Less	(Page 2 of 6)
Project Name:	Date Prepared:

D. Opaque Surface Details – Mass Walls (Section 150.1(c)1)														
01	02	03	04	05	06		07		08	09	10		11	
					Proposed						**Required**			
					Interior Insulation		Exterior Insulation		Appendix JA4 Reference		Interior Insulation		Exterior Insulation	
Tag/ID	Walls Above Grade	Mass Type	Mass Thickness (inches)	Furring Strip Thickness (inches)	R-value	U-factor	R-value	U-factor	Table	Cell	R-value	U-factor	R-value	U-factor

E. Slab Insulation (Table 150.1-A)					
01	02	03	04	05	06
	Proposed		**Required**		
Floor Type	R-value	U-factor	Insulation R-value	Insulation U-factor	Comments

Note:

- Heated slab floors require mandatory slab insulation (see Table 110.8-A).

F. Radiant Barrier (Section 150.1(c)2)	
01	02
Radiant Barrier installed below the roof deck and on all gable end walls	Comment

A radiant barrier is required (for Climate Zones 2-15)

- Radiant barriers shall meet specific eligibility and installation criteria to receive energy credit for compliance with the Building Energy Efficiency Standards for low-rise residential buildings. Refer to RA4.2.1
- The emittance of the radiant barrier shall be less than or equal to 0.05 as tested in accordance with ASTM C1371 or ASTM E408.
- For Prescriptive Compliance the attic shall be ventilated to provide a minimum free ventilation area of not less than one square foot of vent area for each 300 ft^2 of attic floor area with no less than 30 percent upper vents. Ridge vents or gable end vents are recommended to achieve the best performance. The material should be cut to allow for full airflow to the venting.

CERTIFICATE OF COMPLIANCE	CF1R-ADD-01-E
Prescriptive Residential Additions 1,000 ft^2 or Less	(Page 3 of 6)
Project Name:	Date Prepared:

G. Roofing Products (Cool Roof) (Section 150.1(c)11)

01	02	03	04	05	06	07	08	09	10	11	12	13
						Proposed				**Required**		
Tag/ID	Mass Roof 25 lb/ft^2 or greater	Roof Pitch	Method of compliance	Product Type	CRRC Product ID Number	Initial Solar Reflectance	Aged Solar Reflectance	Thermal Emittance	SRI (Optional)	Aged Solar Reflectance	Thermal Emittance	SRI (Optional)

~~NOTES~~Notes:
- Any roof area covered by building integrated photovoltaic panels and solar thermal panels are exempt from the above Cool Roof requirements.
- Liquid field applied coatings must comply with installation criteria from section 110.8(i)4.

H. Fenestration/Glazing Allowed Areas and Efficiencies (Section 150.2(a)1)

01	02	03	04	05	06	07	08	09	10
Addition Type ft^2	Maximum Allowed Fenestration Area for All Orientations ft^2		Maximum Allowed West-Facing Fenestration Area Only ft^2		Maximum Allowed U-factor (Windows)	Maximum Allowed U-factor (Skylights)	Maximum Allowed SHGC (Windows)	Maximum Allowed SHGC (Skylights)	Comments
	The Greater		The Greater						
	Maximum Calculated based on Allowed %	Maximum Calculated Allowed ft^2	Maximum Calculated based on Allowed %	Maximum Calculated Allowed ft^2					

CERTIFICATE OF COMPLIANCE	CF1R-ADD-01-E
Prescriptive Residential Additions 1,000 ft^2 or Less	(Page 4 of 6)
Project Name:	Date Prepared:

I. Fenestration Proposed Areas and Efficiencies

Note: If meeting Exception 1 to 150.1(c)3A, Installing ≤ 3ft^2 glass in door, it is assumed to meet the minimum required U-factor (0.32) & SHGC (0.25).
If meeting Exception 1 to 150.1(c)3A, Installing ≤ 3ft^2 tubular skylight, it is assumed to meet the minimum required U-factor (0.55) & SHGC (0.30).

01	02	03	04	05	06	07	08	09	10	11	12	13	14
Tag/ID	Fenestration Type	Frame Type	Dynamic Glazing	Orientation N, S, W, E or Roof	Number of Panes	Proposed Fenestration Area ft2	Proposed West Facing Fenestration Area ft2	Proposed U-factor	Source	Proposed SHGC	Source	Exterior Shading Device	Combined SHGC from CF1R-ENV-03

15	Total Proposed Fenestration Area	
16	Maximum Allowed Fenestration Area	
17	Compliance Statement:	
18	Total Proposed West-Facing Fenestration Area	
19	Maximum Allowed West-Facing Fenestration Area	
20	Compliance Statement:	
21	Proposed Fenestration U-factor (Windows)	
22	Required Fenestration U-factor (Windows)	
23	Compliance Statement:	
24	Proposed Fenestration SHGC (Windows)	
25	Required Fenestration SHGC (Windows)	
26	Compliance Statement:	
27	Proposed Fenestration U-factor (Skylights)	
28	Required Fenestration U-factor (Skylights)	
29	Compliance Statement:	
30	Proposed Fenestration SHGC (Skylights)	
31	Required Fenestration SHGC (Skylights)	
32	Compliance Statement:	

CERTIFICATE OF COMPLIANCE	CF1R-ADD-01-E
Prescriptive Residential Additions 1,000 ft^2 or Less	(Page 5 of 6)
Project Name:	Date Prepared:

J. Space Conditioning (SC) Systems – Heating/Cooling – Single Family Dwelling (Section 150.2(b) or (Section 150.1(c)7)

01	02	03
Dwelling Unit Name	Dwelling Unit Total CFA = Sum of Existing + Addition (ft^2)	Comments

K. Water Heating Systems (Section 150.1(c)8)
List water heaters and boilers for both domestic hot water (DHW) heaters and hydronic space heating.

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Water Heating System ID or Name	Water Heating System Type	Water Heater Type	# of Water Heaters in system	Water Heater Storage Volume (gal)	Fuel Type	Rated Input Type	Rated Input Value	Heating Efficiency Type	Heating Efficiency Value	Standby Loss (%)	Exterior Insul. R-Value	Back-Up Solar Savings Fraction	Central DHW System Distribution Type	Dwelling Unit DHW System Distribution Type

L. Space Conditioning Systems and Water Heating Systems in Multifamily Dwelling Units

01	02	03	04	05	06
Dwelling Unit Name	Dwelling Unit Total CFA = Sum of Existing + Addition (ft^2)	Central Water Heating System Identification or Name	Dwelling Unit Water Heating System Identification or Name	Dwelling Unit: Installing a New Space Conditioning System?	Comments

CERTIFICATE OF COMPLIANCE	CF1R-ADD-01-E
Prescriptive Residential Additions 1,000 ft^2 or Less	(Page 6 of 6)
Project Name:	Date Prepared:

DOCUMENTATION AUTHOR'S DECLARATION STATEMENT	
1. I certify that this Certificate of Compliance documentation is accurate and complete.	
Documentation Author Name:	Documentation Author Signature:
Company:	Signature Date:
Address:	CEA/ HERS Certification Identification (if applicable):
City/State/Zip:	Phone:

RESPONSIBLE PERSON'S DECLARATION STATEMENT

I certify the following under penalty of perjury, under the laws of the State of California:

1. The information provided on this Certificate of Compliance is true and correct.
2. I am eligible under Division 3 of the Business and Professions Code to accept responsibility for the building design or system design identified on this Certificate of Compliance (responsible designer).
3. That the energy features and performance specifications, materials, components, and manufactured devices for the building design or system design identified on this Certificate of Compliance conform to the requirements of Title 24, Part 1 and Part 6 of the California Code of Regulations.
4. The building design features or system design features identified on this Certificate of Compliance are consistent with the information provided on other applicable compliance documents, worksheets, calculations, plans and specifications submitted to the enforcement agency for approval with this building permit application.
5. I will ensure that a registered copy of this Certificate of Compliance shall be made available with the building permit(s) issued for the building, and made available to the enforcement agency for all applicable inspections. I understand that a registered copy of this Certificate of Compliance is required to be included with the documentation the builder provides to the building owner at occupancy.

Responsible Designer Name:	Responsible Designer Signature:
Company :	Date Signed:
Address:	License:
City/State/Zip:	Phone:

For assistance or questions regarding the Energy Standards, contact the Energy Hotline at: 1-800-772-3300

CF1R-ADD-01-E User Instructions

Minimum requirements for prescriptive addition compliance can be found in Building Energy Efficiency Standards Section 150.2(a), and Table 150.1-A (Package A). Completing these forms will require that you have the Reference Appendices for the 2016~~3~~ Building Energy Efficiency Standards (P400-2012-005), which contain the Joint Appendices used to determine climate zone and to complete the section for opaque surfaces. When the term CF1R is used it means the CF1R-ADD-01. Worksheets are identified by their entire name and subsequently by only the worksheet number, such as WS-02.

Instructions for sections with column numbers and row letters are given separately.

If any part of the addition does not comply, prescriptive compliance fails, in which case the performance (or computer) compliance approach may be used in an attempt to achieve compliance. Only the new construction is required to meet the requirements specified in this documentation. If any alterations to the existing building are occurring, those are documented on one or more of the CF1R-ALT forms.

A. General Information

1. Project Name: Identifying information, such as owner's name.
2. Date Prepared: Date of document preparation.
3. Project Location: Legal street address of property or other applicable identifying information.
4. Building Front Orientation: Building front expressed in degrees, where North = 0, East = 90, South = 180, and West = 270. The S~~s~~tandards (~~s~~Section 100.1) include the following additional details for determining orientation:
   - North is oriented to within 45 degrees of true north, including 45 degrees east of north;
   - East is oriented to within 45 degrees of true east, including 45 degrees south of east;
   - South is oriented to within 45 degrees of true south, including 45 degrees west of south;
   - West is oriented to within 45 degrees of true west, including 45 degrees north of west.
5. CA City: Legal city/town of property.
6. Number of Dwelling Units with Additions: 1 for single-family, 1 or more for multifamily.
7. Zip Code: 5-digit zip code for the project location (used to determine climate zone).
8. Fuel Type: Natural Gas, Liquefied Propane Gas, or Electricity.

   NOTE: Prescriptive compliance only allows electricity if existing appliances are electric and natural gas is not available in the building.

9. Climate Zone: From Joint Appendix JA2.1.1.
10. Total Conditioned Floor Area: Enter the new conditioned floor area, in ft^2, as measured from the outside of exterior walls of the addition.
11. Building Type: Single Family (includes duplex), or Multi Family (a building that shares common walls and common floors or ceilings).
12. Slab Area: Area of the first floor slab of the addition (if any) in ft^2.
13. Project Scope: 300 ft^2 or less, greater than 300 up to 400 ft^2, greater than 400 up to 700 ft^2, greater than 700 up to 1000 ft^2, space heating system, space cooling system, space conditioning duct system, water heating, or fenestration.
14. Exceptions to Fenestration U-factor and SHGC: Installing less than or equal to 3 ft^2 glass in door, Installing less than or equal to 3 ft^2 tubular skylight, or Installing less than or equal to 16 ft^2 skylight

B. Opaque Surface Details - Framed

Additions of 700 ft^2 or less require only R-13 wall insulation. Unless otherwise noted, all other requirements of Package A are required when using prescriptive compliance.

1. Tag/ID: A label (if any) from the plans, such as A1.4 or wall.
2. Assembly Type: Roof, Ceiling, Wall, or Floor.
3. Frame Type: Wood or Metal.
4. Frame Depth: Nominal dimensions (in inches) of framing material such as 2x4 or 2x6.
5. Frame Spacing: 16, 24, or 48 (inches on center).
6. Proposed Cavity R-value: Insulation installed between framing members.

   NOTE: Wall U-factor required for all climate zones is 0.0~~6~~5. This U-factor can be met by wood framed 2x4 walls with R-13 cavity + R5 continuous insulation (not interrupted by framing), R-15 cavity plus R-4 continuous insulation, or any combination of cavity and/or continuous insulation that results in a U-factor equal to or less than 0.065.

   Proposed Continuous Insulation: R-value of rigid or continuous insulation (not interrupted by framing). See Table 4.3.4. of the Reference Appendices for metal frame construction.
7. Proposed U-factor: The U-factor for the proposed assembly must be less than or equal to column 10 or have an attached Area Weighted Average Calculation Worksheet (CF1R-ENV-01-E) to show that a weighted U-factor for multiple assemblies will meet the maximum value in column 10.
8. Appendix JA4 Table: Table number used to determine the R-value or U-factor (e.g., an attic assembly is 4.2.1).
9. Appendix JA4 Cell: Cell number used to determine the R-value or U-factor (e.g., an R-38 ceiling with 24-inch on center framing is A21).
10. Required U-factor: From Package A or from Section 150.2. Value required based on climate zone and assembly type.
11. Comments: Any notes regarding location, unique conditions, or attachments.

C. Opaque Surface Details – Non-Framed

1. Tag/ID: A label (if any) from the plans, for example, A1.4 or wall.
2. Assembly Type: Roof, Wall.
3. Assembly Materials: SIP OSB, SIP I-Joist, SIP Single 2x, SIP Double 2x.
4. Thickness: Thickness in inches.
5. Proposed Core Insulation R-value: Insulation installed within the materials or on the inside. See Joint Appendix JA4 for guidance.
6. Proposed Continuous Insulation R-value: Insulation installed on the exterior. See Joint Appendix JA4 for guidance.
7. Proposed U-factor: Proposed assembly U-factor from JA4 or CF1R-ENV-02-E. Must be less than or equal to column 10.
8. Appendix JA4 Table: Table number used to determine the R-value or U-factor (e.g., a SIP wall is 4.3.2).
9. Appendix JA4 Cell: Cell number used to determine the R-value or U-factor (e.g., a 4.5-inch thick OSB wall with R-18 core insulation and no continuous insulation is A5).
10. Required U-factor from Package A: Based on assembly type and climate zone.
11. Comments: Any notes regarding location, unique conditions, or attachments.

D. Opaque Surface Details – Mass Walls

1. Tag/ID: A label (if any) from the plans, for example, A1.4 or wall.
2. Walls Above Grade: Yes or No.
3. Mass Type: Clay Brick, Clay Hollow Unit, CMU Light Weight, CMU Medium Weight, CMU Normal Weight, concrete, ICF. See JA4 for guidance.
4. Mass Thickness: Thickness (in inches) of mass.
5. Furring Strips Thickness: If furring strips are required to meet the wall R-value or U-factor shown in columns 10 & 11, indicate the thickness of the furring strip (in inches). See Table 4.3.14 of Joint Appendix 4.
6. Proposed Interior Insulation R-value or U-factor: Enter either the R-value or U-factor of proposed insulation on the inside surface of the mass wall. See JA4 for guidance. Use the same descriptor (R-value or U-factor) throughout Table D.
7. Proposed Exterior Insulation R-value or U-factor: Enter either the R-value or U-factor of proposed insulation on the outside surface of the mass wall. See JA4 for guidance.
8. Appendix JA4 Table: Table number used to determine the R-value or U-factor (e.g., an ICF wall is 4.3.13).
9. Appendix JA4 Cell: Cell number used to determine the R-value or U-factor (e.g., an 8-inch thick ICF wall with 2 inches of EPS (R-15.4) is A6).

10. Required Interior Insulation: The required R-value or U-factor (whichever descriptor was selected in column 6) for interior insulation will be completed based on the Table 150.1-A requirements for the wall type.
11. Required Exterior Insulation: The required R-value or U-factor (whichever descriptor was selected in column 7) for exterior insulation will be completed based on the Table 150.1-A requirements for the wall type.

E. Slab Insulation

Slab edge performance specifications and installation criteria are found in Sections 150.0(l) and 150.1(c)1D (Table 150.1-A). Requirements vary by climate zone and slab conditions.

1. Floor type: Types include slab-on-grade or raised slab.
    - Slab-on-grade floors require slab edge insulation in climate zone 16 only.
    - Raised slab must be insulated to R8 in climate zones 1, 2, 11, 13, 14 and 16, R-4 in climate zones 12 and 15, and no insulation is required in climate zones 3-10.
2. Proposed R-value: When required, insulation can be specified by either R-value or U-factor (use the same descriptor throughout Table E). When specifying an R-value complete column 2.
3. Proposed U-Factor: When required, specify the U-factor of proposed insulation in column 3.
4. Required Insulation R-value: Specify the value required, which will vary by climate zone and type of slab. Values are from Table 150.1-A.
5. Required Insulation U-factor: Specify the value required, which will vary by climate zone and type of slab. Values are from Table 150.1-A.
6. Comments: Any notes regarding location, unique conditions, or attachments.

NOTE: There is a mandatory slab edge insulation requirement for heated slab floors. Since mandatory requirements are not listed on the Certificate of Compliance, this is provided for information purposes only. The specific requirements are in Sections 110.8(g) and Table 110.8-A.

F. Radiant Barrier

1. Radiant Barrier installed below the roof deck and on all gable end walls: Yes or No. Radiant barriers are required in climate zones 2-15.
2. Comments: Any notes regarding location, unique conditions, or attachments.

NOTE: Radiant barrier performance specifications and installation criteria are found in Sections 110.8(j) and 150.1(c)2, and in Residential Appendix RA4.2.1.

G. Roofing Products (Cool Roof)

Roofing requirements are found in Section 110.8(i) and 150.1(c)11. Depending on the climate zone and roof slope, a cool roof (defined as a minimum aged solar reflectance and thermal emittance, or a minimum SRI) may be required by Package A.

NOTE: Exceptions include (1) additions of 300 ft^2 or less, (2) low-slope roofs (pitch 2:12 or less) in climate zones 1-12, 14 and 16; (3) steep slope roof (pitch greater than 2:12) in climate zones 1-9 and 16; (4) roof constructions that have thermal mass over the roof membrane with at least 25 lb/ft^2; and (5) any roof area covered by building integrated photovoltaic panels and solar thermal panels (the area of roof not covered by photovoltaic panels would still need to meet any applicable cool roof requirements).

1. Tag/ID: A label (if any) from the plans, such as R1.
2. Mass Roof 25 lb/ft^2 or greater: Yes or No. Mass roofs are not required to have a cool roof even if the climate zone specifies minimum performance requirements.
3. Roof Pitch: Expressed as 4:12, for example, which means the roof rises 4 foot within a span of 12 feet. When roofs have multiple pitches the requirements are based on the pitch of 50% or more of the roof.
4. Method of Compliance: Indicate if the method of compliance is going to be based on Aged Solar Reflectance and Thermal Emittance or is it going to be based on the Solar Reflectance Index (SRI).
5. Product Type: See Cool Roof Rating Council's directory. Generally product types include single-ply roof, wood shingles, asphalt roof, metal roof, tile roof.
6. The CRRC Product ID Number is obtained from the Cool Roof Rating Council's Rated Product Directory at www.coolroofs.org/products/results. Products are listed by manufacturer, brand, type of installation, roofing material, and color, as well as product performance.
7. Proposed Initial Solar Reflectance: Based on the product chosen from the Cool Roof Rating Council's Rated Product Directory. If using default assumption indicate NA since the Aged Solar Reflectance is available.

8. Proposed Aged Solar Reflectance: Value is from the Cool Roof Rating Council's Rated Product Directory. If the aged value is not available, calculate the calculated Aged Solar Reflectance using the Solar Reflectance Index (SRI) Calculation worksheet located on the California Energy Commission website or the aging 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 below.

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

9. Proposed Thermal Emittance: From the product specification default value. If using a calculated SRI, enter the thermal emittance used to calculate SRI.
10. Proposed SRI: It is optional to meet the SRI, but if chosen to do so use the Solar Reflectance Index (SRI) Calculation Worksheet found on the California Energy Commission website http://energy.ca.gov/title24/2013standards/documents/solar_reflectance/.
11. Required Aged Solar Reflectance: Based on climate zone and roof slope.
12. Required Thermal Emittance: Based on climate zone and roof slope.
13. Required SRI: Based on climate zone and roof slope.

If the cool roofing requirements will be met by a liquid field applied coating, Section 110.8(i)4 requires the coating be applied across the entire roof surface and meet the dry mil thickness or coverage recommended by the manufacturer.

H. Fenestration/Glazing Allowed Areas and Efficiencies
Fenestration areas are expressed in square feet, not square inches.

The climate zone and size of the addition will affect the area of fenestration (also known as glazing) allowed. If limited to 20%, for example, this is calculated as Conditioned Floor Area (CFA) of the addition x 0.20 = Total ft^2 of fenestration allowed.

For additions that are 1000ft^2 or less, but greater than 700ft^2, the limit of total fenestration is the greater of 175ft^2 or 20% of the CFA of the addition.
For additions that are 700ft^2 or less, but greater than 400ft^2, the limit of total fenestration is the greater of 120ft^2 or 25% of the CFA of the addition.
For additions that are 400ft^2 or less, the limit of total fenestration is the greater of 75ft^2 or 30% of the CFA of the addition.
For additions that are 1000ft^2 or less, when west-facing fenestration is limited (in climate zones 2, 4, and 6-16), it is limited to either 70ft^2 (for additions greater than 700ft^2) or 60ft^2 (for additions that are 700ft^2 or less).

1. Addition Type: Based on "Project Scope." The addition's area in square feet—whether ≤300, >300 to ≤400, >400 to ≤700, or >700 to ≤1,000.

(2. through 9.—These fields will be completed based on conditioned floor area of the addition and/or climate zone. The values in these fields will be entered into Section I.)

Maximum allowed fenestration area for all orientations is the <u>greater</u> of the values in column 2 or 3:

2. Maximum Calculated based on Allowed %: The addition's CFA multiplied by the allowed %. The maximum total fenestration area is 30% for additions up to 400 ft^2, 25% for additions greater than 400 ft^2 but no greater than 700 ft^2, and 20% for additions greater than 700 ft^2.
3. Maximum Calculated Allowed ft^2: The maximum total fenestration area is 75ft^2 for additions up to 400 ft^2, 120ft^2 for additions greater than 400 ft^2 but no greater than 700 ft^2, and 175 ft^2 for additions of greater than 700 ft^2.

Maximum allowed west-facing area is the <u>greater</u> of the values in column 4 or 5:

4. Maximum Calculated based on Allowed %: The maximum west-facing fenestration area (in climate zones 2, 4, and 6-16) is 5% for additions greater than 700ft^2.
5. Maximum Calculated Allowed ft^2: The maximum west-facing fenestration area (in climate zones 2, 4, and 6-16) is 60ft^2 for additions no greater than 700ft^2, and 70ft^2 for additions of greater than 700 ft^2.

Addition CFA:	≤ 400 ft^2		> 400 to ≤ 700 ft^2		> 700 to ≤ 1,000 ft^2	
	The Greater Of:		The Greater Of:		The Greater Of:	
Orientation	Percentage	Area (ft^2)	Percentage	Area (ft^2)	Percentage	Area (ft^2)
West-facing (CZs 2, 4, 6-16)	-	60	-	60	-	70
All Orientations	30%	75	25%	120	20%	175

NOTE: West includes any vertical fenestration oriented to within 45 degrees of true west (in either direction), including 45 degrees north of west, any skylights oriented west, and skylights facing any direction with a pitch of less than 1:12.

6. Maximum Allowed U-factor (Windows): Maximum area-weighted average of 0.32 for all climate zones.
7. Maximum Allowed U-factor (Skylights): Maximum area-weighted average of 0.32 for all climate zones, unless meeting one of the Exceptions to 150.1(c)3A. If meeting one of the Exceptions, this field will be 0.55.
8. Maximum Allowed SHGC (Windows): Maximum area-weighted average of 0.25 for climate zones 2, 4, and 6-16; otherwise N/A.
9. Maximum Allowed SHGC (Skylights): Maximum area-weighted average of 0.25 for all climate zones, unless meeting one of the Exceptions to 150.1(c)3A. If meeting one of the Exceptions, this field will be 0.30.
10. Comments: Any notes regarding location, unique conditions, or attachments.

I. Fenestration/Glazing Proposed Areas and Efficiencies

1. Tag/ID: Provide a name or designator for each unique type of fenestration surface. This designator should be used consistently throughout the plan set (elevations, finish schedules, etc.) such as Window-1, Skylight-1, etc. to identify each surface. It should also be consistently used on the other forms in the compliance documentation.
2. Fenestration Type: Indicate the type of fenestration construction e.g., Fixed Window, Operable Window, Skylight, Tubular Skylight, or Glass in Door.

NOTE: Doors with glazing are counted in one of two ways. The entire area of a door with 50% or more glazing is considered fenestration. A door with less than 50% glazing can be considered as all fenestration, or can be calculated as the actual glass area with a 2-inch (0.17 ft) frame all around.

3. Frame Type: Metal, metal thermal break, or non-metal.
4. Dynamic Glazing: Indicate whether the fenestration has an integrated shading device, chromogenic glazing, or none for no dynamic glazing. Chromogenic glazing shall be considered separately from other fenestration types.
5. Orientation: Orientation can be North, East, South, or West. If documentation is for a building that may be built in any direction, in a climate zone that limits west-facing fenestration, complete this section assuming the side of the building with the most fenestration faces west.

NOTE: West includes any vertical fenestration oriented to within 45 degrees of true west, excluding 45 degrees south of west; any skylights oriented west; and skylights facing any direction with a pitch of less than 1:12.

6. Number of Panes: Indicate the number of panes for each Tag/ID; is it a single, double, or triple pane window?
7. Proposed Fenestration Area (ft^2): The size of any windows, doors with glass, or skylights within the floor area of the addition (combine windows with the same characteristics). Indicate the area (in square feet) of each exterior fenestration type, including west-facing fenestration.
8. Proposed West Facing Fenestration Area ft^2: In climate zones 2, 4, and 6-16, enter the size of any west-facing windows, doors with glass, or skylights within the floor area of the addition. Indicate the area (in square feet) of each exterior west-facing fenestration type separately.
9. Proposed U-factor: Enter
   (a) the NFRC U-factor based on the proposed brand and type of fenestration using National Fenestration Rating Council (www.nfrc.org) certified values, or

(b) the default value from Table 110.6-A, or
(c) the NA6.2 alternate default U-factor (for non-rated site-built fenestration only), or
(d) the Area-weighted Average from CF1R-ENV-02

If any products (other than the exceptions noted below) have a higher U-factor than 0.32, first complete a CF1R-ENV-02-E to calculate the area-weighted average U-factor, which must be 0.32 or less, and attach it to the CF1R-ADD-01-E.

NOTES: (1) For the exceptions - up to 3 ft^2 of tubular skylights and up to 16 ft^2 of skylight area, enter 0.55.
(2) For the exception – up to 3 ft^2 of glass in door, enter 0.32.
(3) Dynamic glazing is a glazing system that changes its performance U-factor and SHGC based on the physical environment. Dynamic glazing includes chromogenic glazing or integrated shading systems (this does not include ~~internally or~~ externally mounted shading devices). If using dynamic glazing, use the lowest tested U-factor and SHGC in Columns 9 and 11~~0~~.

10. Source: The source of the U-factor data for the fenestration product—indicate whether NFRC, Tables 110.6-A and 110.6-B, Equations NA6-1 and NA6-2, or Area-weighted Average Worksheet (ENV-02).
11. Proposed SHGC: In climate zones 2, 4, and 6-16, enter
    (a) the NFRC SHGC based on the proposed brand and type of fenestration using National Fenestration Rating Council (www.nfrc.org) certified values, or
    (b) the default value from Table 110.6-B, or
    (c) the NA6.3 alternate default SHGC (for non-rated site-built fenestration only), or
    (d) the Area-weighted Average from CF1R-ENV-02.

    If any products (other than the exceptions noted below) have a higher SHGC than 0.25 in a climate zone with a maximum SHGC value, first complete a CF1R-ENV-02-E to calculate the area-weighted average SHGC, which must be 0.25 or less, and attach it to the CF1R-ADD-01-E.

    NOTES: (1) For the exceptions - up to 3 ft^2 of tubular skylights and up to 16 ft^2 of skylight area, enter 0.30.
    (2) For the exception – up to 3 ft^2 of glass in door, enter 0.25.

12. Source: The source of the SHGC data for the fenestration product—indicate whether NFRC, Tables 110.6-A and 110.6-B, Equations NA6-1 and NA6-2, or Area-weighted Average Worksheet (ENV-02).
13. Exterior Shading Device: If exterior shading devices are used to meet the SHGC requirement, indicate the type of device (from Table S-1 of CF1R-ENV-03-E Solar Heat Gain Coefficient Worksheet) and attach the CF1R-ENV-03-E.

    NOTES: (1) An exterior shading device is not used for products with an NFRC rated U-factor and SHGC based on a factory integrated shading device.
    (2) Chromogenic glazing shall be considered separately from other fenestration.
14. Combined SHGC from CF1R-ENV-03: If exterior shading devices are combined with the SHGC value of the fenestration to meet the prescriptive SHGC requirements (as indicated in column I. 13), indicate the SHGC calculated on form CF1R-ENV-03 and attach the form for each window with an exterior shading device.

15.-32. Automatically completed entries; no user input required.

J. Space Conditioning Systems – Heating/Cooling – Single Family Dwelling

If an existing space system will condition an addition, the prescriptive requirements do not apply to that system (Exception 4 to Section 150.2(a)). The enforcement agencies may require verification that the capacity of the existing heating system is adequate to meet the added load of the additional conditioned floor area. Since there is no health and safety code requirement to provide cooling, the enforcement agency will not ask for verification that the capacity of the existing system is adequate to meet the added load of the additional conditioned floor area.

If a new system is installed complete a Certificate of Compliance for Alterations to Space Conditioning Systems (CF1R-ALT-02).

1. Dwelling Unit Name: Name of dwelling unit or any other identifying name.
2. Dwelling Unit Total CFA – Sum of Existing Plus Addition (ft^2): Total dwelling unit conditioned floor area in ft^2, as measured from the outside of exterior walls of the dwelling unit or building being altered.
3. Comments: Any notes regarding location or unique conditions.

K. Water Heating Systems for Additions

Water heating compliance for an addition is described in Section 150.2(a). When a water heater is added as part of an addition in a single dwelling, a gas or propane water heater, with a storage tank of 60 gallons maximum or instantaneous, can be used. Electric water heaters can only be used if gas or propane is not available.~~, and no recirculation pump can be used.~~

1. Water Heating System Identification or Name: Enter a unique name for the Water Heating System.
2. Water Heating System Type: Domestic Hot Water (DHW), Hydronic, Combined Hydronic, or Central. DHW is for domestic hot water, hydronic is a water heating system used for space heating only; combined hydronic are when the water heater will provide both space conditioning and domestic hot water.
3. Water Heater Type: For non-central systems only Small Storage or Small Instantaneous are allowed. For central systems pick from Large Storage, Small Storage, Heat Pump, Boiler, Large Instantaneous, Small Instantaneous, or Indirect.
4. Number of Water Heaters in System: In single-family and multi-family with water heaters in each dwelling units the value is 1. For multi-family central systems serving multiple dwelling units enter the total number of water heaters.
5. Water Heater Volume (gal): Tank capacity in gallons. For individual water heaters for a dwelling unit this will be 60 gallons or less. If instantaneous, enter n/a. For multi-family central systems enter the total storage volume.
6. Fuel Type: Gas, Propane, or Electric (only if natural gas is not available)
7. Rated Input Type: Enter the equipment input rating type, for gas or propane fired system the units are Btuh, for electric fired system the units are kW.
8. Rated Input Value: Enter the numeric value of rated input.
9. Heating Efficiency Type: Energy Factor, AFUE, or Thermal Efficiency. From product literature or a California Energy Commission directory.
10. Heating Efficiency Value: Enter the value from product literature or a California Energy Commission directory
11. Standby Loss (percent): Applies only to large storage water heaters. Enter n/a for small storage or instantaneous water heaters.
12. Exterior Insulation R-Value: Enter the R-value if exterior insulation on the storage tank is installed
13. Back-up Solar Savings Fraction: If compliance requires a back-up solar system, indicate the solar contribution (e.g., 0.30). External calculations are required.
14. Central DHW System Distribution Type: For multi-family buildings using a central distribution system a demand recirculation system with at least two distribution loops must be installed. This requirement applies to any building with eight or more units. If the system is non-central or project has individual units enter n/a.
15. Dwelling Unit DHW System Distribution Type: For a Central DHW this field shall be Standard. If non-central then pick from Standard, Demand Recirculation – Manual Control, Demand Recirculation – Sensor Control. Non-central electric water heater must be Standard, no recirculation system shall be installed.

L. Space Conditioning and Water Heating in Multifamily Dwelling Units If an existing space system will condition an addition, the prescriptive requirements do not apply to that system (Exception 4 to Section 150.2(a)). The enforcement agencies may require verification that the capacity of the existing heating system is adequate to meet the added load of the additional conditioned floor area. Since there is no health and safety code requirement to provide cooling, the enforcement agency will not ask for verification that the capacity of the existing system is adequate to meet the added load of the additional conditioned floor area. If a new space conditioning system is installed complete a Certificate of Compliance for Alterations to Space Conditioning Systems (CF1R-ALT-02)

1. Dwelling Unit Name: Enter one unique name for each of the number of dwelling units with additions as identified in Section A field 06.
2. Dwelling Unit Total CFA – Sum of Existing Plus Addition (ft^2): Total dwelling unit conditioned floor area in ft2, as measured from the outside of exterior walls of the dwelling unit or building being altered.
3. Central Water Heating System Identification or Name: Enter the central DHW system names from K. 01.
4. Dwelling Unit Water Heating System Identification or Name: Note the applicable water heating system name(s) that were entered in section K or L. If more than one water heating system type is needed in the dwelling unit, add another row of data for the dwelling unit and enter the additional water heating system name.
5. Dwelling Unit - Installing a New Space Conditioning System?: If a new Space Conditioning system is planned to be installed, then enter yes, otherwise enter no.
6. Comments: Any notes regarding location or unique conditions.

Documentation Declaration Statements

1. The person who prepared the CF1R will sign and complete the fields for their name, company (if applicable), address, phone number, certification information (if applicable), date and signature (may be electronic).
2. The person who is assuming responsibility for the project being built to comply with Title 24, Part 6, will complete the fields for their name, company (if applicable), address, phone number, license number (if applicable), date and signature (may be electronic).

Registration

The CF1R must be registered with a HERS provider prior to submitting for a building permit.

1. **References**Water Heaters:

Section 150.1(c) allows a limited number of conditions for water heating. If conditions other than these are proposed, the prescriptive compliance approach cannot be used:

Single Dwelling Unit

A. A single gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank, and that meets the requirements of Sections 110.1 and 110.3.

B. A single gas or propane storage type water heater with an input of 105,000 Btu per hour or less, rated volume less than or equal to 55 gallons and that meets the requirements of Sections 110.1 and 110.3. The dwelling unit shall meet all of the requirements for Quality Insulation Installation (QII) as specified in the Reference Appendix RA3.5.

C. A single gas or propane storage type water heater with an input of 105,000 Btu per hour or less, rate volume of more than 55 gallons, and that meets the requirements of Sections 110.1 and 110.3.

Central System

D. All water heaters installed mustcomply with Sections 110.1 and 110.3. The distribution system shall be equipped with a demand recirculation control allowing pump operation to be based on measurement of hot water demand and hot water return temperature. The system shall have at least two loops. Buildings with 8 or less units do not have to comply with the demand recirculation requirement.

~~A. 150.1(c)8A one gas or propane storage water heater, up to 75,000 Btu/hour input (typically 50 gallons or less), with either no recirculating system or a demand recirculation system with manual controls. If the Energy Factor is less than or equal to the federal minimum, it must have an R-12 external wrap. See D. below.~~

~~B. 150.1(c)8B one gas or propane instantaneous (tankless) water heater with an input of 200,000 Btu per hour or less, no storage tank, and either no recirculating system, or a demand recirculation system with manual controls. .~~

~~C. 150.1(c)8C a central water-heating system that includes the following components (1) gas or propane water heaters, boilers or other water heating equipment, (2) a water heating recirculation loop that meets the requirements of Section 110.3(c)2 and Section 110.3(c)5 equipped with automatic controls for the recirculation pump based on measurement of hot water demand and hot water return temperature, and if more than 8 dwelling units, two recirculation loops each serving half of the building; (3) a solar water-heating system with a minimum solar savings fraction of 0.20 in climate zones 1 through 9 or a minimum solar savings fraction of 0.35 in climate zones 10 through 16 (installation criteria is in Reference Residential Appendix RA4).~~

~~D. 150.1(c)8D if natural gas is not available, an electric-resistance storage, or instantaneous water heater with addition criteria that it be located inside the conditioned space, has no recirculation pumps, and has a solar water-heating system with a minimum solar savings fraction of 0.50 (installation criteria is in Reference Residential Appendix RA4).~~

CERTIFICATE OF COMPLIANCE	CF1R-ALT-01-E
Prescriptive Residential Alterations	(Page 1 of 6)
Project Name:	Date Prepared:

A. General Information					
01	Project Name:		02	Date Prepared:	
03	Project Location:		04	Building Front Orientation (deg or cardinal):	
05	CA City:		06	Number of Altered Dwelling Units:	
07	Zip Code:		08	Fuel Type:	
09	Climate Zone:		10	Total Conditioned Floor Area (ft^2):	
11	Building Type:		12	Slab Area (ft^2)	
13	Project Scope:		14	Exceptions to Minimum Aged Solar Reflectance and Minimum Thermal Emittance or SRI ~~150.2(b)1Hi:~~	

B. Building Insulation Details (Section 150.2(b)1)

01	02	03	04	05	06		07	08	09	10	11
					Proposed					Required	
								Appendix JA4 Reference			
Tag/ID	Assembly Type	Frame Type	Frame Depth (inches)	Frame Spacing (inches)	Cavity R-value	Continuous Insulation R-value	U-factor	Table	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. Roof Replacement (Section 150.2(b)1H)

01	02	03	04	05	06	07	08	09	10	11	12	13	14	
							Proposed				Minimum Required			
Tag/ ID	Method of Compliance	Roof Pitch	Exception	CRRC Product ID Number	Product Type	R-value Deck Insulation	Initial Solar Reflectance	Aged Solar Reflectance	Thermal Emittance	SRI (Optional)	Aged Solar Reflectance (Max)	Aged Solar Reflectance (Min)	Thermal Emittance	SRI (Optional)

NOTES:

- Roof area covered by building integrated photovoltaic panels and solar thermal panels are exempt from the above Cool Roof requirements.
- Liquid field applied coatings must comply with installation criteria from section 110.8(i)4.

CERTIFICATE OF COMPLIANCE	CF1R-ALT-01-E
Prescriptive Residential Alterations	(Page 2 of 6)
Project Name:	Date Prepared:

D. Fenestration/Glazing Allowed Areas and Efficiencies (Section 150.2(b)1)

01	02	03	04		05		06		07
Alteration Type	Maximum Allowed Fenestration Area For All Orientations (ft^2)	Maximum Allowed West-Facing Fenestration Area Only (ft^2)	Existing Fenestration Area for All Orientations (ft^2)	Existing West-Facing Fenestration Area (ft^2)	Maximum Allowed U-factor (Windows)	Maximum Allowed U-factor (Skylights)	Maximum Allowed SHGC (Windows)	Maximum Allowed SHGC (Skylights)	Comments

CERTIFICATE OF COMPLIANCE	CF1R-ALT-01-E
Prescriptive Residential Alterations	(Page 3 of 6)
Project Name:	Date Prepared:

E. Fenestration/Glazing Proposed Areas and Efficiencies – Add (Section 150.2(b)1A)

01	02	03	04	05	06	07	08	09	10	11	12	13	14
Tag/ID	Fenestration Type	Frame Type	Dynamic Glazing	Orientation N, S, W, E	Number of Panes	Proposed Fenestration Area (ft^2)	Proposed West Facing Fenestration Area (ft^2)	Proposed U-factor	Source	Proposed SHGC	Source	Exterior Shading Device	Combined SHGC from CF1R-ENV-03

15	Existing + Proposed Fenestration Area	
16	Maximum Allowed Fenestration Area	
17	Compliance Statement:	
18	Existing + Proposed West-Facing Fenestration Area	
19	Maximum Allowed West Fenestration Area	
20	Compliance Statement:	
21	Proposed Fenestration U-factor (Windows)	
22	Required Fenestration U-factor (Windows)	
23	Compliance Statement:	
24	Proposed Fenestration SHGC (Windows)	
25	Required Fenestration SHGC (Windows)	
26	Compliance Statement:	
27	Proposed Fenestration U-factor (Skylights)	
28	Required Fenestration U-factor (Skylights)	
29	Compliance Statement:	
30	Proposed Fenestration SHGC (Skylights)	
31	Required Fenestration SHGC (Skylights)	
32	Compliance Statement:	

CERTIFICATE OF COMPLIANCE	CF1R-ALT-01-E
Prescriptive Residential Alterations	(Page 4 of 6)
Project Name:	Date Prepared:

F. Fenestration/Glazing Proposed Areas and Efficiencies – Replace (Section 150.2(b)1B)

01	02	03	04	05	06	07	08	9	10	11	12	13	14
Tag/ ID	Fenestration Type	Frame Type	Dynamic Glazing	Orientation N, S, W, E	Area Removed (ft^2)	Area Added (ft^2)	Net Added Area (ft^2)	Proposed U-factor	Source	Proposed SHGC	Source	Exterior Shading Device	Combined SHGC from CF1R-ENV-03

15	Net Added West-facing Fenestration Area	
16	Is Net Added Fenestration Area ≤ 0 for west-facing fenestration?	
17	Net Added Fenestration Area (all orientations)	
18	Is Net Added Fenestration Area ≤ 0 for all orientations?	
19	Proposed Fenestration U-factor (Windows)	
20	Required Fenestration U-factor (Windows)	
21	Compliance Statement:	
22	Proposed Fenestration SHGC (Windows)	
23	Required Fenestration SHGC (Windows)	
24	Compliance Statement:	
25	Proposed Fenestration U-factor (Skylights)	
26	Required Fenestration U-factor (Skylights)	
27	Compliance Statement:	
28	Proposed Fenestration SHGC (Skylights)	
29	Required Fenestration U-factor (Skylights)	
30	Compliance Statement:	

CERTIFICATE OF COMPLIANCE	CF1R-ALT-01-E
Prescriptive Residential Alterations	(Page 5 of 6)
Project Name:	Date Prepared:

G. Space Conditioning (SC) Systems - Heating/Cooling (Section 150.2(b))		
01	02	03
Dwelling Unit Name	Dwelling Unit Total CFA (ft^2)	Comments

H. Water Heating Systems (Section 150.2(b)1G)														
01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Water Heating System Identification or Name	Water Heating System Type	Water Heater Type	# of Water Heaters in system	Water Heater Storage Volume (gal)	Fuel Type	Rated Input Type	Rated Input Value	Heating Efficiency Type	Heating Efficiency Value	Standby Loss (%)	Exterior Insul. R-Value	Back-Up Solar Savings Fraction	Central DHW System Distribution Type	Dwelling Unit DHW System Distribution Type

I. Space Conditioning Systems and Water Heating Systems in Multifamily Dwelling Unit					
01	02	03	04	05	06
Dwelling Unit Name	Dwelling Unit Total CFA (ft^2)	Central Water Heating System Identification or Name	Dwelling Unit Water Heating System Identification or Name	Dwelling Unit: Alteration to the Space Conditioning System(s)?	Comments

CERTIFICATE OF COMPLIANCE	CF1R-ALT-01-E
Prescriptive Residential Alterations	(Page 6 of 6)
Project Name:	Date Prepared:

DOCUMENTATION AUTHOR'S DECLARATION STATEMENT	
1. I certify that this Certificate of Compliance documentation is accurate and complete.	
Documentation Author Name:	Documentation Author Signature:
Company:	Signature Date:
Address:	CEA/ HERS Certification Identification (if applicable):
City/State/Zip:	Phone:

RESPONSIBLE PERSON'S DECLARATION STATEMENT

I certify the following under penalty of perjury, under the laws of the State of California:

1. The information provided on this Certificate of Compliance is true and correct.
2. I am eligible under Division 3 of the Business and Professions Code to accept responsibility for the building design or system design identified on this Certificate of Compliance (responsible designer).
3. That the energy features and performance specifications, materials, components, and manufactured devices for the building design or system design identified on this Certificate of Compliance conform to the requirements of Title 24, Part 1 and Part 6 of the California Code of Regulations.
4. The building design features or system design features identified on this Certificate of Compliance are consistent with the information provided on other applicable compliance documents, worksheets, calculations, plans and specifications submitted to the enforcement agency for approval with this building permit application.
5. I will ensure that a registered copy of this Certificate of Compliance shall be made available with the building permit(s) issued for the building, and made available to the enforcement agency for all applicable inspections. I understand that a registered copy of this Certificate of Compliance is required to be included with the documentation the builder provides to the building owner at occupancy.

Responsible Designer Name:	Responsible Designer Signature:
Company:	Date Signed:
Address:	License:
City/State/Zip:	Phone:

For assistance or questions regarding the Energy Standards, contact the Energy Hotline at: 1-800-772-3300

CF1R-ALT-01-E User Instructions

Minimum requirements for prescriptive alteration compliance can be found in Building Energy Efficiency Standards Section 150.2(b)1.

Completing these forms will require that you have the Reference Appendices for the 2016~~3~~ Building Energy Efficiency Standards (P400-2012-005). This document contains the Joint Appendices which are used to determine climate zone and to complete the section for opaque surfaces. When the term CF1R is used it means the CF1R-ALT-01.

Instructions for sections with column numbers and row numbers are given separately.

If any part of the alteration does not comply, prescriptive compliance fails, in which case the performance compliance approach must be used in an attempt to achieve compliance.

A. General Information

1. Project Name: Identifying information, such as owner's name.
2. Date: Date of document preparation.
3. Project Location: Legal street address of property or other applicable identifying information.
4. Building Front Orientation: Building front expressed in degrees, where North = 0, East = 90, South = 180, and West = 270. Indicate cardinal if it is a subdivision or multi-family project built in multiple orientations. The standards (section 100.1) include the following additional details for determining orientation:
   - Cardinal covers all orientations (for buildings that will be built in multiple orientations);
   - North is oriented to within 45 degrees of true north, including 45 degrees east of north;
   - East is oriented to within 45 degrees of true east, including 45 degrees south of east;
   - South is oriented to within 45 degrees of true south, including 45 degrees west of south;
   - West is oriented to within 45 degrees of true west, including 45 degrees south of west.
5. CA City: Legal city/town of property.
6. Number of Altered Dwelling Units: 1 for single-family, 1 or more for multifamily.
7. Zip Code: 5-digit zip code for the project location (used to determine climate zone).
8. Fuel Type: Natural Gas, Liquefied Propane Gas, or Electricity.

   NOTE: Prescriptive compliance only allows electricity if existing appliances are electric and natural gas is not available in the building.

9. Climate zone: From Joint Appendix JA2.1.1.
10. Total Conditioned Floor Area: Enter the new conditioned floor area in ft^2, as measured from the outside of exterior walls of the dwelling unit or building being altered.
11. Building Type: Single Family (includes duplex), or Multi Family (a building that shares common walls and common floors or ceilings).
12. Slab Area: Area of the first floor slab (if any) in ft^2.
13. Project Scope: Check all that apply – insulation, roof replacement > 50%, space heating system, space cooling system, duct system, water heating, adding fenestration/glazing, replacing fenestration/glazing, adding fenestration/glazing ≤ 75 ft^2 windows, replacing fenestration/glazing ≤ 75 ft^2 window, adding fenestration/glazing ≤ 16 ft^2 skylight and or replacing fenestration/glazing skylights
14. Exceptions to Minimum Aged Solar Reflectance and Minimum Thermal Emittance or SRI: No exception, Air-space of 1.0 inch (25mm) is provided between the top of the roof deck to the bottom of the roofing product, the installed roofing product has a profile ratio of rise to width of 1 to 5 for 50 percent or greater of the width of the roofing product, existing ducts in the attic are insulated and sealed according to Section 150.1(c)9, building with at least R-38 ceiling insulation, buildings with a radiant barrier in the attic meeting the requirements of Section 150.1(c)2, buildings that have no ducts in attic, R-24 or greater insulation above the roof deck.

B. Building Insulation Details (Section 150.2(b)1)

1. Tag/ID: A label (if any) from the plans, such as A1.4 or wall.
2. Assembly Type: Roof, Ceiling, Wall, Floor.
3. Frame Type: Wood or Metal.
4. Frame Depth: Nominal dimensions (in inches) of framing material such as 2x4 or 2x6.
5. Frame Spacing: 16, 24, or 48 inches on center.
6. Proposed Cavity R-value: Insulation installed between framing.

   NOTE: Section 110.8(d) specifies that if adding insulation to an existing attic, the resulting attic insulation must total R-30. However, the amount of insulation required is limited to the amount of room available for insulation without conflicting with Building Code Section 1203.2.

   Proposed Continuous Insulation R-value: Insulation installed on the exterior. See Joint Appendix JA4 for guidance.
7. Proposed U-factor: The U-factor for the entire wall, roof or floor assembly.
8. Appendix JA4 Table: Table number used to determine the R-value or U-factor (e.g., an attic assembly is 4.2.1).
9. Appendix JA4 Cell: Cell number used to determine the R-value or U-factor (e.g., an R-38 ceiling with 24-inch on center framing is A21).
10. Required U-factor: From mandatory requirements in Sections 110.0 and 150.0.
11. Comments: Any notes regarding location or unique conditions.

C. Roof Replacement (Section 150.2(b)1H)

When 50% or more of the roof is being replaced the roofing requirements are triggered. Any areas of roof covered by building integrated photovoltaic panels and solar thermal panels (the area of roof not covered by photovoltaic panels would still need to meet any applicable cool roof requirements). Additionally, there are many alternatives/exceptions when a cool roof is required.

When the roof is steep slope (pitch greater than 2:12) the roof requirements include a cool roof in climate zones 10-15. The minimum requirement is 0.20 aged solar reflectance, 0.75 thermal emittance, or a minimum SRI of 16.

1. Tag/ID: A label, if any, from the plans, for example R-1.
2. Method of Compliance: Indicate if the method of compliance is going to be based on Aged Solar Reflectance and Thermal Emittance, the Solar Reflectance Index (SRI), or an Exception.
3. Roof Pitch: Expressed as 4:12, for example, which means the roof rises 4 foot within a span of 12 feet. When roofs have multiple pitches the requirements are based on the pitch of 50% or more of the roof.
4. Exception: If meeting one of the exceptions. Indicate which exception is, or will be, met.

   NOTE: Exceptions and alternatives for steep slope roofs:~~EXCEPTIONS AND ALTERNATIVES FOR STEEP SLOPE ROOFS:~~

   (a) Mass roof 25 lbs/ft^2 or greater (uncommon situation such as sod roof);
   (b) Air space 1” from top of roof deck to bottom of roofing;
   (c) Roofing product has a profile ratio of rise to width of 1 to 5 for 50 percent or greater of the width of the roofing product;
   (d) Ducts already meet Section 150.1(c) insulation and duct leakage requirements;
   (e) Roof has R-38 insulation;
   (f) Roof has a radiant barrier;
   (g) No ducts are installed in the attic; or
   (h) R-~~4~~2 insulation above the roof deck.

In climate zones 13-15, when there is a low slope roof (pitch 2:12 or less) the cool roof requirements are for a minimum Aged Solar Reflectance of 0.63, a minimum 0.75 Thermal Emittance, or a minimum SRI of 75.

NOTE: Exceptions and alternatives for low slope roofs:~~EXCEPTIONS AND ALTERNATIVES FOR LOW SLOPE ROOFS:~~

(a) Mass roof 25 lbs/ft^2 or greater (uncommon situation such as sod roof);
(b) No ducts are installed in the attic; or
(c) Roof deck installation trade off—by installing roof deck insulation, a lower aged solar reflectance is required: R-2 (0.62-0.60), R-4 (0.59-0.55), R-6 (0.54-0.50), R-8 (0.49-0.45), R-12 (0.44-0.40), R-16 (0.39-0.35), R-20 (0.34-0.30), R-24 (0.29-0.25).

NOTE: If one of the exceptions above has been selected than the rest of Section C is Not Required.

5. The CRRC Product ID Number is obtained from the Cool Roof Rating Council's Rated Product Directory at www.coolroofs.org/products/results. Products are listed by manufacturer, brand, type of installation, roofing material, and color, as well as product performance.
6. Product Type: See Cool Roof Rating Council's directory. Generally product types include single-ply roof, wood shingles, asphalt roof, metal roof, tile roof.
7. R-value Deck Insulation: If one of the exceptions selected includes adding roof deck insulation, indicate the R-value of insulation.
8. Proposed Initial Solar Reflectance: Based on the product chosen from the Cool Roof Rating Council's Rated Product Directory. If using default assumption indicate NA since the Aged Solar Reflectance is available.
9. Proposed Aged Solar Reflectance: Value is from the Cool Roof Rating Council's Rated Product Directory. If the aged value is not available, calculate the calculated Aged Solar Reflectance using the Solar Reflectance Index (SRI) Calculation worksheet located on the California Energy Commission website or the aging equation ρ_{aged}=[0.2+β[$\rho_{initial}$-0.2], where $\rho_{initial}$ = the initial solar reflectance and soiling resistance β is listed by product type below.

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

10. Proposed Thermal Emittance: From the product specification default value. If using a calculated SRI place the Thermal Emittance used to calculate SRI.
11. Proposed SRI: It is optional to meet the SRI but if chosen to do so, use the Solar Reflectance Index (SRI) Calculation Worksheet found on the California Energy Commission website http://www.energy.ca.gov/title24/2013standards/documents/solar_reflectance/.
12. Minimum Required Aged Solar Reflectance: Based on climate zone and roof slope.
13. Minimum Required Thermal Emittance: Based on climate zone and roof slope.
14. Minimum Required SRI: Based on climate zone and roof slope.

NOTE: If the cool roofing requirements will be met by a liquid field applied coating, Section 110.8(i)4 requires the coating be applied across the entire roof surface and meet the dry mil thickness or coverage recommended by the manufacturer.

D. Fenestration/Glazing Allowed Areas and Efficiencies (Section 150.2(b)1)

The climate zone and scope of the alteration will affect the amount of fenestration (also known as glazing) allowed. If limited to 20%, this is calculated as Conditioned Floor Area x 0.20 = total ft^2 of fenestration allowed (20%). Fenestration areas are expressed in feet, not inches. When west-facing fenestration is limited (in climate zones 2, 4, and 6-16), it is limited to a maximum of 5%. Additions of 1,000 ft^2 or less have alternate requirements. For example, the limit may be 120 ft^2 of fenestration or 25%. While west-facing fenestration may be limited, if there is no west fenestration the upper limit remains at 120 ft^2 or 25% (or the values shown in columns 2 and 3).

The Alteration Type and Fenestration Type will affect how the ~~s~~Standards apply and whether the fenestration area is limited. Percentages are determined as Conditioned Floor Area x 0.20 = total ft^2 of fenestration allowed (20%). Depending on the climate zone, if west-facing fenestration is limited, it is limited to a maximum of 5%. The overall total fenestration area is limited to 20%, not 25%. Fenestration areas are expressed in feet, not inches.

1. Alteration Type. Auto-filled with the project scope in A13: adding fenestration/glazing, replacing fenestration/glazing, adding fenestration/glazing ≤ 75 ft^2 windows, replacing fenestration/glazing ≤ 75 ft^2 window, adding fenestration/glazing ≤ 16 ft^2 skylight and or replacing fenestration/glazing skylights.
2. Maximum Allowed Fenestration Area for All Orientations (ft^2): The maximum total fenestration area is 20%. Depending on the type of fenestration and the alteration type, this field may show values such as 75 ft^2 or 16 ft^2.
3. Maximum Allowed West-Facing Fenestration Area Only: Calculated value based on conditioned floor area time 5 percent (Used in climate zones 2, 4, and 6-16)

   NOTE: (1) If adding fenestration/glazing ≤ 75 ft^2 window or ≤ 16 ft^2 skylight, enter NA
   (2) West includes any vertical fenestration oriented to within 45 degrees of true west, including 45 degrees south of west. For skylights, west also includes any skylight area facing any direction with a pitch of less than 1:12

4. Existing Fenestration Area for All Orientations: Enter the area, in square feet, of the existing fenestration/glazing.
   Existing West-Facing Fenestration Area: Enter the area, in square feet, of the existing west-facing fenestration/glazing. If project has no existing west-facing fenestration then enter "0".
5. Maximum Allowed U-factor: Maximum U-factor from Package A or Table 150.1-A. This field will almost always be 0.32 unless the U-factor will be the area weighted average, CF1R-ENV-02, with other higher fenestration windows. For skylights this will be 0.55.
6. Maximum Allowed SHGC: Maximum SHGC from Package A or Table 150.1-A. This field will almost always be either 0.25 or N/A, depending on climate zone. N/A means there is no maximum SHGC required in this climate zone. The SHGC will be the area weighted average, CF1R-ENV-02, with other higher fenestration windows. For skylights this will be 0.30.
7. Comments: Note any special location or comment here.

E. Fenestration/Glazing Proposed Areas and Efficiencies – Add (Section 150.2(b)1A)

1. Tag/ID: A label (if any) from the plans, such as W1.
2. Fenestration Type: Indicate the type of fenestration construction e.g., Fixed Window, Operable Window, or Skylight.

   NOTE: Doors with glazing are counted in one of two ways. A door with 50% or more glazing is counted as the entire door area. A door with less than 50% glazing can be counted as the entire door area or can be calculated as the actual glass area with a 2-inch (0.17 ft^2) frame all around.

3. Frame type: Metal, metal thermal break, or non-metal.
4. Dynamic Glazing: Indicate~~d~~ if the fenestration has integrated shading device, chromogenic glazing or none for no dynamic glazing. Chromogenic glazing shall be considered separately from other fenestration types.

5. Orientation (North, East, South, West). In climate zones where the West-facing glazing is limited, list west-facing individually. The definitions in the Energy Efficiency Standards include these specific details:
   - North is oriented to within 45 degrees of true north, including 45 degrees east of north;
   - East is oriented to within 45 degrees of true east, including 45 degrees south of east;
   - South is oriented to within 45 degrees of true south, including 45 degrees west of south;
   - West is oriented to within 45 degrees of true west, including 45 degrees north of west.

   NOTE: Skylights in a roof pitch greater than 1:12 can be included as facing the same orientation as that portion of the roof angle. If the skylight is in a roof with a pitch less than 1:12, the skylight is assumed to face west.

6. Number of Panes: Indicate the number of panes for each Tag/ID; is it single, double, or triple pane window?
7. Proposed Fenestration Area (ft^2): Indicate the area (in square feet) of each exterior fenestration type, excluding west-facing fenestration.
8. Proposed West Facing Fenestration Area (ft^2): In climate zones 2, 4, 6-16, indicate the area (in square feet) of each exterior west-facing fenestration type separately.

   NOTE: Skylights installed in a roof with pitch less than 1:12 are considered to face west.

9. Proposed U-factor: Enter
   (a) the NFRC U-factor based on the proposed brand and type of fenestration using National Fenestration Rating Council (www.nfrc.org) certified values, or
   (b) the default value from Table 110.6-A, or
   (c) the NA6.2 alternate default U-factor (for non-rated site-built fenestration only), or
   (d) the Area-weighted Average from CF1R-ENV-02.

   If any products (other than skylights) have a higher U-factor than 0.32, first complete a CF1R-ENV-02 to calculate the area-weighted average U-factor, and attach it to the CF1R-ALT-01.

   NOTE: Dynamic glazing is a glazing system that changes its performance U-factor and SHGC based on the physical environment. Dynamic glazing includes chromogenic glazing or integrated shading systems (this does not include ~~internally or~~ externally mounted shading devices). If using dynamic glazing, use the lowest tested U-factor and SHGC in Columns 9~~8~~ and 11.

10. Source: NFRC, Table 100.6-A and 110.6-B, Equations NA6-1 and NA6-2, or Area-weighted Average Worksheet (ENV-02). The source of the U-factor data for the fenestration product.
11. Proposed SHGC: In climate zones 2, 4, 6-16 enter
    (a) the NFRC-SHGC based on the proposed brand and type of fenestration using National Fenestration Rating Council (www.nfrc.com) certified values, or
    (b) the default value Table 110.6-B, or
    (c) the NA6.3 alternate default SHGC (for non-rated site-built fenestration only), or
    (d) the Area-weighted Average from CF1R-ENV-02.

    If any products (other than skylights) have a higher SHGC than required by Package A, first complete a form CF1R-ENV-02 to calculate the area-weighted average SHGC and attach it to the CF1R-ALT-01.

12. Source: NFRC, Table 100.6-A and 110.6-B, Equations NA6-1 and NA6-2, or Area-weighted Average Worksheet (ENV-02). The source of the SHGC data for the fenestration product.
13. Exterior Shading Device: If exterior shading devices are used to meet the SHGC requirement, indicate the type of device (from Table S-1 of CF1R-ENV-03 Solar Heat Gain Coefficient Worksheet) and attach an ENV-03.

    NOTES:(1) An exterior shading device is not used for products with an NFRC rated U-factor and SHGC based on a factory integrated shading device.
    (2) Chromogenic glazing shall be considered separately from other fenestration.
    (3) If using an overhang for south-facing glazing, the glazing must be fully shaded at solar noon on August 21 and substantially exposed to direct sunlight at solar noon on December 21 (see Residential Manual, Section 3.5.5).

14. Combined SHGC from CF1R-ENV-03: If exterior shading devices are combined with the SHGC value of the fenestration to meet the prescriptive SHGC requirements (as indicated by a value in column E. 13), indicate the SHGC calculated on form CF1R-ENV-03 and attach the form for each window with an exterior shading device.

15.-32. Automatically completed entries; no user input required.

F. Fenestration/Glazing Proposed Areas and Efficiencies – Replace (Section 150.2(b)1B)

1. Tag/ID: A label (if any) from the plans, such as W1.
2. Fenestration Type: Indicate the type of fenestration construction e.g., Fixed Window, Operable Window, or Skylight.

    NOTE: Doors with glazing are counted in one of two ways. A door with 50% or more glazing is counted as the entire door area. A door with less than 50% glazing can be counted as the entire door area or can be calculated as the actual glass area with a 2-inch (0.17 ft^2) frame all around.

3. Frame type: Metal, metal thermal break, or non-metal.
4. Dynamic Glazing: Indicate if the fenestration has integrated shading device, chromogenic glazing or none for no dynamic Glazing. Chromogenic glazing shall be considered separately from other fenestration types.
5. Orientation (North, East, South, West). In climate zones where the West-facing glazing is limited, list west-facing individually. The definitions in the Energy Efficiency Standards include these specific details:
    - North is oriented to within 45 degrees of true north, including 45 degrees east of north;
    - East is oriented to within 45 degrees of true east, including 45 degrees south of east;
    - South is oriented to within 45 degrees of true south, including 45 degrees west of south;
    - West is oriented to within 45 degrees of true west, including 45 degrees north of west.

    NOTE: Skylights in a roof pitch greater than 1:12 can be included as facing the same orientation as that portion of the roof angle. If the skylight is in a roof with a pitch less than 1:12, the skylight is assumed to face west.

6. Area Removed (ft^2): Enter the area, in square feet, of the fenestration/glazing being removed.
7. Area Added (ft^2): Enter the area, in square feet, of the fenestration/glazing being added.
8. Net Added Area (ft^2): The difference between the Area Added and the Area Removed.

9. Proposed U-factor: Enter
   (a) the NFRC U-factor based on the proposed brand and type of fenestration using National Fenestration Rating Council (www.nfrc.org) certified values, or
   (b) the default value from Table 110.6-A, or
   (c) the NA6.2 alternate default U-factor (for non-rated site-built fenestration only), or
   (d) the Area-weighted Average from CF1R-ENV-02.

   If any products (other than skylights) have a higher U-factor than 0.32, first complete a CF1R-ENV-02 to calculate the area-weighted average U-factor and attach it to the CF1R-ALT-01.

   NOTE: Dynamic glazing is a glazing system that changes its performance U-factor and SHGC based on the physical environment. Dynamic glazing includes chromogenic glazing or integrated shading systems (this does not include internally or externally mounted shading devices). If using dynamic glazing, use the lowest tested U-factor and SHGC in Columns 9~~8~~ and 11.

10. Source: NFRC, Table 110.6-A and 110.6-B, Equations NA6-1 and NA6-2, or Area-weighted Average Worksheet (ENV-02). The source of the U-factor data for the fenestration product.
15. Proposed SHGC: In climate zones 2, 4, 6-16 enter
   (e) the NFRC-SHGC based on the proposed brand and type of fenestration using National Fenestration Rating Council (www.nfrc.com) certified values, or
   (f) the default value Table 110.6-B, or
   (g) the NA6.3 alternate default SHGC (for non-rated site-built fenestration only), or
   (h) the Area-weighted Average from CF1R-ENV-02.

   If any products (other than skylights) have a higher SHGC than required by Package A, first complete a form CF1R-ENV-02 to calculate the area-weighted average SHGC and attach it to the CF1R-ALT-01.

11. Source: NFRC, Table 110.6-A and 110.6-B, Equations NA6-1 and NA6-2, or Area-weighted Average Worksheet (ENV-02). The source of the SHGC data for the fenestration product.
12. Exterior Shading Device: If exterior shading devices are used to meet the SHGC requirement, indicate the type of device (from Table S-1 of CF1R-ENV-03 Solar Heat Gain Coefficient Worksheet) and attach an ENV-03.

   NOTES: (1) An exterior shading device is not used for products with an NFRC rated U-factor and SHGC based on a factory integrated shading device.
   (2) Chromogenic glazing shall be considered separately from other fenestration.
   (3) If using an overhang for south-facing glazing, the glazing must be fully shaded at solar noon on August 21 and substantially exposed to direct sunlight at solar noon on December 21 (see Residential Manual, Section 3.5.5).

13. Combined SHGC from CF1R-ENV-03: If exterior shading devices are combined with the SHGC value of the fenestration to meet the prescriptive SHGC requirements (as indicated by a value in column F. 13), indicate the SHGC calculated on form CF-1R-ENV-03 and attach the form for each window with an exterior shading device.

15.-30. Automatically completed entries; no user input required.

G. Space Conditioning (SC) Systems – Heating/Cooling (Section 150.2(b))

Requirements of the standards apply to a heating and cooling system alteration based on the type of alteration and the system type (Section 150.2(b)1). A completely new system will meet all mandatory and prescriptive requirements, which vary by climate zone (based on Section 150.2(b)1C). [NOTE: Computer performance compliance can be used to trade-off any requirements that are not mandatory.] When parts of a system are replaced, it may trigger some of the same requirements that apply to new systems and duct alterations. A Certificate of Compliance for Alterations to Space Conditioning Systems (CF1R-ALT-02) is required for each dwelling unit with a space conditioning system alteration.

1. Dwelling Unit Name: Name of dwelling unit or any other identifying name.
2. Dwelling Unit Total CFA (ft^2): Conditioned floor area in ft^2, as measured from the outside of exterior walls of the dwelling unit or building being altered.
3. Comments: Any notes regarding location or unique conditions.

H. Water Heating Systems (Section 150.2(b)1G)

Water heating compliance for an alteration is described in Section 150.2(b)1G. For a single dwelling unit, a gas or propane water heater that meets the requirements of 150.1(c)8 can be used. ~~-~~If no natural gas is connected to the building, an electric water heater with an energy factor greater than or equal to the minimal energy factor required under the Appliance Efficiency Regulation, and with storage capacity of less than 60 gallons can be used. ~~-~~Dwelling Unit distribution systems are limited to Standard trunk and branch or demand recirculation for gas or propane water heater. ~~-~~Demand recirculation is not allowed for electric water heater. If there is no natural gas connected to the building, an electric water heater may be replaced with another electric water heater. However, changing from gas to electric is not allowed~~. Multi-family central systems must use certified equipment as defined under Section 110.1 and 110.3.~~ unless the conditions of Section 150.2(b)1Giic or 150.2(b)1Giid are met. Multi-family central systems must use certified equipment as defined under Section 110.1 and 110.3.

1. Water Heating System Identification or Name: Enter a unique name for the Water Heating System.
2. Water Heating System Type: Domestic Hot Water (DHW), Hydronic, Combined Hydronic, or Central. DHW is for domestic hot water, hydronic is a water heating system used for space heating only; combined hydronic are when the water heater will provide both space conditioning and domestic hot water.
3. Water Heater Type: For non-central systems only Small Storage or Small Instantaneous are allowed. For central systems pick from Large Storage, Small Storage, Heat Pump, Boiler, Large Instantaneous, Small Instantaneous or Indirect.
4. Number of Water Heaters in System: In single-family and multi-family with water heaters in each dwelling units the value is 1. For multi-family central systems serving multiple dwelling units enter the total number of water heaters.
5. Water Heater Volume (gal): Tank capacity in gallons. For individual water heaters for a dwelling unit this will be 60 gallons or less. If instantaneous, enter n/a. For multi-family central systems enter the total storage volume.
6. Fuel Type: Gas, Propane, Electric (Only if natural gas is not available, or if the conditions of Section 150.2(b)1Giic or 150.2(b)1Giid are met)

NOTE: The following table lists replacement heat pump water heating systems by climate zone that meet the requirements of 150.2(b)Giic and/or 150.2(b)Giid.

Precalculated Replacement Heat Pump Water Heating Systems for Single Dwelling Units

CZ	**Energy Factor greater than or equal to**
1	2.75
2	2.75
3	2.75
4	2.8
5	2.75
6	2.33
7	2.5
8	2.33
9	2.33
10	2.33
11	2.5
12	2.8
13	2.5
14	2.5
15	2.33
16	EF ≥ 3, plus a solar water heating system with solar saving fraction ≥ 0.4

7. Rated Input Type: Enter the equipment input rating type, for gas or propane fired system the units are Btuh, for electric fired system the units are kW.
8. Rated Input Value: Enter the numeric value of rated input.
9. Heating Efficiency Type: Energy Factor, AFUE, or Thermal Efficiency. From product literature or a California Energy Commission directory.
10. Heating Efficiency Value: Enter the value from product literature or a California Energy Commission directory
11. Standby Loss (percent): Applies only to large storage water heaters. Enter n/a for small storage or instantaneous water heaters.
12. Exterior Insulation R-Value: Enter the R-value if exterior insulation on the storage tank is installed
13. Back-Up Solar Savings Fraction: If compliance requires a back-up solar system, indicate the solar contribution (e.g., 0.30). External calculations are required.
14. Central DHW Distribution System: For multi-family buildings with using a central distribution system a demand recirculation system with at least two distribution loops must be installed. This requirement applies to any building with eight or more units. If the system is non-central or project is individual units enter n/a.
15. Dwelling Unit DHW Distribution Type: For a Central DHW this field shall be Standard. If non-central then pick from Standard, Demand Recirculation – Manual Control, Demand Recirculation – Sensor Control. If non-central electric water heater this must be Standard, no recirculation system shall be installed.

I. Space Conditioning Systems and Water Heating Systems in Multifamily Dwelling Units

Requirements of the ~~s~~Standards apply to a heating and cooling system alteration based on the type of alteration and the system type (Section 150.2(b)1). A completely new system will meet all mandatory and prescriptive requirements, which vary by climate zone (based on Section 150.2(b)1C). [NOTE: Computer performance compliance can be used to trade-off any requirements that are not mandatory.] When parts of a system are replaced, it may trigger some of the same requirements that apply to new systems and duct alterations. A Certificate of Compliance for Alterations to Space Conditioning Systems (CF1R-ALT-02) is required for each dwelling unit with a space conditioning system alteration.

1. Dwelling Unit Name: Name of dwelling unit or any other identifying name.
2. Dwelling Unit Total CFA (ft^2): Conditioned floor area in ft^2, as measured from the outside of exterior walls of the dwelling unit or building being altered.
3. Central Water Heating System Identification or Name: Select one of the central DHW system names.
4. Dwelling Unit Water Heating System Identification or Name: Select the applicable water heating system name(s) that were entered in ~~s~~Section ~~G~~H or select n/a if no water heating systems are planned to be installed in this dwelling. If more than one water heating system type is needed in the dwelling unit, enter another row of data for the dwelling unit and select the additional water heating system name.
5. Dwelling Unit - Alteration to the Space Conditioning System(s)?: If altering one or more of the Space conditioning systems in the dwelling enter yes, otherwise enter no
6. Comments: Any notes regarding location or unique conditions.

Signatures

1. The person who prepared the CF1R will sign and complete the fields for their name, company (if applicable), address, phone number, certification information (if applicable), date and signature (may be electronic).
2. The person who is assuming responsibility for the project being built to comply with Title 24, Part 6, will complete the fields for their name, company (if applicable), address, phone number, license number (if applicable), date and signature (may be electronic).

Registration

1. The CF1R must be registered with a HERS provider prior to submitting for a building permit. See Residential Manual Section 2.1.1.

AREA WEIGHTED AVERAGE CALCULATION WORKSHEET

CERTIFICATE OF COMPLIANCE	CF1R-ENV-02-E
Area Weighted Average Calculation Worksheet	(Page 1 of 1)
Project Name:	Date Prepared:

A. Area-Weighted Average Calculation		
01	Project Name:	
02	Dwelling Name or Number:	
03	Feature Being Area Weighted Averaged:	
04	Property Being Averaged:	

B. U-factor Area-Weighted Average Calculation		
01	02	03
Tag /Identification	Surface Feature Area (ft^2)	U-Factor Value
04 U-Factor Area-weighted Average:		

C. SHGC Area-Weighted Average Calculation		
01	02	03
Tag /Identification	Surface Feature Area (ft^2)	SHGC Value
04 SHGC Area-weighted Average:		

CF1R-ENV-02-E User Instructions

This worksheet is used to calculate the area-weighted average U-factors for building envelope features such as walls, roofs, floors, mass, and fenestration/glazing U-factors or Solar Heat Gain Coefficient (SHGC) values for prescriptive compliance. R-values are not used for area-weighing; only U-factors or SHGC values are allowed.

The area weighted averaging calculation is done when there is more than one level of insulation, window U-factor or SHGC used in a building to meet prescriptive compliance requirements. Each fenestration type (e.g., vertical windows, skylights, dynamic glazing, and window films) is treated independently and cannot be combined. Submit the ENV-02 with the energy compliance forms.

If exterior shading devices are used to meet an SHGC requirement, first complete a CF1R-ENV-03 form (Solar Heat Gain Coefficient (SHGC) Worksheet). If the SHGC exceeds 0.25, then use the weighted-average of other like windows to determine overall compliance with prescriptive SHGC requirements.

A. Area Weighted Average – General Information

1. Project Name: From the CF1R
2. Dwelling Name or Number: From the CF1R
3. Feature Being Area-Weighted Averaged: Indicate what is being area weighted is Fenestration, Wall, Roof, Ceiling or Floors.
4. Property Being Averaged: Indicate if the area-weighted average is for a U-factor, SHGC or Both.

B. U-factor Area Weighted Average Calculation

1. Tag/ID: Same data given on CF1R's; provides an identification Tag or Identification name that uniquely identifies the features being area-weighted.
2. Surface Feature Area: Total area of each occurrence of the feature being area-weighted.

~~2.~~3. U-Factor Value: U-factor of the area described in this row. Values can come from the 2013 Reference Appendices, manufacturer's data or specification sheets.

~~3.~~4. Calculated value; not a user input.

C. SHGC Area Weighted Average Calculation

1. Tag/ID: same data given on CF1R's; provides an identification Tag or Identification name that uniquely identifies the features being area-weighted.
2. Surface Feature Area: Total area of each fenestration being area-weighted.
3. Property being averaged: Value: SHGC of the area being described in this row. Values can come from the 2016~~3~~ Reference Appendices, manufacturer's data or specification sheet.
4. Calculated value; not a user input.

Note: This form may also be used to develop a requirement area-weighted average U-Factor or SHGC, which can occur when any exception allows an area to comply at a higher limit of rated performance if the total area for that product type exceeds the area qualifying for the exception.

CERTIFICATE OF COMPLIANCE	CF1R-NCB-01-E
Prescriptive Newly Constructed Buildings	(Page 1 of 7)
Project Name:	Date Prepared:

A. General Information					
01	Project Name:		02	Date Prepared:	
03	Project Location:		04	Building Front Orientation (deg or cardinal):	
05	CA City:		06	Number of Dwelling Units:	
07	Zip Code:		08	Fuel Type:	
09	Climate Zone:		10	Total Conditioned Floor Area (ft^2):	
11	Building Type:		12	Slab Area (ft^2):	
13	Project Scope:		14	Exceptions to Fenestration U-factor & SHGC 150.1(c)3A	

B. Opaque Surface Details – Framed (Section 150.1(c)1)

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

C. Opaque Surface Details – Non-framed (Section 150.1(c)1)

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

CERTIFICATE OF COMPLIANCE	CF1R-NCB-01-E
Prescriptive Newly Constructed Buildings	(Page 2 of 7)
Project Name:	Date Prepared:

D. Opaque Surface Details – Mass Walls (Section 150.1(c)1)

01	02	03	04	05	06		07		08	09	10		11	
					Proposed						**Required**			
					Interior Insulation		Exterior Insulation		Appendix JA4 Reference		Interior Insulation		Exterior Insulation	
Tag/ID	Walls Above Grade	Mass Type	Mass Thickness (inches)	Furring Strip Thickness (inches)	R-value	U-factor	R-value	U-factor	Table	Cell	R-value	U-factor	R-value	U-factor

E. Slab Insulation (Table 150.1-A)

01	02		03		04
	Proposed		**Required**		
Floor Type	R-value	U-factor	Insulation R-value	Insulation U-factor	Comments

Note:

- Heated slab floors require mandatory slab insulation (see Table 110.8-A).

F. Ceiling/Roof Insulation (Section 150.1(c)1A)

01	02	03	04	05	06	07
Option	Air Space (Yes/No)	Above Roof Deck R-value	Below Roof Deck R-value	Ceiling Insul. R-value	Radiant Barrier Required?	Vented Attic? (Yes/No)

CERTIFICATE OF COMPLIANCE	CF1R-NCB-01-E
Prescriptive Newly Constructed Buildings	(Page 3 of 7)
Project Name:	Date Prepared:

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.

~~**F. Radiant Barrier** (Section 150.1(c)2)~~

~~01~~	~~02~~
~~Radiant Barrier installed below the roof deck and on all gable end walls~~	~~Comment~~

~~**A radiant barrier is required (for Climate Zones 2-15)**~~
- ~~Radiant barriers shall meet specific eligibility and installation criteria to receive energy credit for compliance with the Building Energy Efficiency Standards for low-rise residential buildings. Refer to RA4.2.1~~
- ~~The emittance of the radiant barrier shall be less than or equal to 0.05 as tested in accordance with ASTM C1371 or ASTM E408.~~
- ~~For Prescriptive Compliance the attic shall be ventilated to provide a minimum free ventilation area of not less than one square foot of vent area for each 300 ft^2 of attic floor area with no less than 30 percent upper vents. Ridge vents or gable end vents are recommended to achieve the best performance. The material should be cut to allow for full airflow to the venting.~~

G. Roofing Products (Cool Roof) (Section 150.1(c)11)

01	02	03	04	05	06	07	08	09	10	11	12	13
						Proposed				**Minimum Required**		
Tag/ID	Mass Roof 25 lb/ft^2 or greater	Roof Pitch	Method of compliance	Product Type	CRRC Product ID Number	Initial Solar Reflectance	Aged Solar Reflectance	Thermal Emittance	SRI (Optional)	Aged Solar Reflectance	Thermal Emittance	SRI (Optional)

~~**NOTES**~~**Notes**:
- Any roof area covered by building integrated photovoltaic panels and solar thermal panels is exempt from the above Cool Roof requirements.
- Liquid field applied coatings must comply with installation criteria from section 110.8(i)4.

H. Fenestration/Glazing Allowed Areas and Efficiencies (Section 150.1(c)3)

01	02	03	04	05	06	07
Maximum Allowed Fenestration Area for All Orientation (ft^2)	Maximum Allowed West-Facing Fenestration Area Only (ft^2)	Maximum Allowed U-factor (Windows)	Maximum Allowed U-factor (Skylights)	Maximum Allowed SHGC (Windows)	Maximum Allowed SHGC (Skylights)	Comments

CERTIFICATE OF COMPLIANCE	CF1R-NCB-01-E
Prescriptive Newly Constructed Buildings	(Page 4 of 7)
Project Name:	Date Prepared:

I. Fenestration Proposed Areas and Efficiencies

Note: If meeting Exception 1 to 150.1(c)3A, Installing ≤ 3ft^2 glass in door, it is assumed to meet the minimum required U-factor (0.32) & SHGC (0.25).
If meeting Exception 1 to 150.1(c)3A, Installing ≤ 3ft^2 tubular skylight, it is assumed to meet the minimum required U-factor (0.55) & SHGC (0.30).

01	02	03	04	05	06	07	08	09	10	11	12	13	14
Tag/ID	Fenestration Type	Frame Type	Dynamic Glazing	Orientation N, S, W, E or Roof	Number of Panes	Proposed Fenestration Area (ft^2)	Proposed West Facing Fenestration Area (ft^2)	Proposed U-factor	Source	Proposed SHGC	Source	Exterior Shading Device	Combined SHGC from CF1R-ENV-03
15	Total Proposed Fenestration Area												
16	Maximum Allowed Fenestration Area												
17	Compliance Statement												
18	Total Proposed West-Facing Fenestration Area												
19	Maximum Allowed West-Facing Fenestration Area												
20	Compliance Statement												
21	Proposed Fenestration U-factor (Windows)												
22	Required Fenestration U-factor (Windows)												
23	Compliance Statement												
24	Proposed Fenestration SHGC (Windows)												
25	Required Fenestration SHGC (Windows)												
26	Compliance Statement												
27	Proposed Fenestration U-factor (Skylights)												
28	Required Fenestration U-factor (Skylights)												
29	Compliance Statement												
30	Proposed Fenestration SHGC (Skylights)												
31	Required Fenestration SHGC (Skylights)												
32	Compliance Statement												

CERTIFICATE OF COMPLIANCE	CF1R-NCB-01-E
Prescriptive Newly Constructed Buildings	(Page 5 of 7)
Project Name:	Date Prepared:

J. Space Conditioning (SC) Systems – Heating/Cooling/Ducts (Section 150.1(c)7)

01	02	03	04	05	06	07	08	09	10	11	12
Space Conditioning System Identification or Name	Heating System Type	Heating Efficiency Type	Heating Efficiency Value	Cooling System Type	Cooling Efficiency SEER	Cooling Efficiency EER	Distribution System Type	Duct Location	Duct R-value	Thermostat Type	Comments

Notes:

- Central gas furnaces have a minimum efficiency of ~~78~~81% AFUE, heat pumps 8.0~~7.7~~ HSPF. Any gas heating appliance sold in California will meet the minimum appliance efficiency standard and is allowed. Heat pumps and mini-split heat pumps are the only type of electric heating system allowed.
- Central cooling systems and heat pumps have a minimum efficiency of 14~~3~~ SEER. Any cooling appliance sold in California will meet the minimum appliance efficiency standard and is allowed.
- The prescriptive requirements preclude the use of bypass ducts in association with zonally controlled systems. A HERS Rater shall verify that zonally controlled systems have no bypass ducts.

K. Ventilation Cooling in Climate Zones 8-14 (Section 150.1(c)12)

01	02
Required Airflow Rate (CFM) (~~2~~ 1.5 CFM per ft² of Conditioned Floor Area)	Minimum Attic Vent Free Area (in²) (column 1 x 0.~~384~~192)

L. Water Heating Systems (Section 150.1(c)8)
List water heaters and boilers for both domestic hot water (DHW) heaters and hydronic space heating.

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Water Heating System ID or Name	Water Heating System Type	Water Heater Type	# of Water Heaters in system	Water Heater Storage Volume (gal)	Fuel Type	Rated Input Type	Rated Input Value	Heating Efficiency Type	Heating Efficiency Value	Standby Loss (%)	Exterior Insul. R-Value	Back-Up Solar Savings Fraction	Central DHW System Distribution Type	Dwelling Unit DHW System Distribution Type

CERTIFICATE OF COMPLIANCE	CF1R-NCB-01-E
Prescriptive Newly Constructed Buildings	
Project Name:	Date Prepared:

M. Space Conditioning Systems and Water Heating Systems in Multifamily Dwelling Units

01	02	03	04	05	06
Dwelling Unit Name	Dwelling Unit Total CFA (ft^2)	Central Water Heating System Identification or Name	Dwelling Unit Water Heating System Identification or Name	Dwelling Unit Space Conditioning System Identification or Name	Comments

N. HERS Verification Summary

The enforcement agency shall pay special attention to the HERS Measures specified in this checklist below. A registered Certificate of Verification for all the measures specified shall be submitted to the building inspector before final inspection.

Duct Leakage Verification- Section 150.0(m)11

- Duct leakage testing is required (Residential Appendix RA3.1) in all climate zones for ducted heating and cooling systems.
- System is zonally controlled. No bypass ducts are allowed, as confirmed by HERS verification

Zonally Controlled Systems – Bypass Dampers - Section 150.1(c)13

- If system is zonally controlled, no bypass ducts are allowed, as confirmed by HERS verification (See RCM Appendix F)

Refrigerant Charge Verification – Section 150.1(c)7a

- Refrigerant Charge Testing is required (Residential Appendix RA3.2) in climate zones 2 and 8-15 for all air source A/C and heat pumps.
- Some exceptions apply to factory charged package systems

Central System Air Handlers – Air Flow and Fan Efficacy Verification - Section 150.0(m)13

- Airflow (min 350 cfm/ton) and Fan Efficacy (max 0.58 watts/cfm) on systems with ducted air conditioning will be field verified by a HERS rater or Return Duct and Filter System Design according to tables 150.0-B~~C~~/~~D~~C will be HERS verified
- Heat-only systems with Central Fan Integrated (CFI) ventilation are required to have less than 0.58 watts per cfm as verified by a HERS rater.

Indoor Air Quality Mechanical Ventilation

- Mechanical ventilation airflow rate according to ASHRAE 62.2 is required to be verified by a HERS rater (RA3.7)

DOCUMENTATION AUTHOR'S DECLARATION STATEMENT	
1. I certify that this Certificate of Compliance documentation is accurate and complete.	
Documentation Author Name:	Documentation Author Signature:
Company:	Signature Date:
Address:	CEA/ HERS Certification Identification (if applicable):
City/State/Zip:	Phone:

RESPONSIBLE PERSON'S DECLARATION STATEMENT

I certify the following under penalty of perjury, under the laws of the State of California:

1. The information provided on this Certificate of Compliance is true and correct.
2. I am eligible under Division 3 of the Business and Professions Code to accept responsibility for the building design or system design identified on this Certificate of Compliance (responsible designer).
3. That the energy features and performance specifications, materials, components, and manufactured devices for the building design or system design identified on this Certificate of Compliance conform to the requirements of Title 24, Part 1 and Part 6 of the California Code of Regulations.
4. The building design features or system design features identified on this Certificate of Compliance are consistent with the information provided on other applicable compliance documents, worksheets, calculations, plans and specifications submitted to the enforcement agency for approval with this building permit application.
5. I will ensure that a registered copy of this Certificate of Compliance shall be made available with the building permit(s) issued for the building, and made available to the enforcement agency for all applicable inspections. I understand that a registered copy of this Certificate of Compliance is required to be included with the documentation the builder provides to the building owner at occupancy.

Responsible Designer Name:	Responsible Designer Signature:
Company:	Date Signed:
Address:	License:
City/State/Zip:	Phone:

For assistance or questions regarding the Energy Standards, contact the Energy Hotline at: 1-800-772-3300

CF1R-NCB-01-E User Instructions

Minimum requirements for prescriptive compliance can be found in Building Energy Efficiency Standards Section 150.1(c), and Table 150.1-A (Package A). Completing these forms will require that you have the Reference Appendices for the 2016~~3~~ Building Energy Efficiency Standards, which contains the Joint Appendices used to determine climate zone and to complete the table for opaque surfaces. When the term CF1R is used it means the CF1R-NCB-01. Worksheets are identified by their entire name and subsequently by only the worksheet number, such as CF1R-ENV-02.

Instructions for tables with column numbers and row letters are given separately.

A. General Information

1. Project Name: Identifying information, such as owner's name.
2. Date: Date of document preparation.
3. Project Location: Legal street address of property or other applicable location identifying information.
4. Building Front Orientation: Building front expressed in degrees, where North = 0, East = 90, South = 180, and West = 270. Indicate cardinal if it is a subdivision or multi-family project that will be built in multiple orientations. The ~~s~~Standards (~~s~~Section 100.1) include the following additional details for determining orientation:
    - Cardinal covers all orientations (for buildings that will be built in multiple orientations);
    - North is oriented to within 45 degrees of true north, including 45 degrees east of north;
    - East is oriented to within 45 degrees of true east, including 45 degrees south of east;
    - South is oriented to within 45 degrees of true south, including 45 degrees west of south;
    - West is oriented to within 45 degrees of true west, including 45 degrees south of west.
5. CA City: Legal city/town of property.
6. Number of Dwelling Units: 1 for single-family, 2 or more for multifamily.
7. Zip Code: 5-digit zip code for the project location (used to determine climate zone).
8. Fuel Type: Natural Gas, Liquefied Propane Gas, or Electricity.

    NOTE: Prescriptive compliance only allows electricity if existing appliances are electric and natural gas is not available in the building.

9. Climate zone: From Joint Appendix JA2.1.1.
10. Total Conditioned Floor Area: Enter the new conditioned floor area in ft^2, as measured from the outside of exterior walls. If the project is an addition, this form is used for additions that are greater than 1,000 ft^2.
11. Building Type: Single Family (includes duplex), or Multi Family (a building that shares common walls and common floors or ceilings).
12. Slab Area: Area of the first floor slab (if any) in ft^2.
13. Project Scope: Newly constructed building or new addition greater than 1,000 ft^2.
14. Exceptions to Fenestration U-factor and SHGC: Installing less than or equal to 3 ft^2 glass in door, Installing less than or equal to 3 ft^2 tubular skylight, or Installing less than or equal to 16 ft^2 skylight, or Not Applicable.

B. Opaque Surface Details – Framed

1. Tag/ID: A label (if any) from the plans, such as A1.4 or wall.
2. Assembly Type: ~~-~~Roof, Ceiling, Wall, Floor.
3. Frame type: Wood or Metal.
4. Frame Depth: Nominal dimensions (in inches) of framing material such as 2x4 or 2x6.
5. Frame Spacing: 16, 24, or 48 (inches on center).
6. Proposed Cavity R-value: Cavity R-value of insulation installed between framing members.

   NOTE: Wall U-factor required for all climate zones is ~~0.065~~0.05. This U-factors can be met by wood framed 2x4 walls with R-13 cavity + R5 continuous insulation (not interrupted by framing), R-15 cavity plus R-4 continuous insulation, or any combination of cavity and/or continuous insulation that results in a U-factor equal to or less than ~~0.065~~0.05.

   Proposed Continuous Insulation R-value: R-value of rigid or continuous insulation (not interrupted by framing).
7. Proposed U-factor: The U-factor for the proposed assembly. Must be less than or equal to column 10 or have an attached CF1R-ENV-02-E to show that a weighted U-factor for multiple assemblies will meet the maximum value in column 10.
8. Appendix JA4 Table: Table number used to determine the R-value or U-factor (e.g., an ICF wall is 4.3.13).
9. Appendix JA4 Cell: Cell number used to determine the R-value or U-factor (e.g., an 8-inch thick ICF wall with 2 inches of EPS (R-15.4) is A6).
10. Required U-factor from Package A: Value required based on climate zone and assembly type.
11. Comments: Any notes regarding location, unique conditions, or attachments.

C. Opaque Surface Details – Non-framed

1. Tag/ID: A label (if any) from the plans, for example, A1.4 or wall.
2. Assembly Type: Roof, Wall.
3. Assembly materials: SIP OSB, SIP I-Joist, SIP single 2x, SIP double 2x, see JA4 for guidance.
4. Thickness: Thickness in inches.
5. Proposed Core Insulation R-value: Insulation installed within the materials or on the inside. See Joint Appendix JA4 for guidance.
6. Proposed Continuous Insulation R-value: Insulation installed on the exterior. See Joint Appendix JA4 for guidance.
7. Proposed U-factor: Assembly U-factor from JA4 or WS-01. Must be less than or equal to column 10.
8. Appendix JA4 Table: Table number used to determine the R-value or U-factor (e.g., an ICF wall is 4.3.13).
9. Appendix JA4 Cell: Cell number used to determine the R-value or U-factor (e.g., an 8-inch thick ICF wall with 2 inches of EPS (R-15.4) is A6).
10. Required U-factor from Package A: Based on assembly type and climate zone.
11. Comments: Any notes regarding location, unique conditions, or attachments.

D. Opaque Surface Details – Mass Walls

1. Tag/ID: A label (if any) from the plans, for example, A1.4 or wall.
2. Walls Above Grade: Yes or No.
3. Mass Type: Clay Brick, Clay Hollow Unit, CMU Light Weight, CMU Medium Weight, CMU Normal Weight, concrete, ICF. See JA4 for guidance.
4. Mass Thickness: Thickness (in inches) of mass.
5. Furring Strips Thickness: If furring strips are required to meet the required wall R-value or U-factor shown in columns 10 and 11, indicate the thickness of the furring strip (in inches). See Table 4.3.14 of Joint Appendix 4.
6. Proposed Interior Insulation R-value or U-factor: Enter either the R-value or U-factor of proposed insulation on the inside surface of the mass wall. See column 10 for the required interior insulation value for the wall type selected. See JA4 for guidance. Use the same descriptor (R-value or U-factor) throughout Table D.
7. Proposed Exterior Insulation R-value or U-factor: Enter either the R-value or U-factor of proposed insulation on the outside surface of the mass wall. See column 11 for the required exterior insulation value for the wall type selected. See JA4 for guidance.
8. Appendix JA4 Table: Table number used to determine the R-value or U-factor (e.g., an ICF wall is 4.3.13).
9. Appendix JA4 Cell: Cell number used to determine the R-value or U-factor (e.g., an 8-inch thick ICF wall with 2 inches of EPS (R-15.4) is A6).
10. Required Interior Insulation R-value or U-factor: The required R-value or U-factor (whichever descriptor was selected in column 6) for interior insulation will be completed based on the Table 150.1-A requirements for the wall type.
11. Required Exterior Insulation R-value or U-factor: The required R-value or U-factor (whichever descriptor was selected in column 7) for exterior insulation will be completed based on the Table 150.1-A requirements for the wall type.

E. Slab Insulation

Slab edge performance specifications and installation criteria are found in Sections 150.0(l) and 150.1(c)1D (Table 150.1-A). Requirements vary by climate zone and slab conditions.

1. Floor type: Types include slab-on-grade or raised slab.
   - Slab-on-grade floors require slab edge insulation in climate zone 16 only.
   - Raised slab must be insulated to R8 in climate zones 1, 2, 11, 13, 14 and 16, R-4 in climate zones 12 and 15, and no insulation is required in climate zones 3-10.
2. Proposed R-value: When required, insulation can be specified by either R-value or U-factor. If specifying an R-value complete column 2.
   Proposed U-Factor: When required, specify the U-factor of proposed insulation in column 3.
3. Required Insulation R-value: Whichever descriptor was used (R-value or U-factor) in column 2 or 3 will be used to specify the value required, which will vary by climate zone and type of slab. Values are from Table 150.1-A.
   Required Insulation U-factor: Whichever descriptor was used (R-value or U-factor) in column 2 or 3 will be used to specify the value required, which will vary by climate zone and type of slab. Values are from Table 150.1-A.
4. Comments: Any notes regarding location, unique conditions, or attachments.

   NOTE: A suggestion is provided to highlight that there is a mandatory slab edge insulation requirement for heated slab floors. Since mandatory requirements are not listed on the Certificate of Compliance, this is provided for information purposes only. The specific requirements are in Sections 110.8(g) and Table 110.8-A.

F. Roof/Ceiling Insulation

1. Option: Option A (Continuous Insulation), Option B (Below Roof Deck Insulation), or Option C.
2. Air Space: Yes or No.
3. Above Roof Deck R-value: This field will be auto populated. The required above roof deck R-value will vary depending on climate zone and whether or not there is an air space.
4. Below Roof Deck R-value: This field will be auto populated. The required below roof deck R-value will vary depending on climate zone and whether or not there is an air space.
5. Insulation R-value: This field will be auto populated. The required insulation R-value will vary depending on climate zone.
6. Radiant Barrier Required?: This field will be auto populated. The radiant barrier requirement will vary depending on compliance option used and climate zone.
7. Vented Attic?: Yes or No.

Note: If attic is unvented, prescriptive compliance cannot be used. Compliance may be attempted using the performance approach.

~~**F. Radiant Barrier**~~

1. ~~Radiant Barrier installed below the roof deck and on all gable end walls: Yes or No~~
2. ~~Comments: Any notes regarding location, unique conditions, or attachments.~~

~~Radiant barrier performance specifications and installation criteria are found in Sections 110.8(j) and 150.1(c)2, and in Residential Appendix RA4.2.1.~~

~~Radiant barriers are required by Package A in climate zones 2-15.~~

G. Roofing Products (Cool Roof)

Roofing requirements are found in Sections 110.8(i) and 150.1(c)11. Depending on the climate zone and roof slope, a cool roof (defined as a minimum aged solar reflectance and thermal emittance, or a minimum SRI) may be required by Package A.

Exceptions include (1) low-slope roofs (pitch 2:12 or less) in climate zones 1-12, 14 and 16; (2) steep slope roof (pitch greater than 2:12) in climate zones 1-9 and 16; (3) roof constructions that have thermal mass over the roof membrane with at least 25 lb/ft^2; and (4) any roof area covered by building integrated photovoltaic panels and solar thermal panels (the area of roof not covered by photovoltaic panels would still need to meet any applicable cool roof requirements).

1. Tag/ID: A label (if any) from the plans, such as R1.
2. Mass roof 25 lb/ft^2 or greater: Yes or No. Mass roofs are not required to have a cool roof even if the climate zone specifies minimum performance requirements.
3. Roof Pitch: Expressed as 4:12, for example, which means the roof rises 4 foot within a span of 12 feet. When roofs have multiple pitches the requirements are based on the pitch of 50% or more of the roof.
4. Method of Compliance: Indicate if the method of compliance is going to be based on Aged Solar Reflectance and Thermal Emittance or is it going to be based on the Solar Reflectance Index (SRI).
5. Product Type: See Cool Roof Rating Council's directory. Generally product types include single-ply roof, wood shingles, asphalt roof, metal roof, tile roof.
6. The CRRC Product ID Number is obtained from the Cool Roof Rating Council's Rated Product Directory at www.coolroofs.org/products/results. Products are listed by manufacturer, brand, type of installation, roofing material, and color, as well as product performance.
7. Proposed Initial Solar reflectance: Based on the product chosen from the Cool Roof Rating Council's Rated Product Directory. If using default assumption indicate NA since the Aged Solar Reflectance is available.

8. Proposed Aged Solar Reflectance: Value is from the Cool Roof Rating Council's Rated Product Directory. If the aged value is not available, calculate the calculated Aged Solar Reflectance using the Solar Reflectance Index (SRI) Calculation worksheet located on the California Energy Commission website or the aging 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 below.

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

9. Proposed Thermal Emittance: From the product specification default value. If using a calculated SRI place the Thermal Emittance used to calculate SRI.
10. Proposed SRI: It is optional to meet the SRI but if chosen to do so, use the Solar Reflectance Index (SRI) Calculation Worksheet found on the California Energy Commission website http://energy.ca.gov/title24/2013standards/documents/solar_reflectance/.
11. Minimum Required Aged Solar Reflectance: Based on climate zone and roof slope.
12. Minimum Required Thermal Emittance: Based on climate zone and roof slope.
13. Minimum Required SRI: Based on climate zone and roof slope.

If the cool roofing requirements will be met by a liquid field applied coating, Section 110.8(i)4 requires the coating be applied across the entire roof surface and meet the dry mil thickness or coverage recommended by the manufacturer.

H. Fenestration/Glazing Allowed Areas and Efficiencies

1. Maximum Allowed Fenestration Area for All Orientation: Calculated value based on conditioned floor area times 20 percent for all orientations.
2. Maximum Allowed West-Facing Fenestration Area Only: Calculated value based on conditioned floor area times 5 percent (Used in climate zones 2, 4, and 6-16 for west-facing fenestration).
3. Maximum Allowed U-factor (Windows): Maximum U-factor from Package A or Table 150.1-A. This field will always be 0.32 unless the U-factor will be the area weighted averaged, CF1R-ENV-02, with other higher fenestration windows.
4. Maximum Allowed U-factor (Skylights): Maximum U-factor from Package A or Table 150.1-A. This field will almost always be 0.32 unless meeting one of the Exceptions to 150.1(c)3A. If meeting one of the Exceptions, this field will be 0.55.
5. Maximum Allowed SHGC (Windows): Maximum SHGC from Package A or Table 150.1-A. This field will either be 0.25 or N/A, depending on the climate zone. N/A means there is no maximum SHGC required in this climate zone. The SHGC will be the area weighted averaged, CF1R-ENV-02, with other higher fenestration windows.
6. Maximum Allowed SHGC (Skylights): Maximum SHGC from Package A or Table 150.1-A. This field will almost always be 0.25 unless meeting one of the Exceptions to 150.1(c)3A. If meeting one of the Exceptions, this field will be 0.30.
7. Comments: Any notes regarding location, unique conditions, or attachments.

I. Fenestration Proposed Areas and Efficiencies

1. Tag/ID: Provide a name or designator for each unique type of fenestration surface. This designator should be used consistently throughout the plan set (elevations, finish schedules, etc.) such as Window-1, Skylight-1, etc. to identify each surface. It should also be consistently used on the other forms in the compliance documentation.
2. Fenestration Type: Indicate the type of fenestration construction e.g., Fixed Window, Operable Window, Skylight, Tubular Skylight, or Glass in Door.

NOTE: Doors with glazing are counted in one of two ways. The entire door area of a door with 50% or more glazing is considered fenestration. A door with less than 50% glazing can be considered as all fenestration, or can be calculated as the actual glass area with a 2-inch (0.17 ft) frame all around.

3. Frame Type: Indicate the frame type as either metal, metal thermal break, or nonmetal.
4. Dynamic Glazing: Indicate whether the fenestration has an integrated shading device, chromogenic glazing, or none for no dynamic glazing. Chromogenic glazing shall be considered separately from other fenestration types.
5. Orientation: Orientation can be North, East, South, West. If documentation is for a building that may be built in any direction, in a climate zone that limits west-facing fenestration, complete this section assuming the side of the building with the most fenestration faces west.

NOTE: West includes any vertical fenestration oriented to within 45 degrees of true west, excluding 45 degrees south of west; any skylights oriented west; and skylights facing any direction with a pitch of less than 1:12.

6. Number of Panes: Indicate the number of panes for each Tag/ID; is it a single, double, or triple pane window?
7. Proposed Fenestration Area (ft^2): Indicate the area (in square feet) of each exterior fenestration type, excluding west-facing fenestration.
8. Proposed West Facing Fenestration Area (ft^2): In climate zones 2, 4, and 6-16, indicate the area (in square feet) of each exterior west-facing fenestration type separately.

NOTE: Skylights installed in a roof with a pitch less than 1:12 are considered to face west.

9. Proposed U-factor: Enter
   (a) the NFRC U-factor based on the proposed brand and type of fenestration using National Fenestration Rating Council (www.nfrc.org) certified values, or
   (b) the default value from Table 110.6-A, or
   (c) the NA6.2 alternate default U-factor (for non-rated site-built fenestration only), or
   (d) the Area-weighted Average from CF1R-ENV-02.

   If any products (other than the exceptions) have a higher U-factor than 0.32, first complete a form CF1R-ENV-02 to calculate the area-weighted average U-factor, which must be 0.32 or less, and attach it to the CF1R-NCB-01.

   NOTE: (1) For the exceptions – up to 3 ft^2 of tubular skylights and up to 16 ft^2 of skylight area, enter 0.55.
   (2) For the exception – up to 3 ft^2 of glass in door, enter 0.32.
   (3) Dynamic glazing is a glazing system that changes its performance U-factor and SHGC based on the physical environment. Dynamic glazing includes chromogenic glazing or integrated shading systems (this does not include ~~internally or~~ externally mounted shading devices). If using dynamic glazing, use the lowest tested U-factor and SHGC in Columns 9 and 10.

10. Source: NFRC, Tables 110.6-A and 110.6-B, Equations NA6-1 and NA6-2, or Area-weighted Average Worksheet (ENV-02). The source of the U-factor data for the fenestration product.
11. Proposed SHGC: In climate zones 2, 4, and 6-16, enter the SHGC from
   (a) NFRC-rated certification information, or
   (b) default table 110.6-B, or
   (c) the NA6.3 alternate default SHGC (for non-rated site-built fenestration only), or
   (d) the Area-weighted Average from CF1R-ENV-02.

If any products (other than the exceptions) have a higher SHGC than required by Package-A, first complete a form CF1R-ENV-02 to calculate the area-weighted average SHGC and attach it to the CF1R-NCB-01.

NOTE: (1) For the exceptions – up to 3 ft^2 of tubular skylights and up to 16 ft^2 of skylight area, enter 0.30.
(2) For the exception – up to 3 ft^2 of glass in door, enter 0.25.

12. Source: NFRC, Tables 110.6-A and 110.6-B, Equations NA6-1 and NA6-2, or Area-weighted Average Worksheet (ENV-02). The source of the SHGC data for the fenestration product.
13. Exterior Shading Device: If exterior shading devices are used to meet the SHGC requirement, indicate the type of device (from Table S-1 of CF1R-ENV-03-E Solar Heat Gain Coefficient Worksheet) and attach the CF1R-ENV-03-E.

NOTE: An exterior shading device is not used for products with an NFRC rated U-factor and SHGC based on a factory integrated shading device. Chromogenic glazing shall be considered separately from other fenestration.

14. Combined SHGC from CF1R-ENV-03: If exterior shading devices are combined with the SHGC value of the fenestration to meet the prescriptive SHGC requirements (as indicated in column ~~I~~J. 13), indicate the SHGC calculated on form CF1R-ENV-03 and attach the form for each window with an exterior shading device.

15.–32. Automatically completed entries; no user input required.

J. Space Conditioning (SC) Systems – Heating/Cooling/Ducts

1. Space Conditioning System Identification or Name: Provide a unique name for each unique space conditioning system type in the building. If the same space conditioning system type is used in more than one location in the building, it is sufficient to list the unique space conditioning system type only once. In order for one space conditioning system type to be considered the same as another, it must have the same description in fields 2 through 9.
2. Heating system type: Indicate heating system type as furnace, central heat pump, boiler, hydronic, wood heat, wall furnace, room heat pump, or electric resistance if it meets the exception. An exception to Section 150.1(c)6 allows electric resistance heating only when it is supplemental to another system, as indicated by a capacity of < 2 KW or 7,000 Btu/hr, and a time-limiting control device that allows it to be operated for 30-minutes at a time.
3. Heating Efficiency Type: AFUE, HSPF, COP
4. Heating Efficiency Value: For central gas heating systems, the minimum efficiency required by the appliance efficiency standards is 81~~78~~% AFUE. Heat pumps have an HSPF of 8.0~~7.7~~ or higher. Other appliance types will have different efficiency levels (e.g., a gas wall furnace may have a minimum requirement of 73% AFUE or lower, depending on the size and type). Any gas heating appliance (or heat pump) sold in California is acceptable. The only electric heating appliance allowed is a heat pump.
5. Cooling System Type: Indicate cooling system type or specify "no cooling system installed." Categories include central air split system, central air package system, heat pump, room air or room heat pump, mini-split heat pump, or no cooling.
6. Cooling Efficiency SEER: For central cooling systems, the minimum efficiency required by the appliance efficiency standards is 14~~3~~ SEER.
7. Cooling Efficiency EER: Other appliance types will have different efficiency levels (e.g., a room air conditioner may have a minimum requirement of 9 EER (when an appliance standard is an EER this is considered equivalent to an SEER). Any cooling appliance sold in California is acceptable.
8. Distribution System Type: This could be ducted, radiant floor, piping, or ductless.
9. Duct Location: If the system has ducts, indicate where they will be installed. Locations include attic, garage, conditioned space, radiant floor.
10. Duct R-value: This value is from Package A~~. Ducted systems in Climate Zones 1-10 and 12-13 require R-6 duct insulation, and in climate zones 11 and 14-16 ducted systems require R-8 duct insulation. If ducts are installed in conditioned space (which must be field verified), this field will be N/A~~. If system is ductless this field will be N/A.

11. Thermostat Type: Select a setback thermostat or an Energy Management System (EMS) for most systems, or N/A if exempt. Controls for most systems can be by a device that allows a person to program up to 4 temperature setpoints within 24 hours. See Section P.1 for more information and for a list of systems that do not have to meet the setback thermostat requirements.
12. Comments: Include any comments here.

K. Ventilation Cooling

In climate zones 8-14, a whole house fan is required to provide ventilation. The requirement is found in Section 150.1(c)12.

1. Required Whole House Fan Airflow Rate (CFM): ~~2~~1.5 CFM per ft^2 of conditioned floor area (auto complete).
2. Minimum Attic Free Vent Area (in^2): Minimum attic vent free area = column 1 multiplied by 144 and divided by ~~375~~750, which is equivalent to multiplying by 0.192~~384~~ (auto complete).

L. Water Heating Systems

1. Water Heating System Identification or Name: Provide a unique name for each unique water heating system type in the building. If the same water heating system type is used in more than one location in the building, it is sufficient to list the unique water heating system type only once. In order for one water heating system type to be considered the same as another, it must have the same description in fields 2 through 12.
2. Water Heating System Type: Domestic Hot Water (DHW), Hydronic, Combined Hydronic, or Central. DHW is for domestic hot water, hydronic is a water heating system used for space heating only; combined hydronic are when the water heater will provide both space conditioning and domestic hot water. A central water heater serves multiple dwelling units in a multi-family building.
3. Water Heater Type: Prescriptive Standards allow four options under Section 150.1(c)8 (see Section P.2 for more detailed information on these requirements).

Single Dwelling Unit

A. ~~One gas or propane storage water heater for each dwelling unit, with an input of up to 75,000 Btu/hour and a storage capacity no greater than 60 gallons. Distribution system type for individual dwelling units shall be either trunk and branch (standard) with no recirculating system or a demand recirculation system with manual controls~~A single gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank, and that meets the requirements of Sections 110.1 and 110.3.

B. ~~One gas or propane instantaneous (tankless) water heater for each dwelling unit. With an input no greater than 200,000 Btu/hour. Distribution system type is limited to either trunk and branch system (standard) with no recirculating system or a demand recirculation system with manual controls.~~A single gas or propane storage type water heater with an input of 105,000 Btu per hour or less, rated volume less than or equal to 55 gallons and that meets the requirements of Sections 110.1 and 110.3. The dwelling unit shall meet all of the requirements for Quality Insulation Installation (QII) as specified in the Reference Appendix RA3.5.

C. ~~All water heaters installed must comply with Section 110.1 and 110.3. The distribution system shall be equipped with a demand recirculation control allowing pump operation to be based on measurement of hot water demand and hot water return temperature. The system shall have at least two loops. Buildings with 8 or less units do not have to comply with the demand recirculation requirement.~~A single gas or propane storage type water heater with an input of 105,000 Btu per hour or less, rate volume of more than 55 gallons, and that meets the requirements of Sections 110.1 and 110.3.

Central System

~~C.~~D. ~~If natural gas is not available, an electric-resistance storage or instantaneous water heater with additional criteria that it be located inside the conditioned space, has no recirculation pumps, and has a solar water-heating system with a solar fraction of at least 50 percent.~~All water heaters installed must comply with Sections 110.1 and 110.3. The distribution system shall be equipped with a demand recirculation control allowing pump operation to be based on measurement of hot water demand and hot water return temperature. The system shall have at least two loops. Buildings with 8 or less units do not have to comply with the demand recirculation requirement.

~~3.~~4. Number of Water Heaters in System: In single-family and multi-family with water heaters in each dwelling units the value is 1. For multi-family central systems serving multiple dwelling units enter the total number of water heaters.

~~4.~~5. Water Heater Storage Volume (gal): Tank capacity in gallons. For individual water heaters for a dwelling unit this will be 60 gallons or less. If instantaneous, enter n/a. For multi-family central systems enter the total storage volume.

~~5.~~6. Fuel Type: Gas, Propane, Electric (special conditions apply, see M.1.D and Q.4.D).

~~6.~~7. Rated Input Type: Enter the equipment input rating type, for gas or propane fired system the units are Btuh, for electric fired system the units are kW.

~~7.~~8. Rated Input Value: Enter the numeric value of rated input.

~~8.~~9. Heating Efficiency Type: Energy Factor, AFUE, or Thermal Efficiency. From product literature or a California Energy Commission directory.

~~9.~~10. Heating Efficiency Value: Enter the value from product literature or a California Energy Commission directory

~~10.~~11. Standby Loss (percent): Applies only to large storage water heaters, Enter n/a for small storage or instantaneous water heaters.

~~11.~~12. Exterior Insulation R-Value: Enter the R-value if exterior insulation on the storage tank is installed
~~12.~~13. Back-Up Solar Savings Fraction: If compliance requires a back-up solar system, indicate the solar contribution (e.g., 0.30). External calculations are required.
~~13.~~14. Central DHW System Distribution Type: For multi-family buildings ~~with~~ using a central distribution system a demand recirculation system with at least two distribution loops must be installed. This requirement applies to any building with eight or more units. If the system is non-central or project is individual units enter n/a.
~~14.~~15. Dwelling Unit DHW System Distribution Type: For a Central DHW this field shall be Standard. If non-central then pick from Standard, Demand Recirculation – Manual Control, Demand Recirculation – Sensor Control.

M. Space Conditioning Systems and Water Heating Systems in Multifamily Dwelling Units

1. Dwelling Unit Name: Enter one unique name for each of the number of dwelling units identified in Section A field 06.
2. Dwelling Unit Total CFA: Enter the conditioned floor area for the dwelling unit.
3. Central Water Heating System Identification or Name: Select one of the central DHW system names
4. Dwelling Unit Water Heating System Identification or Name: Select one of the Dwelling Unit water heating system names entered in Section M~~L~~. If more than one water heating system type is needed in the dwelling unit, enter another row of data for the dwelling unit and select the additional water heating system name.
5. Dwelling Unit Space Conditioning System Identification or Name: Select one of the Space conditioning system names that were entered in Section K~~J~~. If more than one space conditioning system type is needed in the dwelling unit, enter another row of data for the dwelling unit and select the additional space conditioning system name
6. Comments: Include any comments here.

N. HERS Verification Summary

1. Duct Leakage verification: All duct systems must meet maximum duct leakage requirements. Typically the maximum leakage is ~~6~~5% but varies for when the duct leakage test is performed and the type of building (single family, townhouse, multifamily). The only exception is if the heating and cooling systems are ductless.
2. Zonally Controlled Systems - Bypass Dampers: The prescriptive requirements preclude the use of bypass ducts in association with zonally controlled systems. A HERS Rater will verify that zonally controlled systems have no bypass ducts.
3. Refrigerant Charge Verification: Some type of refrigerant charge verification or Charge Indicator Display is required in climate zones 2 and 8-15 for most common systems such as ducted split and packaged systems, and mini-split systems. See Section 150.1(c)7A. or Reference Residential Appendix RA3.2. If a building is built in climate zones 1, 3-17 or 16, or has no cooling system, no refrigerant charge verification is required.
4. Central System Air Handlers - Airflow Rate and Fan Efficacy Verification: Unless a building has no cooling system or has a non-ducted cooling system, the system must meet mandatory and prescriptive requirements for an airflow greater than 350 CFM per ton of nominal cooling capacity, and a fan efficacy less than or equal to 0.58 W/CFM. See 150.0(m)13, 150.1(c)10, and Reference Residential Appendix RA3.
5. Indoor Air Quality Mechanical Ventilation: All new dwellings are required to meet the whole-building mechanical ventilation airflow rate according to ASHRAE 62.2 is required (RA3.7).

Documentation Declaration Statements

1. The person who prepared the CF-1R will sign and complete the fields for their name, company (if applicable), address, phone number, certification information (if applicable), date and signature (may be electronic).
2. The person who is assuming responsibility for the project being built to comply with Title 24, Part 6, will complete the fields for their name, company (if applicable), address, phone number, license number (if applicable), date and signature (may be electronic).

Registration

The CF1R must be registered with a HERS provider prior to submitting for a building permit.

Standards References

1. Thermostats
   a. Thermostat requirements are found in Section 110.2(c) with special requirements for heat pumps in Section 110.2(b). Controls for most systems can be by a central energy management control system ("EMS") or a setback thermostat with a mechanism allowing a person to program up to 4 temperature setpoints within 24 hours ("setback").

      EXCEPTIONS: If the heating system type is a gravity gas wall, floor or room heater, non-central electric heater, fireplace or decorative gas appliance, or wood stove, a setback thermostat or energy management control system is not required.

      If the cooling system type is a room air conditioner or room air conditioner heat pump setback thermostat or energy management control system is not required.

2. Water Heaters:
   Section 150.1(c) allows a limited number of conditions for water heating. If conditions other than these are proposed, the prescriptive compliance approach cannot be used:

   Single Dwelling Unit

   A. A single gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank, and that meets the requirements of Sections 110.1 and 110.3.
   B. A single gas or propane storage type water heater with an input of 105,000 Btu per hour or less, rated volume less than or equal to 55 gallons and that meets the requirements of Sections 110.1 and 110.3. The dwelling unit shall meet all of the requirements for Quality Insulation Installation (QII) as specified in the Reference Appendix RA3.5.
   C. A single gas or propane storage type water heater with an input of 105,000 Btu per hour or less, rate volume of more than 55 gallons, and that meets the requirements of Sections 110.1 and 110.3.

   Central System

   D. All water heaters installed must comply with Sections 110.1 and 110.3. The distribution system shall be equipped with a demand recirculation control allowing pump operation to be based on measurement of hot water demand and hot water return temperature. The system shall have at least two loops. Buildings with 8 or less units do not have to comply with the demand recirculation requirement.
   ~~A. 150.1(c)8A one gas or propane storage water heater, up to 75,000 Btu/hour input (typically 50 gallons or less), with either no recirculating system or a demand recirculation system with manual controls. If the Energy Factor is less than or equal to the federal minimum, it must have an R-12 external wrap. See D. below.~~
   ~~B. 150.1(c)8B one gas or propane instantaneous (tankless) water heater with an input of 200,000 Btu per hour or less, no storage tank, and either no recirculating system or a demand recirculation system with manual controls. .~~
   ~~C. 150.1(c)8C a central water-heating system that has includes the following components (1) gas or propane water heaters, boilers or other water heating equipment, (2) a water heating recirculation loop that meets the requirements of Section 110.3(c)2 and Section 110.3(c)5 equipped with automatic controls for the recirculation pump based on measurement of hot water demand and hot water return temperature, and if more than 8 dwelling units, two recirculation loops each serving half of the building; (3) a solar water-heating system with a minimum solar savings fraction of 0.20 in climate zones 1 through 9 or a minimum solar savings fraction of 0.35 in climate zones 10 through 16 (installation criteria is in Reference Residential Appendix RA4).~~

~~D. 150.1(c)8D if natural gas is not available, an electric-resistance storage or instantaneous water heater with addition criteria that it be located inside the conditioned space, it has no recirculation pumps, and has a solar water-heating system with a minimum solar savings fraction of 0.50 (installation criteria is in Reference Residential Appendix RA4).~~

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft^2 or Less, or Additions That Do Not Require HERS Field Verification		(Page 1 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

This compliance document is only applicable to additions 300 ft^2 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 (ft^2) (Addition):	
11	Building Type:		12	Slab Area (ft^2):	
13	Project Scope:				

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft^2 or Less, or Additions That Do Not Require HERS Field Verification		(Page 2 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

Insulation

The altered components shall comply with all applicable requirements in The Energy Efficiency Standards Sections 110.7, 110.8, 150.0; 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 exhilaration.

B. Roof/Ceiling Insulation

01	02	03	04	05	06	07	08	09	10
I.D.	Manufacturer & Brand	Framing Material	Framing Size & Spacing	Insulation Type	ESR Number	Cavity Insulation R-value	Insulation Depth (inches)	Above Deck Insulation R-value	Below Deck Insulation R-value

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. Wall Insulation

01	02	03	04	05	06	07	08	09	10
I.D.	Manufacturer & Brand	Framing Material	Framing Size & Spacing	Insulation Type	ESR Number	Cavity Insulation R-value	Insulation Depth (inches)	Exterior Wall Insulation R-value	Interior Wall Insulation R-value

D. Mas Insulation

01	02	03	04	05	06	07	08
I.D.	Manufacturer & Brand	Location	Mass Thickness (inches)	Furring Strip Type/ Depth (inches)	Insulation Type	Exterior Insulation R-value	Interior Insulation R-value

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft² or Less, or Additions That Do Not Require HERS Field Verification		(Page 3 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

E. Raised Floor Insulation

01	02	03	04	05	06	07	08	09	10
I.D.	Manufacturer & Brand	Framing Material	Framing Size & Spacing	Insulation Type	ESR Number	Cavity Insulation R-value	Insulation Depth (inches)	Exterior Floor Insulation R-value	Interior Floor Insulation R-value

F. Slab Floor/Perimeter Insulation

01	02	03	04	05	06	07	08
I.D.	Manufacturer & Brand	Floor Type	Insulation Type	Insulation Depth (inches)	Insulation R-Value	Vertical Insulation Length (inches)	Horizontal Insulation Length (feet)

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft^2 or Less, or Additions That Do Not Require HERS Field Verification		(Page 4 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

Roofing and Radiant Barrier

G. Radiant Barrier		
01	Brand Name and Product Number	
02	Installation Type	
03	Total Attic Area (ft^2)	

H. Required Vent Area		
01	Combined NFA of installed upper and lower vents (in^2)	
02	Minimum required combined NFA of upper and lower vents (in^2)	
03	NFA of installed upper vents (in^2)	
04	Minimum required NFA of upper vents (in^2)	

I. Roofing products (Cool Roof) Installation Information

01	02	03	04	05	06	07	08
Roof Pitch	CRRC Product ID Number	Product Type	CRRC Listed Aged Solar Reflectance	Initial Solar Reflectance	Aged Solar Reflectance	Thermal Emittance	SRI

J. Radiant Barrier and Attic Ventilation – Additional Requirements	
Radiant Barrier	
01	Radiant barrier must be installed on all vertical surfaces in the attic including gable ends.
02	The emittance of the radiant barrier shall be less than or equal to 0.05 as tested with ASTM C1371, or E408.
03	The product shall meet all requirements for California certified insulation materials [radiant barriers] of the Department of Consumer Affairs, Bureau of Home Furnishings and Thermal Insulation, as specified by CCR, Title 24, Part 12, Chapter 12-13, Standards for Insulating Material
04	When determining the Total Attic Area, the area over unconditioned spaces such as the garage is included when the attic spaces are connected.
Lower Vents	
05	Lower vents are within one foot of the eave.
Upper Vents	
06	Upper vents are within three feet of the ridge
Vent Area	
07	The NFA of upper vents must be within required NFA range of upper vents Note: per Exception to R806.2 of the CBC Title 24, Part2, Vol.2.5, if the net free ventilating area is less than 1:150, then the upper ventilation must be at least 40% and no more than 50%. Part 2 contains additional requirements that must be met if the area is less than 1:150.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

K. Roofing Products (Cool Roof) – Additional Requirements	
01	Any roof area covered by building integrated photovoltaic panels and solar thermal panels are exempt from the above Cool Roof requirements.
02	Liquid field applied coatings must comply with installation criteria from section 110.8(i)4.
03	Mass roof 25 lb ft^2 or greater: Mass roofs are not required to have a cool roof even if the climate zone specifies minimum performance requirements.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft^2 or Less, or Additions That Do Not Require HERS Field Verification		(Page 6 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

Fenestration

L. Fenestration/Glazing

Includes all Windows, Skylights, Greenhouse/Bay Windows, and Glazed Doors

01	02	03	04	05	06	07	08	09	10	11
Tag/ID	Manufacturer/ Brand	Fenestration Area (ft^2)	Orientation	Chromogenic	U-factor	SHGC	Source of U-factor and SHGC	Fenestration Type	Exterior Shading Devices (Describe)	Comments/Special Features

M. Fenestration/Glazing – Additional Requirements

01	For existing buildings the U-factor and SHGC values should be the same or better than the required Energy Commission prescriptive requirements.
02	Temporary labels should not be removed until verified by the building inspector.
03	The fenestration product manufacturer's installation specifications shall be followed when installing these products. The space between the fenestration product and rough opening shall be completely filled with insulation. If batt insulation is used, it is cut to size and placed properly around the fenestration product.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft^2 or Less, or Additions That Do Not Require HERS Field Verification		(Page 7 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

Mechanical and Plumbing

N. Space Conditioning (SC) Systems – Heating/Cooling (Section 150.2(b))

Alterations to Space Conditioning Systems shall be exempt from HERS verification requirements as prerequisite for use of the CF1R-ADD-02 and CF2R-ADD-02 Compliance Documents. If new space conditioning systems are installed or existing systems are altered and are not exempt from HERS verification, then a CF1R-ADD-01 shall be completed and registered with a HERS Provider Data Registry. In each row below for each dwelling unit in the building, check the box that indicates the exemption from HERS verification compliance:

☐ a: space conditioning system was not altered;
☐ b: less than 40 ft of ducts were added or replaced;
☐ c: (exempt from duct leakage testing) if: the existing duct system was insulated with asbestos;
☐ d: (exempt from duct leakage testing) if: the existing duct system was previously tested and passed by a HERS Rater.

01	02	03	04
Dwelling Unit Name	SC System Identification or Name	SC System Location or Area Served	Exemption from HERS Verification
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft^2 or Less, or Additions That Do Not Require HERS Field Verification		(Page 8 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

O. Installed Water Heating Systems (Section 150.2(b)1G)

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Dwelling Unit Name	Water Heating System Identification or Name	Water Heating System Location or Area Served	Water Heating System Type	Water Heater Type	# of Water Heaters in System	Water Heater Storage Volume (gal)	Fuel Type	Rated Input Type	Rated Input Value	Heating Efficiency Type	Heating Efficiency Value	Standby Loss (%)	Exterior Insul. R-Value	Back-Up Solar Savings Fraction

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft² or Less, or Additions That Do Not Require HERS Field Verification		(Page 9 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

P. Installed Water Heater Manufacturer Information

01	02	03
Water Heating System ID or Name	Manufacturer	Model Number

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft^2 or Less, or Additions That Do Not Require HERS Field Verification		(Page 10 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

Lighting

General Lighting Requirements
Additional new lighting, and altered lighting, shall comply with all applicable requirements specified in Section 150.0(k).

~~**Kitchen Lighting requirements**~~
~~150.0(k)1C: The wattage of permanently installed luminaires should be determined as specified in Section 130.0(c).~~
~~150.0(k)1C: In the kitchen, Any electrical boxes finished with a blank cover count as 180 watts of low efficacy lighting.~~
~~Compliance demonstrated using Method (a) because only high efficacy luminaires have been installed in the kitchen.~~ ~~Compliance demonstrated using Method (b). At least 50% of the installed watts from permanently installed high efficacy. Total A ≥ Total B in Installed Wattage Calculation Table (below)~~ ~~Compliance demonstrated with additional low efficacy wattage allowance of EXCEPTION to 150(k)3~~
~~EXCEPTION to 150.0(k)3: Additional low efficacy watts may be allowed when all luminaires in the kitchen are controlled by a vacancy sensor or dimmers, and~~ ~~1. See 150.0(k)2A where high efficacy and low efficacy luminaires must be separately controlled.~~ ~~2. See 150.0(k)2G where EMCS may be used as a dimmer; Section 150.0(k)2H where EMCS may be used as a vacancy sensor; or, 150.0(k)2I where multi-scene programmable controller may be used as a dimmer.~~ ~~NOTES: Compliance demonstrated using Method (c). Kitchen lighting qualifies for additional low efficacy lighting and as demonstrated in Installed Wattage Calculation Table in Method (b) (above) in addition to Additional Low Efficacy Wattage Calculation Table (below).~~
~~**The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.**~~

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft² or Less, or Additions That Do Not Require HERS Field Verification		(Page 11 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

~~Q. Installed Kitchen Lighting Compliance~~

~~In each row below for each dwelling unit in the building, check the box that indicates the method of compliance. If required by the enforcement agency, provide a Kitchen Lighting Requirements Worksheet for each kitchen in the dwelling unit that complies using method b or c.~~

~~☐ Method A: Compliance demonstrated using Method (a) - only high efficacy luminaires have been installed in the kitchen.~~
~~☐ Method B: At least 50% of installed watts are from permanently installed high efficacy lighting~~
~~☐ Method C: Installation qualifies for additional low efficacy lighting allotment~~
~~☐ N/A: No kitchen lighting is installed~~

~~01~~	~~02~~	~~03~~	~~04~~	~~05~~
~~Dwelling Unit Name~~	~~Kitchen Lighting Compliance Method~~	~~Total High Efficacy (Method B)~~	~~Total Low Efficacy (Method B)~~	~~Total Additional Low Efficacy (Method C)~~
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft^2 or Less, or Additions That Do Not Require HERS Field Verification		(Page 12 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft^2 or Less, or Additions That Do Not Require HERS Field Verification		(Page 13 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

~~Kitchen Lighting Requirements Worksheet~~
~~Dwelling Unit Name:___________________~~

~~This Table is applicable only if Kitchen Lighting using Method (b) or (c) is selected in Table Q~~

~~Method (b) Total Wattage Calculation~~								
	~~Luminaire (Fixture)~~					~~Total Watts~~		
~~Luminaire Type~~	~~High Efficacy Watts~~	~~Low Efficacy Watts~~		~~Quantity~~		~~High Efficacy~~		~~Low Efficacy~~
			~~x~~		~~=~~			
			~~x~~		~~=~~			
			~~x~~		~~=~~			
			~~x~~		~~=~~			
			~~x~~		~~=~~			
			~~x~~		~~=~~			
	~~Complies with method (b) if Total A ≥ Total B~~							
						~~A~~	~~≥~~	~~B~~

~~Method (c) Total Additional Low Efficacy Wattage Calculation (see footnote)~~			
~~Watts from Method (b)~~		~~Additional Watts Low Efficacy~~	
~~High Efficacy~~	~~Low Efficacy~~		~~Total Low Efficacy Watts Allowed~~
~~1. Insert 50 if house is ≤ 2.500 square feet; Insert 100 if house is > 2,500 square feet.~~			

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft^2 or Less, or Additions That Do Not Require HERS Field Verification		(Page 14 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

Pool and Spa

~~R~~Q. Pool and Spa System Type		
01	Pool and Spa System Type	

~~S~~R. **Pool and Spa Systems and Equipment Requirements** (Section 110.4(a) and 110.5)	
01	Heater has a thermal efficiency that complies with the Appliance Efficiency Regulations.
02	A readily accessible on-off switch is mounted on the outside of the heater, which allows the heater to be shut off without the user adjusting the thermostat setting.
03	A weatherproof plate or card containing instructions for the energy-efficient operation of the pool or spa heater is permanently mounted.
04	No electric resistance heating except for listed package units that have fully insulated enclosures and tight fitting covers that are insulated to at least R-6. Or if documentation is provided that at least 60 % of the annual heating energy is from site solar energy or recovered energy.
05	Heating system has no pilot light.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

~~T~~S. **Pool and Spa System Installation Requirements** (Section 110.4(b))	
01	To allow for the future addition of solar heating equipment, at least 36" of pipe is installed between the filter and heater, or dedicated suction and return lines are installed, or built-in or built-up connections for future solar heating are provided.
02	A cover is provided for outdoor pools or spas that have a heat pump or gas heater.
03	Pool system has directional inlets to adequately mix the pool water
04	Pool system has a time switch that allows the pump to be set or programmed to run during off-peak periods only
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft^2 or Less, or Additions That Do Not Require HERS Field Verification		(Page 15 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

~~U~~T. **Pool Pump Sizing and Flow Rate Specification** (Section 150.0(p))			
01	The pool pump specified is listed in the CEC database of certified pool pumps.		
02	The pool pump flow rate shall not exceed the maximum pump flow rate calculated based on pool sizing in the table below. The return pipe diameter, suction pipe diameter, and filter area shall be at least as large as the required minimums shown in the table. Alternatively, a flow calculation or flow test result shall be provided to demonstrate that the pump flow rate is less than 6 hour filtration turnover, and the return pipe flow rate does not exceed 8 feet per second and that the suction pipe flow rate does not exceed 6 feet per second.		
03	An alternative compliance calculation or a flow test result is provided for this pool or spa use (must attach flow calculation or flow test result to this form)		
04	The pump is capable of operating at 2 or more speeds (not applicable if pump is less than 1 horsepower).		
05	Each auxiliary pool load is served by either a separate pump, or the system is served by a multi-speed pump.		
06	Volume of pool (gallons):		
07	Filter Type (Cartridge, Sand, DE):		
08a Required Min Return Pipe Diameter (inches)	08b Required Min Suction Pipe Diameter (inches)	08c Required Min Filter Area (ft^2)	08d Required Max Pump Flow (gpm)
09	Return Pipe Diameter (inches).		
10	Suction Pipe Diameter (inches).		
11	Filter Surface Area (ft^2).		
12	Max Pump Flow Rate (gallons per minute).		
13	Measured Flow Rate Return Line (feet per second)		
14	Measured Flow Rate Suction Line (feet per second)		
15	Compliance Statement	U. 03 = Yes, U. 13 ≤ U. 08, and U. 14 ≤ U. 06	☐ Yes ☐ No
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.			

~~V~~U. **Pool System Piping** (Section 150.0(p)2)	
01	The suction side pipe is straight for at least 4 pipe diameters before entering the pump (See table below for the required straight run lengths for various pipe sizes).
02	All elbows are sweep elbows, or an elbow type that has a pressure drop that is less than the pressure drop of a straight pipe with a length of 30 pipe diameters.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

~~W~~V. **Pool Filters and Valves** (Section 150.0(p)3 and 4)	
01	If a filter is used in a pool intended for public use: The size of the filter is at least the size specified in NSF/ANSI 50.
02	If a backwash valve is used: The diameter of the backwash valve is at least 2 inches, or the diameter of the return pipe, whichever is greater.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

CERTIFICATE OF INSTALLATION		CF2R-ADD-02-E
Prescriptive Residential Additions 300 Ft^2 or Less, or Additions That Do Not Require HERS Field Verification		(Page 16 of 16)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

DOCUMENTATION AUTHOR'S DECLARATION STATEMENT	
1. I certify that this Certificate of Installation documentation is accurate and complete.	
Documentation Author Name:	Documentation Author Signature:
Documentation Author Company Name:	Date Signed:
Address:	CEA/HERS Certification Identification (If applicable):
City/State/Zip:	Phone:

RESPONSIBLE PERSON'S DECLARATION STATEMENT

I certify the following under penalty of perjury, under the laws of the State of California:

1. The information provided on this Certificate of Installation is true and correct.
2. I am eligible under Division 3 of the Business and Professions Code in the applicable classification to accept responsibility for the system design, construction, or installation of features, materials, components, or manufactured devices for the scope of work identified on this Certificate of Installation, and attest to the declarations in this statement (responsible builder/installer), otherwise I am an authorized representative of the responsible builder/installer.
3. The constructed or installed features, materials, components or manufactured devices (the installation) identified on this Certificate of Installation conforms to all applicable codes and regulations, and the installation conforms to the requirements given on the plans and specifications approved by the enforcement agency.
4. I reviewed a copy of the Certificate of Compliance approved by the enforcement agency that identifies the specific requirements for the scope of construction or installation identified on this Certificate of Installation, and I have ensured that the requirements that apply to the construction or installation have been met.
5. I will ensure that a registered copy of this Certificate of Installation shall be posted, or made available with the building permit(s) issued for the building, and made available to the enforcement agency for all applicable inspections. I understand that a registered copy of this Certificate of Installation is required to be included with the documentation the builder provides to the building owner at occupancy.

Responsible Builder/Installer Name:	Responsible Builder/Installer Signature:	
Company Name: (Installing Subcontractor or General Contractor or Builder/Owner)	Position With Company (Title):	
Address:	CSLB License:	
City/State/Zip:	Phone	Date Signed:

For assistance or questions regarding the Energy Standards, contact the Energy Hotline at: 1-800-772-3300

CF2R-ADD-02-E User Instructions

NOTE: If more space is needed, print a duplicate page and fill in.

Minimum requirements for prescriptive addition compliance can be found in Building Energy Efficiency Standards Section 150.2(a), and Table 150.1-A (Package A). Completing these forms will require that you have the Reference Appendices for the 2013 Building Energy Efficiency Standards (P400-2012-005), which contain the Joint Appendices used to determine climate zone. When the term CF2R is used it means the CF2R-ADD-02. Worksheets are identified by their entire name and subsequently by only the worksheet number, such as CF1R-ENV-02.

Instructions for sections with column numbers and row numbers are given separately.

If any part of the addition does not comply, prescriptive compliance fails, in which case the performance (or computer) compliance approach may be used in an attempt to achieve compliance. Only the new construction is required to meet the requirements specified in this documentation. If any alterations to the existing building are occurring, those are documented on one or more of the CF1R-ALT forms.

A. General Information

1. Project Name: Identifying information, such as owner's name.
2. Date Prepared: Date of document preparation.
3. Project Location: Legal street address of property or other applicable identifying information.
4. Building Front Orientation: Building front orientation expressed in degrees, where North = 0, East = 90, South = 180, and West = 270. The standards (section 100.1) include the following additional details for determining orientation:
    - North is oriented to within 45 degrees of true north, including 45 degrees east of north;
    - East is oriented to within 45 degrees of true east, including 45 degrees south of east;
    - South is oriented to within 45 degrees of true south, including 45 degrees west of south;
    - West is oriented to within 45 degrees of true west, including 45 degrees north of west.
5. CA City: Legal city/town of property.
6. Number of Dwelling Units with Additions: 1 for single-family, 1 or more for multifamily.
7. Zip Code: 5-digit zip code for the project location (used to determine climate zone).
8. Fuel Type: Natural Gas, Liquefied Propane Gas, or Electricity.

    NOTE: Prescriptive compliance only allows electricity if existing appliances are electric and natural gas is not available in the building.

9. Climate Zone: From Joint Appendix JA2.1.1.
10. Total Conditioned Floor Area: Enter the new conditioned floor area, in ft^2, as measured from the outside of exterior walls of the addition.
11. Building Type: Single Family (includes duplex), or Multi Family (a building that shares common walls and common floors or ceilings).
12. Slab Area: Area of the first floor slab of the addition (if any) in ft^2.
13. Project Scope: 300 ft^2 or less, greater than 300 ft^2 up to 400 ft^2, greater than 400 ft^2 up to 700 ft^2, or greater than 700 ft^2 up to 1000 ft^2.

B. Roof/Ceiling Insulation

1. I.D.: A label from the plans (e.g., A1.4 or Roof) documenting the location of the installed insulation.
2. Manufacturer & Brand: Indicate the manufacturer and brand of the product being installed.
3. Framing Material: Wood or Metal.
4. Framing Size & Spacing: Indicate the framing size and spacing (e.g., 2x4 @ 16 in O.C.); enter n/a if not applicable.
5. Insulation Type: List the type of insulation used, such as batt, loose fill, or SPF.
6. ESR Number: If using a non-standard R-value for SPF insulation, complete an ICC Evaluation Service Report and record the ESR number.
7. Cavity Insulation R-value: Indicate the cavity insulation R-value.
8. Insulation Depth: Indicate, in inches, the amount of insulation installed.
9. Above Deck Insulation R-Value: Indicate the R-value of the continuous insulation, having no framing penetration, installed above the roof deck.
10. Below Deck Insulation R-Value: Indicate the R-value of the continuous insulation being installed below the roof deck that has no framing penetration, installed below the roof deck.

C. Wall Insulation

1. I.D.: A label from the plans, (e.g., A1.4 or Wall1) documenting the location of the installed insulation.
2. Manufacturer & Brand: Indicate the manufacturer and brand of the product being installed.
3. Framing Material: Wood or Metal.
4. Framing Size & Spacing: Indicate the framing size and spacing (e.g., 2x4 @ 16 in O.C.); enter n/a if not applicable.
5. Insulation Type: List the type of insulation used, such as: Batt, Loose Fill, or SPF.
6. ESR Number: If using a non-standard R-value for SPF insulation, complete an ICC Evaluation Service Report and record the ESR number.
7. Cavity Insulation R-value: Indicate the cavity insulation R-value.
8. Insulation Depth: Indicate, in inches, the amount of insulation installed.
9. Exterior Wall Insulation R-Value: Indicate the R-value of continuous insulation, having no framing penetration, installed on the outside of the wall.
10. Interior Wall Insulation R-Value: Indicate the R-value of continuous insulation, having no framing penetration, installed on the inside of the wall.

D. Mass Insulation

1. I.D.: A label from the plans (e.g., A1.4 or Wall1) documenting the location of the installed insulation.
2. Manufacturer & Brand: Indicate the manufacturer and brand of the product being installed.
3. Location: Indicate the location of the insulation, such as: Above Grade, Below Grade, Wall, or Roof.
4. Mass Thickness: Indicate the thickness of the mass, in inches, the insulation is applied to.
5. Furring Strip Type/Depth: Indicate the type, and thickness, of furring material installed (e.g., wood/1.0 inch thick).
6. Insulation Type: List the type of insulation used, such as: SPF, EPS, or EPDM.
7. Exterior Insulation R-Value: Indicate the R-value of the continuous insulation, having no framing penetration, installed on the outside of the assembly.
8. Interior Insulation R-Value: Indicate the R-value of the continuous insulation, having no framing penetration, installed on the inside of the assembly.

E. Raised Floor Insulation

1. I.D.: A label from the plans (e.g., A1.4 or Floor1) documenting the location of the installed insulation.
2. Manufacturer & Brand: Indicate the manufacturer and brand of the product being installed.
3. Framing Material: Wood or Metal.
4. Framing Size & Spacing: Indicate the framing size and spacing (e.g., 2x4 @ 16 in O.C.); enter n/a if not applicable.
5. Insulation Type: List the type of insulation used, such as: Batt, Loose Fill, or SPF.

6. ESR Number: If using a non-standard R-value for SPF insulation, complete an ICC Evaluation Service Report and record the ESR number.
7. Cavity Insulation R-value: Indicate the cavity insulation R-value.
8. Insulation Depth: Indicate, in inches, the amount of insulation installed.
9. Exterior Floor Insulation R-Value: Indicate the R-value of continuous insulation, having no framing penetration, installed on the outside of the floor.
10. Interior Floor Insulation R-Value: Indicate the R-value of continuous insulation, having no framing penetration, installed on the inside of the floor.

F. Slab Floor/Perimeter Insulation

1. I.D.: A label from the plans (e.g., A1.4 or Slab Floor1) documenting the location of the installed insulation.
2. Manufacturer & Brand: Indicate the manufacturer and brand of the product being installed.
3. Floor Type: Indicate the type of floor the insulation is being applied to, such as: Heated Slab or Slab on Grade.
4. Insulation Type: List the type of insulation used, such as: EPDM, Polyisocyanurate, or Polystyrene.
5. Insulation Depth: Indicate, in inches, the depth of insulation installed.
6. Insulation R-Value: Indicate the insulation R-value being installed vertically and horizontally (if applicable).
7. Vertical Insulation Length: Indicate, in inches, the length of the insulation being installed.
8. Horizontal Insulation Length: Indicate, in feet, the length of the insulation being installed from the outside edge of the vertical insulation to the center of the slab.

G. Radiant Barrier

1. Brand Name and Product Number: Indicate the brand name and product number of the product used.
2. Installation Type: Indicate the installation type from the following list:
    a. Attached to underside of roof deck
    b. Attached to bottom of truss/rafters
    c. Attached between truss/rafters
    d. Draped over top of truss/rafters

    One of these four installation methods must be used; no other methods are allowed.

3. Total Attic Area (ft^2): Provide the total attic area over conditioned space. When determining the total attic area, the area over unconditioned spaces such as a garage is included when the attic spaces are connected. At least one square foot of net free venting area is required for each 300 square feet of attic (1:300).

H. Required Vent Area

1. Combined NFA of installed upper and lower vents (in^2): Indicate the total combined NFA of installed upper and lower vents in square inches.
2. Minimum required combined NFA of upper and lower vents (in^2): Total attic area divided by 300 and multiplied by 144.
3. NFA of installed upper vents (in^2): Indicate the total NFA of installed upper vents in square inches.
4. Minimum required NFA of upper vents (in^2): Table H item 1 (combined NFA of installed upper and lower vents) multiplied by 0.3.

I. Roofing Products (Cool Roof) Installation Information

1. Roof Pitch: Indicate whether the roof pitch is ≤2:12 or >2:12
2. CRRC Product ID Number: If a cool roof is installed, obtain the Product ID Number from the Cool Roof Rating Council's (CRRC) product packaging label or rated products directory (http://coolroofs.org/products/results).
3. Product Type: Indicate the product type being used.
4. CRRC Listed Aged Solar Reflectance: State whether the 3-year aged solar reflectance value of the product used is listed on the CRRC product packaging label or rated products directory—Yes or No.
5. Initial Solar Reflectance: Indicate the initial solar reflectance value of the product used; obtained from the CRRC product packaging label or rated products directory.
6. Aged Solar Reflectance: Indicate the aged solar reflectance value of the product used; obtained from the CRRC product packaging label or rated product directory.

   Note: If the 3-year aged value is not available then use the equation in Section 110.8(i)2 of the Energy Standards to calculate the 3-year aged solar reflectance. One can also use the "Calculated Aged Solar Reflectance" from the Solar Reflectance Index (SRI) Calculation Worksheet" available at the California Energy Commission's website.

7. Thermal Emittance: Indicate the thermal emittance value of the product used; obtained from the CRRC product packaging label or rated products directory. This can be either the initial or aged value.
8. SRI: If applicable, obtain the value of the product used from the CRRC rated products directory, or the "Solar Reflectance Index (SRI) Calculation Worksheet" available at the California Energy Commission's website.

J. Radiant Barrier and Attic Ventilation – Additional Requirements

This section contains additional requirements for Radiant Barriers, Lower Vents, Upper Vents, and Vent Area.

K. Roofing Products (Cool Roof) – Additional Requirements

This section contains additional requirements for Roofing Products. Other exceptions apply for additions and/or alterations.

L. Fenestration/Glazing

1. Tag/ID: The labeling format used in the plans- ensure each unique type is used consistently throughout the plan set (elevations, finish schedules, etc.) to indentify each matching fenestration product, such as: Window-1, Skylight-1 etc. It should also be consistently used on the other forms in the same compliance documentation.
2. Manufacturer/Brand: Provide the manufacturer and brand name which identifies the fenestration product being installed.
3. Fenestration Area (ft^2): Indicate the total installed surface area (ft²) of the fenestration.
4. Orientation: Indicate the orientation of the same like fenestration. Use different lines if the orientation of the same fenestration varies. Enter N, S, E, or W.
5. Chromogenic: Is the glazing product chromogenic? Yes or No
6. U-factor: Indicate the specified U-factor of the fenestration product(s) being installed. Do not mix different types on the same line.
7. SHGC: Indicate the specified SHGC of the fenestration product(s) being installed. Do not mix different types on the same line.
8. Source of U-factor and SHGC: NFRC, CEC Default, NA6 Alternative. Enter the appropriate temporary label certificate identified as either NFRC, CEC Default or by using the information in NA6. All ~~windows~~ installed must have a label certificate which identifies the ~~window's~~ efficiencies. NFRC rated products have a temporary label that can be looked up in the NFRC product directory (http://search.nfrc.org/search/searchDefault.aspx).
9. Fenestration Type: Provide a description of the window type, for instance, the frame material, coatings, whether it is operable or fixed.
10. Exterior Shading Devices: If exterior shading devices are installed in conjunction with fenestration then indicate the type used (e.g. sunscreens, vertical roller or shades, retractable or drop arm or operable awnings, or roll down blinds or slats); or if an overhang is, or will be installed.
11. Comments/Special Features: Additional information for the field inspector.

M. Fenestration/Glazing – Additional Requirements
This section contains additional requirements for Fenestration/Glazing.

N. Space Conditioning (SC) Systems – Heating/Cooling
If an existing space system will condition an addition, the prescriptive requirements do not apply to that system (Exception 4 to Section 150.2(a)). The enforcement agencies may require verification that the capacity of the existing heating system is adequate to meet the added load of the additional conditioned floor area. Since there is no health and safety code requirement to provide cooling, the enforcement agency will not ask for verification that the capacity of the existing system is adequate to meet the added load of the additional conditioned floor area.

If a new system is installed complete a Certificate of Compliance for Alterations to Space Conditioning Systems (CF1R-ALT-02).

1. Dwelling Unit Name: Name of dwelling unit or any other identifying name.
2. SC System Identification or Name: Name of the Space Conditioning (SC) System or any other identifying name.
3. SC System Location or Area Served: Zone, or area, served by the Space Conditioning (SC) System.
4. Exemption from HERS Verification: Section 150.2(b)1E
    a. Space Conditioning (SC) System was not altered.
    b. Duct systems that have been documented to have been previously sealed as confirmed through field verification and diagnostic testing in accordance with procedures in the Reference Residential Appendix RA3.1.
    c. Duct systems with less than 40 linear feet in unconditioned spaces as determined by visual inspection.
    d. Existing duct systems constructed, insulated or sealed with asbestos.

O. Installed Water Heating Systems

Water heating compliance for an addition is described in Section 150.2(a). When a water heater is added as part of an addition in a single dwelling a gas or propane water heater, with a storage tank of 60 gallons maximum or instantaneous, can be used. Electric water heaters can only be used if gas or propane is not available and no recirculation pump can be used.

1. Dwelling Unit Name: Name of dwelling unit or any other identifying name.
2. Water Heating System Identification or Name: Name of the Water Heating System or any other identifying name.
3. Water Heating System Location or Area Served: Zone, or area, served by the Water Heating System.
4. Water Heating System Type: Domestic Hot Water (DHW), Hydronic, Combined Hydronic, or Central. DHW is for domestic hot water, hydronic is a water heating system used for space heating only; combined hydronic is when the water heater will provide both space conditioning and domestic hot water.
5. Water Heater Type: For non-central systems only Small Storage or Small Instantaneous are allowed. For central systems pick from Large Storage, Small Storage, Heat Pump, Boiler, Large Instantaneous, Small Instantaneous or Indirect.
6. Number of Water Heaters in System: In single-family and multi-family with water heaters in each dwelling unit the value is 1. For multi-family central systems serving multiple dwelling units enter the total number of water heaters.
7. Water Heater Storage Volume: Tank capacity in gallons. For individual water heaters for a dwelling unit this will be 60 gallons or less. If instantaneous, enter n/a. For multi-family central systems enter the total storage volume.
8. Fuel Type: Gas, Propane, Electric (Only if natural gas is not available)
9. Rated Input Type: Enter the equipment input rating type, for gas or propane fired the units are Btuh, for electric fired system the units are kW.
10. Rated Input Value: Enter the numeric value of the rated input.
11. Heating Efficiency Type: Energy Factor, AFUE, or Thermal Efficiency. From product literature or a California Energy Commission directory.
12. Heating Efficiency Value: Enter the value from product literature or a California Energy Commission directory
13. Standby Loss (%): Applies only to large storage water heaters; enter n/a for small storage or instantaneous water heaters.
14. Exterior Insulation R-Value: Enter the R-value if exterior insulation on the storage tank is installed
15. Back-Up Solar Savings Fraction: If compliance requires a back-up solar system, indicate the solar contribution (e.g., 0.30). External calculations are required.

P. Installed Water Heater Manufacturer Information

This table reports the manufacturer information of the installed water heater(s). Require one line for each installed water heater.

1. Water Heating System ID or Name: Name of the Water Heating System or any other identifying name.
2. Manufacturer: Provide the manufacturer's name which identifies the water heater being installed.
3. Model Number: Provide the model number which identifies the water heater being installed.

~~**Q. Installed Kitchen Lighting Compliance**~~

1. ~~Dwelling Unit Name: Name of dwelling unit or any other identifying name.~~
2. ~~Kitchen Lighting Compliance Method: Indicate the compliance method used from the following list:~~
    a. ~~Method A: Only high efficacy luminaires have been installed in the kitchen.~~
    b. ~~Method B: At least 50% of installed watts are from permanently installed high efficacy lighting.~~
    c. ~~Method C: Installation qualifies for additional low efficacy lighting allotment.~~
    d. ~~N/A: No kitchen lighting installed.~~
3. ~~Total High Efficacy (Method B): If using compliance method b, indicate the total watts of high efficacy lighting installed.~~
4. ~~Total Low Efficacy (Method B): If using compliance method b, indicate the total watts of low efficacy lighting installed.~~

~~5. Total Additional Low Efficacy (Method C): If using compliance method c, indicate the total low efficacy watts allowed.~~

~~R~~Q. Pool and Spa System Type

1. Pool and Spa System: Pick from: Pool only, Spa only, or Pool and Spa.

~~S~~R. Pool and Spa Systems and Equipment Requirements

Before any pool or spa heating system or equipment may be installed, the manufacturer must certify to the Energy Commission that the system or equipment complies with §110.4 and §110.5. The requirements include minimum heating efficiency according to Appliance Efficiency Regulations, an on-off switch outside the heater, permanent and weatherproof operating instructions, no continuous pilot light, and no electric resistance heating.

~~T~~S. Pool and Spa System Installation Requirements

A time switch or similar control mechanism must be installed as part of the pool water circulation control system that will allow all pumps to be set or programmed to run only during the off-peak electric demand period and for the minimum time necessary to maintain the water in the condition required by applicable public health standards.

~~U~~T. Pool and Pump Sizing and Flow Rate Specification

The pool filtration flow rate may not be greater than the rate needed to turn over the pool water volume in 6 hours or 36 gpm, whichever is greater. Calculate Max Flow Rate using the following equation:

$$\text{Max Flow Rate (gpm)} = \frac{\underline{\text{Pool Volume (gallons)}}}{\text{360min.}}$$

Pool piping must be sized according to the maximum flow rate needed for all auxiliary loads. Show work to calculate return and suction line flow rate, minimum filter area, and the maximum pump flow rate correspond to the pool volume in accordance to section 150.0(p), or refer to Table 1 below for the prescriptive values. The maximum velocity allowed is 8 fps in the return line and 6 fps in the suction line, and the maximum pump flow rate is less than 6 hour filtration turnover.

3. Indicate whether or not the alternative calculation is used.
6. Volume of Pool: The Pool volume in gallons (gal).
7. Filter Type: Select from Cartridge, Sand, or DE.
8. Requirements:
   a. Required Min Return Pipe Diameter: The minimum diameter required of the return pipe in inches (in).
   b. Required Min Suction Pipe Diameter: The minimum diameter required of the suction pipe in inches (in).
   c. Required Min Filter Area: The minimum filter area required in square feet (ft^2)
   d. Required Max Pump Flow: The maximum pump flow required in gallons per minute (gpm).
9. Return Pipe Diameter (in): The diameter of the return pipe in inches (in).
10. Suction Pipe Diameter (in): The diameter of the suction pipe in inches (in).
11. Filter Surface Area: The surface area of the filter in square feet (ft^2).
12. Max Pump Flow Rate: The maximum pump flow rate in gallons per minute (gpm).
13. Measured Flow Rate Return Line: The measured flow rate of the return line in feet per second (fps).
14. Measured Flow Rate Suction Line: The measured flow rate of the suction line in feet per second (fps).
15. Compliance Statement: Verify that an alternative compliance calculation or flow test result is provided for this pool or spa use (U. 03 = Yes), and verify whether U. 13 is less than or equal to U. 08, and U.14 is less than or equal to U. 06. Indicate Yes or No. If no, project fails prescriptive compliance.

~~V~~U. Pool System Piping
There must be a length of straight pipe that is greater than or equal to at least 4 inches pipe diameters installed before the pump. Refer to Table 2 below for the required pipe length. Traditional hard 90^o elbows are not allowed. All elbows must be sweep elbows or a type of elbow that has a pressure drop less than the pressure drop of straight pipe with a length of 30 pipe diameters.

~~W~~V. Pool Filters and Valves
Backwash valves must be sized to the diameter of the return pipe or two inches, whichever is greater. Multiport backwash valves have a high pressure drop and are discouraged.

Table 1
Pool sizing (Values are based on a maximum allowable turnover rate of 6- hours)
Note: *For pumps greater than 1 hp. The maximum Pump Flow is the lowest speed default filtration*

Max Pool Volume (gallons)	Min Pipe D or Greater (inches)		Min Filter Area or more (square feet)			Max Pump Flow (gpm)
	Return	Suction	Cartridge	Sand	DE	
13,000	1.5	1.5	100	2.4	20	36
17,000	1.5	2	130	3.1	25	47
21,000	2	2	160	3.9	30	58
28,000	2	2.5	210	5.2	40	78
42,000	2.5	3	320	7.8	60	117
48,000	3	3	360	8.9	70	133

Table 2
Pipe Diameter/Pipe Length

Pipe Diameter (inch)	Required Pipe Length leading into pump (inch)
1.5	6
2	8
2.5	10
3	12

Documentation Declaration Statements
1. The person who prepared the CF2R will sign and complete the fields for their name, company (if applicable), address, phone number, certification information (if applicable), date and signature.
2. The person who is assuming responsibility for the project being built to comply with Title 24, Part 6, will complete the fields for their name, company (if applicable), address, phone number, license number (if applicable), date and signature.

References

1. Water Heaters:

Section 150.1(c) allows a limited number of conditions for water heating. If conditions other than these are proposed, the prescriptive compliance approach cannot be used:

Single Dwelling Unit

A. A single gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank, and that meets the requirements of Sections 110.1 and 110.3.

B. A single gas or propane storage type water heater with an input of 105,000 Btu per hour or less, rated volume less than or equal to 55 gallons and that meets the requirements of Sections 110.1 and 110.3. The dwelling unit shall meet all of the requirements for Quality Insulation Installation (QII) as specified in the Reference Appendix RA3.5.

C. A single gas or propane storage type water heater with an input of 105,000 Btu per hour or less, rate volume of more than 55 gallons, and that meets the requirements of Sections 110.1 and 110.3.

Central System

D. All water heaters installed mustcomply with Sections 110.1 and 110.3. The distribution system shall be equipped with a demand recirculation control allowing pump operation to be based on measurement of hot water demand and hot water return temperature. The system shall have at least two loops. Buildings with 8 or less units do not have to comply with the demand recirculation requirement.

~~150.1(c)8A one gas or propane storage water heater, up to 75,000 Btu/hour input (typically 50 gallons or less), with either no recirculating system or a demand recirculation system with manual controls. If the Energy Factor is less than or equal to the federal minimum, it must have an R-12 external wrap. See D. below.~~

~~150.1(c)8B one gas or propane instantaneous (tankless) water heater with an input of 200,000 Btu/hour or less, no storage tank, and either no recirculating system, or a demand recirculation system with manual controls. .~~

~~150.1(c)8C a central water-heating system that includes the following components (1) gas or propane water heaters, boilers or other water heating equipment, (2) a water heating recirculation loop that meets the requirements of Section 110.3(c)2 and Section 110.3(c)5 equipped with automatic controls for the recirculation pump based on measurement of hot water demand and hot water return temperature, and if more than 8 dwelling units, two recirculation loops each serving half of the building; (3) a solar water-heating system with a minimum solar savings fraction of 0.20 in climate zones 1 through 9 or a minimum solar savings fraction of 0.35 in climate zones 10 through 16 (installation criteria is in Reference Residential Appendix RA4).~~

~~150.1(c)8D if natural gas is not available, an electric-resistance storage, or instantaneous water heater with additional criteria that it be located inside the conditioned space, has no recirculation pumps, and has a solar water-heating system with a minimum solar savings fraction of 0.50 (installation criteria is in Reference Residential Appendix RA4)~~

CERTIFICATE OF INSTALLATION		CF2R-ALT-05-E
Prescriptive Residential Alterations That Do Not Require HERS Field Verification		(Page 1 of 15)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

This compliance document is only applicable to simple alterations that do not require HERS verification for compliance. -When HERS verification is required, a CF1R-ALT-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-ALT-05 and CF2R- ALT-05 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-ALT-02 must be completed and registered with a HERS Provider Data Registry.

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-ALT-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 (ft^2) (Addition):	
11	Building Type:		12	Slab Area (ft^2):	
13	Project Scope:		14	Exceptions to Minimum Aged Solar Reflectance and Minimum Thermal Emittance or SRI::	

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Insulation

The altered components shall comply with all applicable requirements in The Energy Efficiency Standards Sections 110.7, 110.8, 150.0; 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 exhilaration.

B. Roof/Ceiling Insulation

01	02	03	04	05	06	07	08	09	10
I.D.	Manufacturer & Brand	Framing Material	Framing Size & Spacing	Insulation Type	ESR Number	Cavity Insulation R-value	Insulation Depth (inches)	Above Deck Insulation R-value	Below Deck Insulation R-value

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. Wall Insulation

01	02	03	04	05	06	07	08	09	10
I.D.	Manufacturer & Brand	Framing Material	Framing Size & Spacing	Insulation Type	ESR Number	Cavity Insulation R-value	Insulation Depth (inches)	Exterior Wall Insulation R-value	Interior Wall Insulation R-value

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D. Mass Insulation

01	02	03	04	05	06	07	08
I.D.	Manufacturer & Brand	Location	Mass Thickness (inches)	Furring Strip Type/ Depth (inches)	Insulation Type	Exterior Insulation R-value	Interior Insulation R-value

E. Raised Floor Insulation

01	02	03	04	05	06	07	08	09	10
I.D.	Manufacturer & Brand	Framing Material	Framing Size & Spacing	Insulation Type	ESR Number	Cavity Insulation R-value	Insulation Depth (inches)	Exterior Floor Insulation R-value	Interior Floor Insulation R-value

F. Slab Floor/Perimeter Insulation

01	02	03	04	05	06	07	08
I.D.	Manufacturer & Brand	Floor Type	Insulation Type	Insulation Depth (inches)	Insulation R-Value	Vertical Insulation Length (inches)	Horizontal Insulation Length (feet)

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Roofing and Radiant Barrier

G. Radiant Barrier		
01	Brand Name and product number	
02	Installation Type	
03	Total Attic Area (ft^2)	

H. Required Vent Area		
01	Combined NFA of installed upper and lower vents (in^2)	
02	Minimum required combined NFA of upper and lower vents (in^2)	
03	NFA of installed upper vents (in^2)	
04	Minimum required NFA of upper vents (in^2)	

I. Roofing Products (Cool Roof) Installation Information

01	02	03	04	05	06	07	08
Roof Pitch	CRRC Product ID Number	Product Type	CRRC Listed Aged Solar Reflectance	Initial Solar Reflectance	Aged Solar Reflectance	Thermal Emittance	SRI

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Dwelling Address:	City:	Zip Code:

J. Radiant Barrier and Attic Ventilation – Additional Requirements	
Radiant Barrier	
01	Radiant barrier must be installed on all vertical surfaces in the attic including gable ends.
02	The emittance of the radiant barrier shall be less than or equal to 0.05 as tested with ASTM C1371, or E408.
03	The product shall meet all requirements for California certified insulation materials [radiant barriers] of the Department of Consumer Affairs, Bureau of Home Furnishings and Thermal Insulation, as specified by CCR, Title 24, Part 12, Chapter 12-13, Standards for Insulating Material
04	When determining the Total Attic Area, the area over unconditioned spaces such as the garage is included when the attic spaces are connected.
Lower Vents	
05	Lower vents are within one foot of the eave.
Upper Vents	
06	Upper vents are within three feet of the ridge
Vent Area	
07	The NFA of upper vents must be within required NFA range of upper vents Note: per Exception to R806.2 of the CBC Title 24, Part2, Vol.2.5, if the net free ventilating area is less than 1:150, then the upper ventilation must be at least 40% and no more than 50%. Part 2 contains additional requirements that must be met if the area is less than 1:150.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

K. Roofing Products (Cool Roof) – Additional Requirements	
01	Any roof area covered by building integrated photovoltaic panels and solar thermal panels are exempt from the above Cool Roof requirements.
02	Liquid field applied coatings must comply with installation criteria from section 110.8(i)4.
03	Mass roof 25 lb ft^2 or greater: Mass roofs are not required to have a cool roof even if the climate zone specifies minimum performance requirements.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

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Fenestration

L. Fenestration/Glazing

Includes all Windows, Skylights, Greenhouse/Bay Windows, and Glazed Doors

01	02	03	04	05	06	07	08	09	10	11
Tag/ID	Manufacturer/ Brand	Fenestration Area (ft^2)	Orientation	Chromogenic	U-factor	SHGC	Source of U-factor and SHGC	Fenestration Type	Exterior Shading Devices (Describe)	Comments/Special Features

M. Fenestration/Glazing – Additional Requirements

01	For existing buildings the U-factor and SHGC values should be the same or better than the required Energy Commission prescriptive requirements.
02	Temporary labels should not be removed until verified by the building inspector.
03	The fenestration product manufacturer's installation specifications shall be followed when installing these products. The space between the fenestration product and rough opening shall be completely filled with insulation. If batt insulation is used, it is cut to size and placed properly around the fenestration product.

The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.

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Mechanical and Plumbing

N. Space Conditioning (SC) Systems – Heating/Cooling(Section 150.2(b))

Alterations to Space Conditioning Systems shall be exempt from HERS verification requirements as prerequisite for use of the CF1R-ALT-05 and CF2R- ALT-05 Compliance Documents. If new space conditioning systems are installed or existing systems are altered and are not exempt from HERS verification, then a CF1R-ALT-01 shall be completed and registered with a HERS Provider Data Registry. In each row below for each dwelling unit in the building, check the box that indicates the exemption from HERS verification compliance:

☐ a: space conditioning system was not altered;
☐ b: less than 40 ft of ducts were added or replaced;
☐ c: (exempt from duct leakage testing) if: the existing duct system was insulated with asbestos;
☐ d: (exempt from duct leakage testing) if: the existing duct system was previously tested and passed by a HERS Rater.

01	02	03	04
Dwelling Unit Name	SC System Identification or Name	SC System Location or Area Served	Exemption from HERS Verification
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d
			☐ a ☐ b ☐ c ☐ d

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Dwelling Address:	City:	Zip Code:

O. Installed Water Heating System (Section 150.2(b)1G)

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Dwelling Unit Name	Water Heating System Identification or Name	Water Heating System Location or Area Served	Water Heating System Type	Water Heater Type	# of Water Heaters in System	Water Heater Storage Volume (gal)	Fuel Type	Rated Input Type	Rated Input Value	Heating Efficiency Type	Heating Efficiency Value	Standby Loss (%)	Exterior Insul. R-Value	Back-Up Solar Savings Fraction

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Dwelling Address:	City:	Zip Code:

P. Installed Water Heater Manufacturer Information

01	02	03
Water Heating System ID or Name	Manufacturer	Model Number

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Dwelling Address:	City:	Zip Code:

Lighting

General Lighting Requirements
Additional new lighting, and altered lighting, shall comply with all applicable requirements specified in Section 150.0(k).

~~**Kitchen Lighting Requirements**~~
~~150.0(k)1C: The wattage of permanently installed luminaires should be determined as specified in Section 130.0(c).~~
~~150.0(k)1C: In the kitchen, Any electrical boxes finished with a blank cover count as 180 watts of low efficacy lighting.~~
~~Compliance demonstrated using Method (a) because only high efficacy luminaires have been installed in the kitchen.~~ ~~Compliance demonstrated using Method (b). At least 50% of the installed watts from permanently installed high efficacy. Total A ≥ Total B in Installed Wattage Calculation Table (below)~~ ~~Compliance demonstrated with additional low efficacy wattage allowance of EXCEPTION to 150(k)3~~
~~EXCEPTION to 150.0(k)3: Additional low efficacy watts may be allowed when all luminaires in the kitchen are controlled by a vacancy sensor or dimmers, and~~ ~~1. See 150.0(k)2A where high efficacy and low efficacy luminaires must be separately controlled.~~ ~~2. See 150.0(k)2G where EMCS may be used as a dimmer; Section 150.0(k)2H where EMCS may be used as a vacancy sensor; or, 150.0(k)2I where multi-scene programmable controller may be used as a dimmer.~~ ~~NOTES: Compliance demonstrated using Method (c). Kitchen lighting qualifies for additional low efficacy lighting and as demonstrated in Installed Wattage Calculation Table in Method (b) (above) in addition to Additional Low Efficacy Wattage Calculation Table (below).~~
~~**The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.**~~

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~~**Q. Installed Kitchen Lighting Compliance**~~

~~In each row below for each dwelling unit in the building, check the box that indicates the method of compliance. If required by the enforcement agency, provide a Kitchen Lighting Requirements Worksheet for each kitchen in the dwelling unit that complies using method b or c.~~

~~☐ Method A: Compliance demonstrated using Method (a) - only high efficacy luminaires have been installed in the kitchen.~~
~~☐ Method B: At least 50% of installed watts are from permanently installed high efficacy lighting~~
~~☐ Method C: Installation qualifies for additional low efficacy lighting allotment~~
~~☐ N/A: No kitchen lighting is installed~~

~~01~~	~~02~~	~~03~~	~~04~~	~~05~~
~~Dwelling Unit Name~~	~~Kitchen Lighting Compliance Method~~	~~Total High Efficacy (Method B)~~	~~Total Low Efficacy (Method B)~~	~~Total Additional Low Efficacy (Method C)~~
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			
	~~☐ a ☐ b ☐ c ☐ N/A~~			

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Prescriptive Residential Alterations That Do Not Require HERS Field Verification		(Page 12 of 15)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

~~Kitchen Lighting Requirements Worksheet~~

~~Dwelling Unit Name:___________________~~

~~This Table is applicable only if Kitchen Lighting using Method (b) or (c) is selected in Table Q~~

~~Method (b) Total Wattage Calculation~~								
	~~Luminaire (Fixture)~~					~~Total Watts~~		
~~Luminaire Type~~	~~High Efficacy Watts~~	~~Low Efficacy Watts~~		~~Quantity~~		~~High Efficacy~~		~~Low Efficacy~~
			~~x~~		~~=~~			
			~~x~~		~~=~~			
			~~x~~		~~=~~			
			~~x~~		~~=~~			
			~~x~~		~~=~~			
			~~x~~		~~=~~			
	~~Complies with method (b) if Total A ≥ Total B~~							
						~~A~~	~~≥~~	~~B~~

~~Method (c) Total Additional Low Efficacy Wattage Calculation (see footnote)~~			
~~Watts from Method (b)~~		~~Additional Watts Low Efficacy~~	
~~High Efficacy~~	~~Low Efficacy~~		~~Total Low Efficacy Watts Allowed~~
~~1. Insert 50 if house is ≤ 2.500 square feet; Insert 100 if house is > 2,500 square feet.~~			

CERTIFICATE OF INSTALLATION		CF2R-ALT-05-E
Prescriptive Residential Alterations That Do Not Require HERS Field Verification		(Page 13 of 15)
Project Name:	Enforcement Agency:	Permit Number:
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Pool and Spa

~~R~~Q. Pool and Spa Type		
01	Pool and Spa System Type	

~~S~~R. **Pool and Spa Systems and Equipment Requirements** (Section 110.4(a) and 110.5)	
01	Heater has a thermal efficiency that complies with the Appliance Efficiency Regulations.
02	A readily accessible on-off switch is mounted on the outside of the heater, which allows the heater to be shut off without the user adjusting the thermostat setting.
03	A weatherproof plate or card containing instructions for the energy-efficient operation of the pool or spa heater is permanently mounted.
04	No electric resistance heating except for listed package units that have fully insulated enclosures and tight fitting covers that are insulated to at least R-6. Or if documentation is provided that at least 60 % of the annual heating energy is from site solar energy or recovered energy.
05	Heating system has no pilot light.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

~~T~~S. **Pool and Spa System Installation Requirements** (Section 110.4(b))	
01	To allow for the future addition of solar heating equipment, at least 36" of pipe is installed between the filter and heater, or dedicated suction and return lines are installed, or built-in or built-up connections for future solar heating are provided.
02	A cover is provided for outdoor pools or spas that have a heat pump or gas heater.
03	Pool system has directional inlets to adequately mix the pool water
04	Pool system has a time switch that allows the pump to be set or programmed to run during off-peak periods only
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

CERTIFICATE OF INSTALLATION		CF2R-ALT-05-E
Prescriptive Residential Alterations That Do Not Require HERS Field Verification		(Page 14 of 15)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

~~U~~T. **Pool Pump Sizing and Flow Rate Specification** (Section 150.0(p))			
01	The pool pump specified is listed in the CEC database of certified pool pumps.		
02	The pool pump flow rate shall not exceed the maximum pump flow rate calculated based on pool sizing in the table below. The return pipe diameter, suction pipe diameter, and filter area shall be at least as large as the required minimums shown in the table. Alternatively, a flow calculation or flow test result shall be provided to demonstrate that the pump flow rate is less than 6 hour filtration turnover, and the return pipe flow rate does not exceed 8 feet per second and that the suction pipe flow rate does not exceed 6 feet per second.		
03	An alternative compliance calculation or a flow test result is provided for this pool or spa use (must attach flow calculation or flow test result to this form)		
04	The pump is capable of operating at 2 or more speeds (not applicable if pump is less than 1 horsepower).		
05	Each auxiliary pool load is served by either a separate pump, or the system is served by a multi-speed pump.		
06	Volume of Pool (Gallons):		
07	Filter Type (Cartridge, Sand, DE):		
08a Required Min Return Pipe Diameter (inches)	08b Required Min Suction Pipe Diameter (inches)	08c Required Min Filter Area (ft^2)	08d Required Max Pump Flow (gpm)
09	Return Pipe Diameter (inches).		
10	Suction Pipe Diameter (inches).		
11	Filter Surface Area (ft^2).		
12	Max Pump Flow Rate (gallons per minute).		
13	Measured Flow Rate Return Line (feet per second)		
14	Measured Flow Rate Suction Line (feet per second)		
15	Compliance Statement	U. 03 = Yes, U. 13 ≤ U. 08, and U. 14 ≤ U. 06	☐ Yes ☐ No
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.			

~~V~~U. **Pool System Piping** (Section 150.0(p)2)	
01	The suction side pipe is straight for at least 4 pipe diameters before entering the pump (See table below for the required straight run lengths for various pipe sizes).
02	All elbows are sweep elbows, or an elbow type that has a pressure drop that is less than the pressure drop of a straight pipe with a length of 30 pipe diameters.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

~~W~~V. **Pool Filters and Valves** (Section 150.0(p)3 and 4)	
01	If a filter is used in a pool intended for public use: The size of the filter is at least the size specified in NSF/ANSI 50.
02	If a backwash valve is used: The diameter of the backwash valve is at least 2 inches, or the diameter of the return pipe, whichever is greater.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

CERTIFICATE OF INSTALLATION		CF2R-ALT-05-E
Prescriptive Residential Alterations That Do Not Require HERS Field Verification		(Page 15 of 15)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

DOCUMENTATION AUTHOR'S DECLARATION STATEMENT	
1. I certify that this Certificate of Installation documentation is accurate and complete.	
Documentation Author Name:	Documentation Author Signature:
Documentation Author Company Name:	Date Signed:
Address:	CEA/HERS Certification Identification (If applicable):
City/State/Zip:	Phone:

RESPONSIBLE PERSON'S DECLARATION STATEMENT

I certify the following under penalty of perjury, under the laws of the State of California:

1. The information provided on this Certificate of Installation is true and correct.
2. I am eligible under Division 3 of the Business and Professions Code in the applicable classification to accept responsibility for the system design, construction, or installation of features, materials, components, or manufactured devices for the scope of work identified on this Certificate of Installation, and attest to the declarations in this statement (responsible builder/installer), otherwise I am an authorized representative of the responsible builder/installer.
3. The constructed or installed features, materials, components or manufactured devices (the installation) identified on this Certificate of Installation conforms to all applicable codes and regulations, and the installation conforms to the requirements given on the plans and specifications approved by the enforcement agency.
4. I reviewed a copy of the Certificate of Compliance approved by the enforcement agency that identifies the specific requirements for the scope of construction or installation identified on this Certificate of Installation, and I have ensured that the requirements that apply to the construction or installation have been met.
5. I will ensure that a registered copy of this Certificate of Installation shall be posted, or made available with the building permit(s) issued for the building, and made available to the enforcement agency for all applicable inspections. I understand that a registered copy of this Certificate of Installation is required to be included with the documentation the builder provides to the building owner at occupancy.

Responsible Builder/Installer Name:	Responsible Builder/Installer Signature:	
Company Name: (Installing Subcontractor or General Contractor or Builder/Owner)	Position With Company (Title):	
Address:	CSLB License:	
City/State/Zip:	Phone	Date Signed:

For assistance or questions regarding the Energy Standards, contact the Energy Hotline at: 1-800-772-3300

CF2R-ALT-05-E User Instructions

NOTE: If more space is needed, print a duplicate page and fill in.

Minimum requirements for prescriptive alteration compliance can be found in Building Energy Efficiency Standards Section 150.2(b)1.

Completing these forms will require that you have the Reference Appendices for the 201~~3~~6 Building Energy Efficiency Standards (P400-2012-005). This document contains the Joint Appendices which are used to determine climate zone. When the term CF2R is used it means the CF2R-ALT-05. Worksheets are identified by their entire name~~ and subsequently by only the worksheet number~~, such as ~~WS-02~~CF1R-ENV-02.

Instructions for sections with column numbers and row letters are given separately.

If any part of the alteration does not comply, prescriptive compliance fails, in which case the performance compliance approach must be used in an attempt to achieve compliance.

A. General Information

1. Project Name: Identifying information, such as owner's name.
2. Date Prepared: Date of document preparation.
3. Project Location: Legal street address of property or other applicable identifying information.
4. Building Front Orientation: Building front orientation expressed in degrees, where North = 0, East = 90, South = 180, and West = 270. Indicate cardinal if it is a subdivision or multi-family project built in multiple orientations. The ~~s~~Standards (~~s~~Section 100.1) include the following additional details for determining orientation:
   - Cardinal covers all orientations (for buildings that will be built in multiple orientations);
   - North is oriented to within 45 degrees of true north, including 45 degrees east of north;
   - East is oriented to within 45 degrees of true east, including 45 degrees south of east;
   - South is oriented to within 45 degrees of true south, including 45 degrees west of south;
   - West is oriented to within 45 degrees of true west, including 45 degrees south of west.
5. CA City: Legal city/town of property.
6. Number of Dwelling Units: 1 for single-family, 1 or more for multifamily.
7. Zip Code: 5-digit zip code for the project location (used to determine climate zone).
8. Fuel Type: Natural Gas, Liquefied Propane Gas, or Electricity.

   NOTE: Prescriptive compliance only allows electricity if existing appliances are electric and natural gas is not available in the building, or if the conditions of Section 150.2(b)1Giic or 150.2(b)1Giid are met.

9. Climate zone: From Joint Appendix JA2.1.1.
10. Total Conditioned Floor Area: Enter the new conditioned floor area in ft^2, as measured from the outside of exterior walls of the dwelling unit or building being altered.
11. Building Type: Single Family (includes duplex), or Multi-Family (a building that shares common walls and common floors or ceilings).
12. Slab Area: Area of the first floor slab (if any) in ft^2.
13. Project Scope: Insulation, Roof Replacement, Fenestration/Glazing, Heating System, Cooling System, Duct System, and/or Water Heating System alteration.
14. Exception to Minimum Aged Solar Reflectance and Minimum Thermal Emittance or SRI: If meeting one of the exceptions. Indicate which exception is, or will be, met.

NOTES: Exceptions and Alternatives for Steep Slope Roofs:

(a) Mass roof 25 lbs/ft^2 or greater (uncommon situation such as sod roof);
(b) Air space 1" from top of roof deck to bottom of roofing;
(c) Roofing product has a profile ratio of rise to width of 1 to 5 for 50 percent or greater of the width of the roofing product;
(d) Ducts already meet Section 150.1(c) insulation and duct leakage requirements;
(e) Roof has R-38 insulation;
(f) Roof has a radiant barrier;
(g) No ducts are installed in the attic; or
(h) R-2 insulation above the roof deck.

NOTES: Exceptions and Alternatives for Low Slope Roofs:

(a) Mass roof 25 lbs/ft^2 or greater (uncommon situation such as sod roof);
(b) No ducts are installed in the attic; or
(c) Roof deck insulation trade off - by installing roof deck insulation, a lower aged solar reflectance is required: R-2 (0.62-0.60), R-4 (0.59-0.55), R-6 (0.54-0.50), R-8 (0.49-0.45), R-12 (0.44-0.40), R-16 (0.39-0.35), R-20 (0.34-0.30), R-24 (0.29-0.25).

B. Roof/Ceiling Insulation

1. I.D.: A label from the plans (e.g., A1.4 or Roof) documenting the location of the installed insulation.
2. Manufacturer & Brand: Indicate the manufacturer and brand of the product being installed.
3. Framing Material: Wood or Metal.
4. Framing Size & Spacing: Indicate the framing size and spacing (e.g., 2x4 @ 16 in O.C.); enter n/a if not applicable.
5. Insulation Type: List the type of insulation used, such as: Batt, Loose Fill, or SPF.
6. ESR Number: If using a non-standard R-value for SPF insulation, complete an ICC Evaluation Service Report and record the ESR number.
7. Cavity Insulation R-value: Indicate the cavity insulation R-value.
8. Insulation Depth: Indicate, in inches, the amount of insulation installed.
9. Above Deck Insulation R-Value: Indicate the R-value of continuous insulation, having no framing penetration, installed above the roof deck.
10. Below Deck Insulation R-Value: Indicate the R-value of the continuous insulation, having no framing penetration, installed below the roof deck.

C. Wall Insulation

1. I.D.: A label from the plans, (e.g., A1.4 or Wall1) documenting the location of the installed insulation.
2. Manufacturer & Brand: Indicate the manufacturer and brand of the product being installed.
3. Framing Material: Wood or Metal.
4. Framing Size & Spacing: Indicate the framing size and spacing (e.g., 2x4 @ 16 in O.C.); enter n/a if not applicable.
5. Insulation Type: List the type of insulation used, such as batt, loose fill, or SPF.
6. ESR Number: If using a non-standard R-value for SPF insulation, complete an ICC Evaluation Service Report and record the ESR number.
7. Cavity Insulation R-value: Indicate the cavity insulation R-value.
8. Insulation Depth: Indicate, in inches, the amount of insulation installed.
9. Exterior Wall Insulation R-Value: Indicate the R-value of the continuous insulation, having no framing penetration, installed on the outside of the wall.
10. Interior Wall Insulation R-Value: Indicate the R-value of the continuous insulation, having no framing penetration, installed on the inside of the wall.

D. Mass Insulation

1. I.D.: A label from the plans (e.g., A1.4 or Wall1) documenting the location of the installed insulation.
2. Manufacturer & Brand: Indicate the manufacturer and brand of the product being installed.
3. Location: Indicate the location of the insulation, such as: Above Grade, Below Grade, Wall, or Roof.
4. Mass Thickness: Indicate the thickness of the mass, in inches, the insulation is applied to.
5. Furring Strip Type/Depth: Indicate the type, and thickness, of furring material installed (e.g., wood/1.0 inch thick).
6. Insulation Type: ~~-~~List the type of insulation used, such as: SPF, EPS, or EPDM.
7. Exterior Insulation R-Value: Indicate the R-value of the continuous insulation, having no framing penetration, installed on the outside of the assembly.
8. Interior Insulation R-Value: Indicate the R-value of the continuous insulation, having no framing penetration, installed on the inside of the assembly.

E. Raised Floor Insulation

1. I.D.: A label from the plans (e.g., A1.4 or Floor1) documenting the location of the installed insulation.
2. Manufacturer & Brand: Indicate the manufacturer and brand of the product being installed.
3. Framing Material: Wood or Metal.
4. Framing Size & Spacing: Indicate the framing size and spacing (e.g., 2x4 @ 16 in O.C.); enter n/a if not applicable.
5. Insulation Type: ~~-~~List the type of insulation used, such as: Batt, Loose Fill, or SPF.
6. ESR Number: If using a non-standard R-value for SPF insulation, complete an ICC Evaluation Service Report and record the ESR number.
7. Cavity Insulation R-value: Indicate the cavity insulation R-value.
8. Insulation Depth: Indicate, in inches, the amount of insulation installed.
9. Exterior Floor Insulation R-Value: Indicate the R-value of the continuous insulation, having no framing penetration, installed on the outside of the floor.
10. Interior Floor Insulation R-Value: Indicate the R-value of the continuous insulation, having no framing penetration, installed on the inside of the floor.

F. Slab Floor/Perimeter Insulation

1. I.D.: A label from the plans (e.g., A1.4 or Slab Floor1) documenting the location of the installed insulation.
2. Manufacturer & Brand: Indicate the manufacturer and brand of the product being installed.
3. Floor Type: Indicate the type of floor the insulation is being applied to, such as: Heated Slab or Slab on Grade.
4. Insulation Type: List the type of insulation used, such as: EPDM, Polyisocyanurate, or Polystyrene.
5. Insulation Depth: Indicate, in inches, the depth of insulation installed. Refer to F02 for additional information.
6. Insulation R-Value: Indicate the insulation R-value being installed vertically and horizontally (if applicable).
7. Vertical Insulation Length: Indicate, in inches, the length of the insulation being installed. Refer to F03 for additional information on installing both vertical and horizontal slab insulation
8. Horizontal Insulation Length: Indicate, in feet, the length of the insulation being installed from the outside edge of the vertical insulation to the center of the slab.

G. Radiant Barrier

1. Brand Name and Product Number: Indicate the brand name and product number of the product used.
2. Installation Type: Indicate the installation type from the following list:
    a. Attached to underside of roof deck
    b. Attached to bottom of truss/rafters
    c. Attached between truss/rafters
    d. Draped over top of truss/rafters

    One of these four installation methods must be used; no other methods are allowed.

3. Total Attic Area (ft^2): Provide the total attic area over conditioned space. -When determining the total attic area, the area over unconditioned spaces such as garage is included when the attic spaces are connected. -At least one square foot of net free venting area is required for each 300 square feet of attic (1:300).

H. Required Vent Area

1. Combined NFA of installed upper and lower vents (in^2): Indicate the total combined NFA of installed upper and lower vents in square inches.
2. Minimum required combined NFA of upper and lower vents (in^2): Total attic area divided by 300 and multiplied by 144.
3. NFA of installed upper vents (in^2): Indicate the total NFA of installed upper vents in square inches.
4. Minimum required NFA of upper vents (in^2): Table H item 1 (combined NFA of installed upper and lower vents) multiplied by 0.3.

I. Roofing Products (Cool Roof) Installation Information

1. Roof Pitch: Indicate whether the roof pitch is ≤2:12 or >2:12
2. CRRC Product ID Number: If a cool roof is installed, obtain the Product ID Number from the Cool Roof Rating Council's (CRRC) product packaging label or rated products directory (http://coolroofs.org/products/results).
3. Product Type: Indicate the product type being used.
4. CRRC Listed Aged Solar Reflectance: ~~-~~State whether the 3-year aged solar reflectance value of the product used is listed on the CRRC product packaging label or rated products directory—Yes or No.
5. Installed Initial Solar Reflectance: Indicate the initial solar reflectance value of the product used; obtained from the CRRC product packaging label or rated products directory.
6. Aged Solar Reflectance: Indicate the aged solar reflectance value of the product used; obtained from the CRRC product packaging label or rated product directory.

   Note: If the 3-year aged value is not available then use the equation in Section 110.8(i)2 of the Energy Standards to calculate the 3-year aged solar reflectance. One can also use the "Calculated Aged Solar Reflectance" from the Solar Reflectance Index (SRI) Calculation Worksheet available at the California Energy Commission's website at: http://energy.ca.gov/title24/2013standards/documents/solar_reflectance/.

7. Thermal Emittance: Indicate the thermal emittance value of the product used; obtained from the CRRC product packaging label or rated products directory. This can be either the initial or aged value.
8. SRI: If applicable, obtain the value of the product used from the CRRC rated products directory, or the "Solar Reflectance Index (SRI) Calculation Worksheet" available at the California Energy Commission's website.

J. Radiant Barrier and Attic Ventilation – Additional Requirements

This section contains additional requirements for Radiant Barriers, Lower Vents, Upper Vents, and Vent Area.

K. Roofing Products (Cool Roof) – Additional Requirements

This section contains additional requirements for Roofing Products. Other exceptions apply for additions and/or alterations.

L. Fenestration/Glazing

1. Tag/ID: The labeling format used in the plans - ensure each unique type is used consistently throughout the plan set (elevations, finish schedules, etc.) to indentify each matching fenestration product, such as: Window-1, Skylight-1 etc. It should also be consistently used on the other forms in the same compliance documentation.
2. Manufacturer/Brand: Provide the manufacturer and brand name which identifies the fenestration product being installed.
3. Fenestration Area (ft^2): Indicate the total installed surface area (ft^2) of the fenestration.
4. Orientation: Indicate the orientation of the same like fenestration. Use different lines if the orientation of the same fenestration varies. Enter:~~-~~ N, S, E, or W.
5. Chromogenic: Is the glazing product chromogenic? Yes or No
6. U-factor: Indicate the specified U-factor of the fenestration product(s) being installed. Do not mix different types on the same line.
7. SHGC: Indicate the specified SHGC of the fenestration product(s) being installed. Do not mix different types on the same line.
8. Source: NFRC, CEC Default, NA6 Alternative. Enter the appropriate temporary label certificate identified as either NFRC, CEC Default or by using the information in NA6. All ~~windows~~ installed must have a label certificate which identifies the ~~window's~~ efficiencies. NFRC rated products have a temporary label that can be looked up in the NFRC product directory (http://search.nfrc.org/search/searchDefault.aspx).
9. Fenestration Type: Provide a description of the window type, for instance, the frame material, coatings, whether it is operable or fixed.
10. Exterior Shading Devices: If exterior shading devices are installed in conjunction with fenestration then indicate the type used (e.g. sunscreens, vertical roller or shades, retractable or drop arm or operable awnings, or roll down blinds or slats); or if an overhang is, or will be installed.
11. Comments/Special Features: Additional information for the field inspector.

M. Fenestration/Glazing – Additional Requirements

This section contains additional requirements for Fenestration/Glazing.

N. Space Conditioning (SC) Systems – Heating/Cooling

Requirements of the standards apply to a heating and cooling system alteration based on the type of alteration and the system type (Section 150.2(b)1). A completely new system will meet all mandatory and prescriptive requirements, which vary by climate zone (based on Section 150.2(b)1C).

NOTE: Computer performance compliance can be used to trade-off any requirements that are not mandatory.

When parts of a system are replaced, it may trigger some of the same requirements that apply to new systems and duct alterations. A Certificate of Compliance for Alterations to Space Conditioning Systems (CF1R-ALT-02) is required for each dwelling unit with a space conditioning system alteration.

1. Dwelling Unit Name: Name of dwelling unit or any other identifying name.
2. SC System Identification or Name: Name of the Space Conditioning (SC) System or any other identifying name.
3. SC System Location or Area Served: Zone, or area, served by the Space Conditioning (SC) System.
4. Exemption from HERS Verification: Section 150.2(b)1E
    a. Space Conditioning (SC) System was not altered.
    b. Duct systems that have been documented to have been previously sealed as confirmed through field verification and diagnostic testing in accordance with procedures in the Reference Residential Appendix RA3.1.
    c. Duct systems with less than 40 linear feet in unconditioned spaces as determined by visual inspection.
    d. Existing duct systems constructed, insulated, or sealed with asbestos.

O. Installed Water Heating System

Water heating compliance for an alteration is described in Section 150.2(b). For a single dwelling a gas or propane water heater, with a storage tank of 60 gallons maximum or instantaneous (tankless), can be used. Dwelling Unit distribution systems are limited to Standard trunk and branch or demand recirculation for gas or propane water heaters. Demand recirculation is not allowed for electric water heaters. If there is no natural gas connected to the building, an electric water heater may be replaced with another electric water heater. ~~-~~However, changing from gas to electric is not allowed unless the conditions of Section 150.2(b)1Giic or 150.2(b)1Giid are met. Multi-family central systems must use certified equipment as defined under Section 110.1 and 110.3.

~~NOTE: If the proposed installation does not meet the requirements allowed specifically for alterations, use form CF1R-NCB-01 to document the water heater alteration.~~

1. Dwelling Unit Name: Name of dwelling unit or any other identifying name.
2. Water Heating System Identification or Name: Name of the Water Heating System or any other identifying name.
3. Water Heating System Location or Area Served: Zone, or area, served by the Water Heating System.
4. Water Heating System Type: Domestic Hot Water (DHW), Hydronic, Combined Hydronic, or Central. DHW is for domestic hot water, hydronic is a water heating system used for space heating only; combined hydronic is when the water heater will provide both space conditioning and domestic hot water.
5. Water Heater Type: For non-central systems only Small Storage or Small Instantaneous are allowed. ~~-~~For central systems pick from Large Storage, Small Storage, Heat Pump, Boiler, Large Instantaneous, Small Instantaneous or Indirect.
6. Number of Water Heaters in System: In single-family and multi-family with water heaters in each dwelling unit the value is 1. For multi-family central systems serving multiple dwelling units enter the total number of water heaters.
7. Water Heater Storage Volume: Tank capacity in gallons. For individual water heaters for a dwelling unit this will be 60 gallons or less. If instantaneous, enter n/a. For multi-family central systems enter the total storage volume.
8. Fuel Type: Gas, Propane, Electric (Only if natural gas is not available, or if the conditions of Section 150.2(b)1Giic or 150.2(b)1Giid are met)

NOTE: The following table lists replacement heat pump water heating systems by climate zone that meet the requirements of 150.2(b)1Giic and/or 150.2(b)1Giid.

Precalculated Replacement Heat Pump Water Heating Systems for Single Dwelling Units

CZ	Energy Factor greater than or equal to
1	2.75
2	2.75
3	2.75
4	2.8
5	2.75
6	2.33
7	2.5
8	2.33
9	2.33
10	2.33
11	2.5
12	2.8
13	2.5
14	2.5
15	2.33
16	EF ≥ 3, plus a solar water heating system with solar saving fraction ≥ 0.4

~~)~~

9. Rated Input Type: Enter the equipment input rating type, for gas or propane fired the units are Btuh, for electric fired system the units are kW.
10. Rated Input Value: Enter the numeric value of the rated input.
11. Heating Efficiency Type: Energy Factor, AFUE, or Thermal Efficiency. From product literature or a California Energy Commission directory.
12. Heating Efficiency Value: Enter the value from product literature or a California Energy Commission directory
13. Standby Loss (%): Applies only to large storage water heaters; enter n/a for small storage or instantaneous water heaters.
14. Exterior Insulation R-Value: Enter the R-value if exterior insulation on the storage tank is installed
15. Back-Up Solar Savings Fraction: If compliance requires a back-up solar system, indicate the solar contribution (e.g., 0.30). External calculations are required.

P. Installed Water Heater Manufacturer Information

This table reports the manufacturer information of the installed water heater(s). Require one line for each installed water heater.

1. Water Heating System ID or Name: Name of the Water Heating System or any other identifying name.
2. Manufacturer: Provide the manufacturer's name which identifies the Water Heater being installed.
3. Model Number: Provide the model number which identifies the Water Heater being installed.

~~Q. Installed Kitchen Lighting Compliance~~

1. ~~Dwelling Unit Name: Name of dwelling unit or any other identifying name.~~
2. ~~Kitchen Lighting Compliance Method: Indicate the compliance method used from the following list:~~
    a. ~~Method A: Only high efficacy luminaires have been installed in the kitchen.~~
    b. ~~Method B: At least 50% of installed watts are from permanently installed high efficacy lighting.~~
    c. ~~Method C: Installation qualifies for additional low efficacy lighting allotment.~~
    d. ~~N/A: No kitchen lighting installed.~~
3. ~~Total High Efficacy (MethodB): If using compliance method b, indicate the total watts of high efficacy lighting installed.~~
4. ~~Total Low Efficacy (Method B): If using compliance method b, indicate the total watts of low efficacy lighting installed.~~
5. ~~Total Additional Low Efficacy (Method C): If using compliance method c, indicate the total low efficacy watts allowed.~~

~~R~~Q. Pool and Spa Type

1. Pool and Spa System: Pick from: Pool only, Spa only, or Pool and Spa.

~~S~~R. Pool and Spa Systems and Equipment Requirements

Before any pool or spa heating system or equipment may be installed, the manufacturer must certify to the Energy Commission that the system or equipment complies with §110.4 and §110.5. The requirements include minimum heating efficiency according to Appliance Efficiency Regulations, an on-off switch outside the heater, permanent and weatherproof operating instructions, no continuous pilot light, and no electric resistance heating.

~~T~~S. Pool and Spa System Installation Requirements

A time switch or similar control mechanism must be installed as part of the pool water circulation control system that will allow all pumps to be set or programmed to run only during the off-peak electric demand period and for the minimum time necessary to maintain the water in the condition required by applicable public health standards.

~~U~~T. Pool and Pump Sizing and Flow Rate Specification

The pool filtration flow rate may not be greater than the rate needed to turn over the pool water volume in 6 hours or 36 gpm, whichever is greater. Calculate Max Flow Rate using the following equation:

$$\text{Max Flow Rate (gpm)} = \frac{\underline{\text{Pool Volume (gallons)}}}{\text{360min.}}$$

Pool piping must be sized according to the maximum flow rate needed for all auxiliary loads. Show work to calculate return and suction line flow rate, minimum filter area, and the maximum pump flow rate correspond to the pool volume in accordance to section 150.0(p), or refer to Table 1 below for the prescriptive values. The maximum velocity allowed is 8 fps in the return line and 6 fps in the suction line, and the maximum pump flow rate is less than 6 hour filtration turnover.

3. Indicate whether or not the alternative calculation is used.
6. Volume of Pool: The Pool volume in gallons (gal).
7. Filter Type: Select from Cartridge, Sand, or DE.

8. Requirements:
   a. Required Min Return Pipe Diameter: The minimum diameter required of the return pipe in inches (in).
   b. Required Min Suction Pipe Diameter: The minimum diameter required of the suction pipe in inches (in).
   c. Required Min Filter Area: The minimum filter area required in square feet (ft^2)
   d. Required Max Pump Flow: The maximum pump flow required in gallons per minute (gpm).
9. Return Pipe Diameter (in): The diameter of the return pipe in inches (in).
10. Suction Pipe Diameter (in): The diameter of the suction pipe in inches (in).
11. Filter Surface Area: The surface area of the filter in square feet (ft^2).
12. Max Pump Flow Rate: The maximum pump flow rate in gallons per minute (gpm).
13. Measured Flow Rate Return Line: The measured flow rate of the return line in feet per second (fps).
14. Measured Flow Rate Suction Line: The measured flow rate of the suction line in feet per second (fps).
15. Compliance Statement: Verify that an alternative compliance calculation or flow test result is provided for this pool or spa use (U. 03 = Yes), and verify whether U. 13 is less than or equal to U. 08, and U. 14 is less than or equal to U. 06. Indicate Yes or No. If no, project fails prescriptive compliance.

~~V~~U. Pool System Piping

There must be a length of straight pipe that is greater than or equal to at least 4 inches pipe diameters installed before the pump. Refer to Table 2 below for the required pipe length. Traditional hard 90° elbows are not allowed. All elbows must be sweep elbows or a type of elbow that has a pressure drop less than the pressure drop of straight pipe with a length of 30 pipe diameters.

~~W~~V. Pool Filters and Valves

Backwash valves must be sized to the diameter of the return pipe or two inches, whichever is greater. Multiport backwash valves have a high pressure drop and are discouraged.

Table 1
Pool sizing (Values are based on a maximum allowable turnover rate of 6- hours)
Note: *For pumps greater than 1 hp. The maximum Pump Flow is the lowest speed default filtration*

Max Pool Volume (gallons)	Min Pipe D or Greater (inches)		Min Filter Area or more (square feet)			Max Pump Flow (gpm)
	Return	Suction	Cartridge	Sand	DE	
13,000	1.5	1.5	100	2.4	20	36
17,000	1.5	2	130	3.1	25	47
21,000	2	2	160	3.9	30	58
28,000	2	2.5	210	5.2	40	78
42,000	2.5	3	320	7.8	60	117
48,000	3	3	360	8.9	70	133

Table 2
Pipe Diameter/Pipe Length

Pipe Diameter (inch)	Required Pipe Length leading into pump (inch)
1.5	6
2	8
2.5	10
3	12

Documentation Declaration Statements

1. The person who prepared the CF2R will sign and complete the fields for their name, company (if applicable), address, phone number, certification information (if applicable), date and signature.
2. The person who is assuming responsibility for the project being built to comply with Title 24, Part 6, will complete the fields for their name, company (if applicable), address, phone number, license number (if applicable), date and signature.

CERTIFICATE OF INSTALLATION		CF2R-ENV-01-E
Fenestration Installation		(Page 1 of 2)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

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. The signer agrees that all applicable Mandatory Measures were met. Temporary labels are not to be removed before verification by the building inspector.

A. Fenestration/Glazing

Includes all Windows, Skylights, Greenhouse/Bay Windows, and Glazed Doors.

Note: If meeting Exception 1 to 150.1(c)3A, Installing ≤ $3ft^2$ glass in door, it is assumed to meet the minimum required U-factor (0.32) & SHGC (0.25).
If meeting Exception 1 to 150.1(c)3A, Installing ≤ $3ft^2$ tubular skylight, it is assumed to meet the minimum required U-factor (0.55) & SHGC (0.30).

01	02	03	04	05	06	07	08	09	10	11	12
Tag/ID	Manufacturer/ Brand	Fenestration Area (ft^2)	Orientation	Chromogenic	U-factor	Source	SHGC	Source	Fenestration Type	Exterior Shading Devices (Describe)	Comments/Special Features

B. Fenestration Installation	
01	For new construction, installed window U-factor and SHGC values should be equal to or less than listed on the CF1R.
02	For existing buildings the U-factor and SHGC values should be the same or better than the required Energy Commission prescriptive requirements.
03	Temporary labels should not be removed until verified by the building inspector.
04	The fenestration product manufacturer's installation specifications shall be followed when installing these products. The space between the fenestration product and rough opening shall be completely filled with insulation. If batt insulation is used, it is cut to size and placed properly around the fenestration product.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

CERTIFICATE OF INSTALLATION		CF2R-ENV-01-E
Fenestration Installation		(Page 2 of 2)
Project Name:	Enforcement Agency:	Permit Number:
Dwelling Address:	City:	Zip Code:

DOCUMENTATION AUTHOR'S DECLARATION STATEMENT	
1. I certify that this Certificate of Installation documentation is accurate and complete.	
Documentation Author Name:	Documentation Author Signature:
Documentation Author Company Name:	Date Signed:
Address:	CEA/HERS Certification Identification (If applicable):
City/State/Zip:	Phone:

RESPONSIBLE PERSON'S DECLARATION STATEMENT

I certify the following under penalty of perjury, under the laws of the State of California:

1. The information provided on this Certificate of Installation is true and correct.
2. I am eligible under Division 3 of the Business and Professions Code in the applicable classification to accept responsibility for the system design, construction, or installation of features, materials, components, or manufactured devices for the scope of work identified on this Certificate of Installation, and attest to the declarations in this statement (responsible builder/installer), otherwise I am an authorized representative of the responsible builder/installer.
3. The constructed or installed features, materials, components or manufactured devices (the installation) identified on this Certificate of Installation conforms to all applicable codes and regulations, and the installation conforms to the requirements given on the plans and specifications approved by the enforcement agency.
4. I reviewed a copy of the Certificate of Compliance approved by the enforcement agency that identifies the specific requirements for the scope of construction or installation identified on this Certificate of Installation, and I have ensured that the requirements that apply to the construction or installation have been met.
5. I will ensure that a registered copy of this Certificate of Installation shall be posted, or made available with the building permit(s) issued for the building, and made available to the enforcement agency for all applicable inspections. I understand that a registered copy of this Certificate of Installation is required to be included with the documentation the builder provides to the building owner at occupancy.

Responsible Builder/Installer Name:	Responsible Builder/Installer Signature:	
Company Name: (Installing Subcontractor or General Contractor or Builder/Owner)	Position With Company (Title):	
Address:	CSLB License:	
City/State/Zip:	Phone:	Date Signed:

CF2R-ENV-01-E User Instructions

Before installation of fenestration, the installer shall verify the fenestration product matches either the CF1R-NCB, or CF1R-ADD, or CF1R-ALT, or CF1R-PRFcertificate form. If the efficiencies are worse (less efficient), then the windows cannot be installed until proof of compliance is shown with an updated certificate form, or computer energy compliance run, documenting the less efficient windows. If the installed fenestration is better (more efficient) than the documentation shows, no updated documentation is required and installation is allowed.

A. Fenestration/Glazing

1. **Tag/ID:** The labeling format used in the plans ensures each unique type is used consistently throughout the plan set (elevations, finish schedules, etc.) to i~~n~~dentify each matching fenestration product, such as: Window-1, Skylight-1 etc. It should also be consistently used on the other forms in the same compliance documentation.
2. **Manufacturer/Brand:** Provide the manufacturer and brand name which identifies the fenestration product being installed.
3. **Fenestration Area (ft^2):** Indicate the total installed surface area (ft^2) of the fenestration.
4. **Orientation:** Indicate the orientation of the same like fenestration. Use different lines if the orientation of the same fenestration varies. Enter N, S, E, or W.
5. **Chromogenic:** Is the glazing product chromogenic? Yes/No
6. **U-factor:** Indicate the specified U-factor of the fenestration product(s) being installed. Do not mix different types on the same line.

   NOTES: (1) For the exceptions - up to 3 ft^2 of tubular skylights and up to 16 ft^2 of skylight area, enter 0.55.
   (2) For the exception – up to 3 ft^2 of glass in door, enter 0.32.

7. **Source**: NFRC, CEC Default, NA6 Alternative, or Area-weighted Average Worksheet (ENV-02). Enter the appropriate temporary label certificate identified as NFRC, CEC Default, NA6, or Area-weighted Average Worksheet (ENV-02). All ~~windows~~ installed must have a label certificate which identifies the ~~window~~'s efficiencies. NFRC rated products have a temporary label that can be looked up in the NFRC product directory (http://search.nfrc.org/search/searchDefault.aspx).
8. **SHGC:** Indicate the specified SHGC that is being installed of the fenestration product(s). Do not mix different types on the same line.

   NOTES: (1) For the exceptions - up to 3 ft^2 of tubular skylights and up to 16 ft^2 of skylight area, enter 0.30.
   (2) For the exception – up to 3 ft^2 of glass in door, enter 0.25.

9. **Source**: NFRC, CEC Default, NA6 Alternative, or Area-weighted Average Worksheet (ENV-02). Enter the appropriate temporary label certificate identified as NFRC, CEC Default, NA6, or Area-weighted Average Worksheet (ENV-02). All ~~windows~~ installed must have a label certificate which identifies the ~~window~~'s efficiencies. NFRC rated products have a temporary label that can be looked up in the NFRC product directory (http://search.nfrc.org/search/searchDefault.aspx).
10. **Fenestration Type**: Provide a description of the ~~window type~~, for instance, the frame material, coatings, whether it is operable or fixed.
11. **Exterior Shading Devices:** If exterior shading devices are installed in conjunction with fenestration then indicate the type used (e.g. sunscreens, vertical roller or shades, retractable or drop arm or operable awnings, or roll down blinds or slats); or if an overhang is, or will be installed.
12. **Comments/Special Features:** Additional information for the field inspector.