



What is an Opaque Envelope?

Opaque envelope assemblies are those that do not transmit light. The 2016 Building Energy Efficiency Standards (Energy Standards) include requirements for nonresidential building envelope components, such as insulation requirements of wood-framed, metal-framed and masonry walls, framed and metal building roofs, and floors.

Why?

Loads from the building envelope are among the most significant loads that affect heating and cooling energy use. Opaque envelope assemblies and their insulation are long-lasting materials that are difficult to retrofit post-construction.

Relevant Code Sections

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

- [Section 110.7](#) – Mandatory Requirements to Limit Air Leakage
- [Section 110.8](#) – Mandatory Requirements for Insulation, Roofing Products and Radiant Barriers
- [Section 120.7](#) – Mandatory Insulation Requirements
- [Section 140.3](#) – Prescriptive Requirements for Building Envelopes
- [Section 141.0\(b\)1](#) – Alterations to Existing Buildings
- [Joint Appendix 4 \(JA4\)](#) – U-factor, C-factor, and Thermal Mass Data

Relevant Compliance Forms

- NRCC-PRF-01-E: Certificate of Compliance – Building Components, Performance
- NRCC-ENV-01-E: Certificate of Compliance – Opaque Envelopes, Prescriptive
- NRCC-ENV-03-E: Certificate of Compliance – SRI Equivalence, Prescriptive Cool Roof
- NRCC-ENV-06-E: Area Weighted Average Calculation Worksheet
- NRCC-CXR-02-E: Design Review Checklist
- NRCC-ENV-01-E: Certification of Installation – Opaque Envelopes

Compliance Requirements

The requirements for nonresidential opaque surfaces include both mandatory measures and Prescriptive requirements.



Mandatory Measures

Insulation – New Construction Section 120.7

All newly constructed nonresidential, high-rise residential, and hotel/motel buildings must meet the minimum insulation requirements in [Section 120.7](#) of the Energy Standards, summarized below in Table 1.

Why?

To improve energy efficiency by reducing heat transfer between the conditioned interior spaces and the outdoors.

Requirements

	Assembly	Max U-factor*
Roof/Ceiling	Metal Building	0.098
	Wood Frame and others	0.075
Walls	Metal Building	0.113
	Metal Framed	0.151
	Light Mass Walls (6" or greater)	0.440
	Heavy Mass Walls (8" or greater)	0.690
	Wood Frame and others	0.110
	Spandrel panels and glass curtain wall	0.280
	Demising walls	0.099-wood / 0.151-metal
Floors	Raised Mass Floors	0.269
	Other floors	0.071
	Heated Slab floors	Section 110.8(g)

*The maximum U-factor applies to the weighted average of the assembly.

Table 1: Mandatory U-factor requirements per [§120.7](#)

Insulation should be installed to limit heat loss and gain between conditioned to unconditioned spaces, and fixed vents or openings to the outdoors or unconditioned spaces should not be installed. Insulation must be installed in direct contact with a continuous roof or finished ceiling. Insulation installed in contact with suspended ceilings with removable ceiling panels should not be considered when determining compliance with insulation requirements.

- An exception has been made if there are conditioned spaces with a combined floor area less than 2000ft² and the space between the suspended ceiling and the roof is greater than 12ft. In this case insulation directly in contact with suspended ceiling tiles complies with the Energy Standard's insulation requirements.

In addition to the requirements shown here in Table 1, [Section 110.8](#) of the Energy Standards includes mandatory requirements for insulation products ([Section 110.8\(a\) through 110.8\(c\)](#)), insulation in existing buildings ([Section 110.8\(d\)](#)), slab-on-grade insulation requirements ([Section 110.8\(g\)](#)), wet insulation systems ([Section 110.8\(h\)](#)), and solar reflectance and thermal emittance ([Section 110.8\(i\)](#)). Radiant barriers, where required, must have a thermal emittance no greater than 0.05 ([Section 110.8\(i\)](#)).

Compliance Documentation

Complete section H on page 3 of [NRCC-ENV-01-E](#).

U-factor? R-value?

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

The R-value is the measure of the [thermal resistance](#) of insulation or any material or building component.

Determining Envelope U-factor

[Joint Appendix 4 \(JA4\)](#) provides data tables which contain effective U-factors for common roof/ceilings, walls, and floor assemblies. U-factors found in these tables can be used only for the Prescriptive approach. CBECC-Com (the California Building Energy Code Compliance modeling software for nonresidential buildings) calculates assembly U-factors for the Performance approach.

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

Insulation – Alterations Section 141.0(b)1

Any altered components of the building envelope must meet the mandatory requirements for insulation per [Section 141.0\(b\)1](#) of the Energy Standards and shown below in Table 2. Designers and builders may choose between meeting the insulation requirements (R-value) or assembly U-factors for compliance.

Why?

To improve energy efficiency by reducing the rate of heat loss and heat gain through building envelope components.

Requirements

	Assembly	Insulation Requirements	Max U-factor*
Roof	Low Sloped	Table 141.0-C**	Table 141.0-C**
	Steep Sloped	Table 141.0-C**	Table 141.0-C**
Walls	Metal Building	R-13	0.113
	Metal Framed	R-13	0.217
	Light Mass Walls	Exempt	Exempt
	Heavy Mass Walls	Exempt	Exempt
	Wood Frame and others	R-11	0.110
	Spandrel panels and glass curtain wall	R-4	0.280
Floors	Raised Framed Floors	R-11	0.071
	Raised Mass (hi-rise res, hotel/motel)	R-6	0.111
	Raised Mass (all other)	None	None

*The maximum U-factor applies to the weighted average of the assembly.

**Exceptions apply. See [Section 141.0\(b\)2Biii](#). [Table 141.0-C](#) applies when roofing is removed to the roof deck, otherwise the insulation requirement is based on [Table 140.3-B, C, or D](#). [Table 141.0-B](#) applies to tradeoffs for aged solar reflectance and U-Factor.

Table 2: Mandatory U-factor requirements for alterations per [Section 141.0](#)

Compliance Documentation

Complete sections A through F on form [NRCC-ENV-01-E](#) for alterations.

Air Sealing Section 110.7

All newly constructed and any altered components of nonresidential, high-rise residential, and hotel/motel buildings must meet the requirements of [Section 110.7](#).

Why?

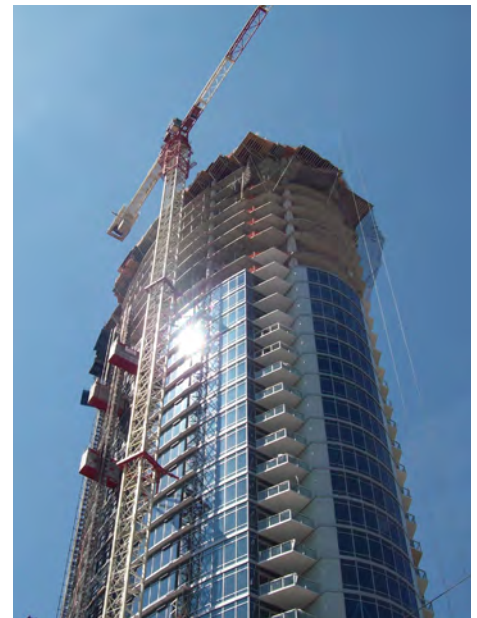
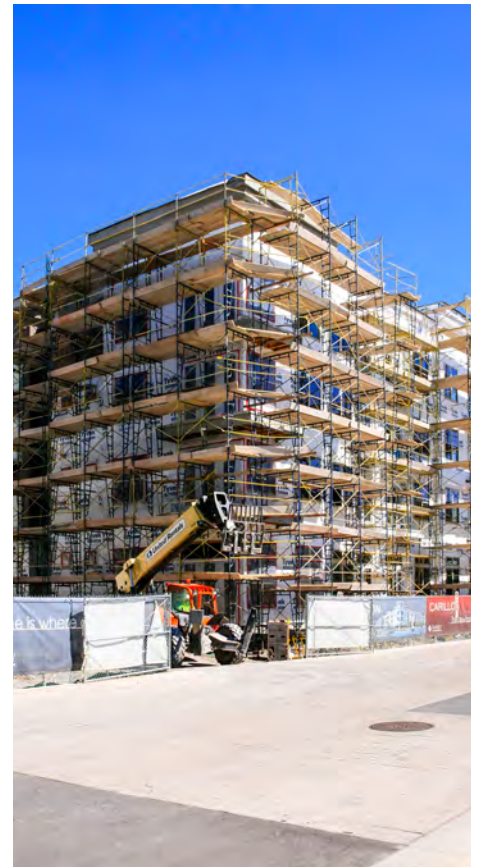
To improve building energy efficiency by limiting air leakage ([infiltration](#) and [exfiltration](#)).

Requirements

All joints, penetrations and other openings in the building envelope that could be potential sources of air leakage must be caulked, gasketed, weather stripped, or otherwise sealed.

Compliance Documentation

Complete section F, page 3 of [NRCC-ENV-01-E](#).



Prescriptive Requirements

Various Components Section 140.3

Building envelopes complying with the Energy Standards prescriptively must meet requirements for various applicable envelope components included in [Section 140.3](#).

Why? To improve energy efficiency by reducing heat loss from conditioned spaces and reducing heat gain to conditioned spaces.

Requirements

Air Barriers

Continuous air barriers are required for nonresidential buildings in climate zones 10-16, for conditioned spaces excluding those in high-rise residential and hotel/ motel spaces.

Air Leakage Rates

There are three options to meet the air barrier requirements:

- Air barrier material must have an air permeance not exceeding 0.004 cfm/ft² (at a pressure differential of 0.3 w.g.) To meet the Prescriptive requirement, the air barrier must be constructed of an approved material (see [Table 140.3-A](#)) and have sealed joints for their entire length of edges
- Assemblies of material and components have an average air leakage not exceeding 0.04 cfm/ft² (at a pressure differential of 0.3 w.g.)
- The entire building will have an air leakage rate not exceeding 0.40 cfm/ft² (at a pressure differential of 0.3 w.g.)

Exterior Doors

All non-swinging doors separating conditioned space from unconditioned space or from ambient shall have a maximum U-factor of 1.45 for climate zones 2-15 or 0.50 in climate zones 1 and 16. All swinging exterior doors shall have a maximum U-factor of 0.70 in all climate zones.

Insulation at Roof and Ceilings, Exterior Walls, and Exterior Floors

Prescriptive requirements for roof, ceiling, wall and floor insulation are covered in the following tables in the Energy Standards:

- [Table 140.3-B](#) Nonresidential buildings
- [Table 140.3-C](#) High-rise residential buildings and hotel/motel
- [Table 140.3-D](#) Public school relocatables

These tables are easy to follow and specify required U-factors, which are calculated based on assembly components (framing, continuous and cavity insulation, etc.). Requirements are dependent upon climate zone, which is how the tables are arranged.

Prescriptive compliance calculations must use assembly values included in Joint Appendix 4 ([JA4](#)). [JA4](#) includes tables that will help determine U-factors based on nominal framing size, type and spacing, cavity insulation R-value and continuous insulation R-value.

Misc. (120.7, 140.3(c))

- An exception has been added so that data center buildings with a design process load greater than 750 kW do not need to comply with mandatory minimum envelope insulation requirements.
- For large spaces above 5000 ft² with high ceilings of 15 ft or greater, a requirement has been added for a minimum skylight area of 3% of the skylit daylight area, to ensure adequate daylight for dimming.

Compliance Documentation

Complete [NRCC-ENV-01-E](#), [NRCC-ENV-02-E](#), and [NRCC-ENV-05-E](#) to document opaque envelope and fenestration thermal performance.

Complete [NRCC-ENV-03-E](#) if SRI is used to demonstrate compliance with Prescriptive cool roof requirements.

Complete [NRCC-ENV-04-E](#) if the building has large floor areas under high ceilings that trigger minimum skylight area requirements.



Performance Compliance Path

Compliance can be achieved using the Performance approach for envelope only, whole building, or in conjunction with indoor lighting or mechanical, as long as these scopes are permitted at the same time. The Performance approach provides the most flexible path to compliance by allowing trade-offs between measures.

If the **envelope only** Performance approach is used, only trade-offs between envelope measures are allowed. Where the **whole building** Performance approach is used, trade-offs can be made amongst the envelope, space conditioning, service water heating, and indoor lighting systems that are included in the permit application.

Compliance Documentation

The [NRCC-PRF-01-E](#) is generated by the nonresidential compliance software.



Forms – Which & When

During Design:

- **NRCC-ENV-01-E: Building Components, Prescriptive**
 - Completed and signed by the designer or installing contractor
 - Submitted to the building department during permit application

Why?: To show compliance with Prescriptive requirements for opaque envelope assemblies

- **NRCC-ENV-03-E: SRI Equivalence, Prescriptive Cool Roof**
 - Completed and signed by the designer or installing contractor
 - Submitted to the building department during permit

Why?: To demonstrate that projects which specify a Solar Reflectance Index (SRI) meet prescriptive Cool Roof requirements.

- **NRCC-ENV-06-E: Area Weighted Average Calculation Worksheet**
 - Completed and signed by the designer, engineer, or installing contractor
 - Submitted to the building department during permit application

Why?: To calculate area-weighted average U-factors when some envelope assemblies do not comply prescriptively on their own in support of the **NRCC-ENV-01-E**.

- **NRCC-PRF-01-E: Building Components, Performance**
 - Completed and signed by the designer, engineer, or installing contractor
 - Submitted to the building department during permit application

Why?: The PRF-01 form is the only form needed to show building components compliance through the Performance path. This form is generated through approved compliance software.

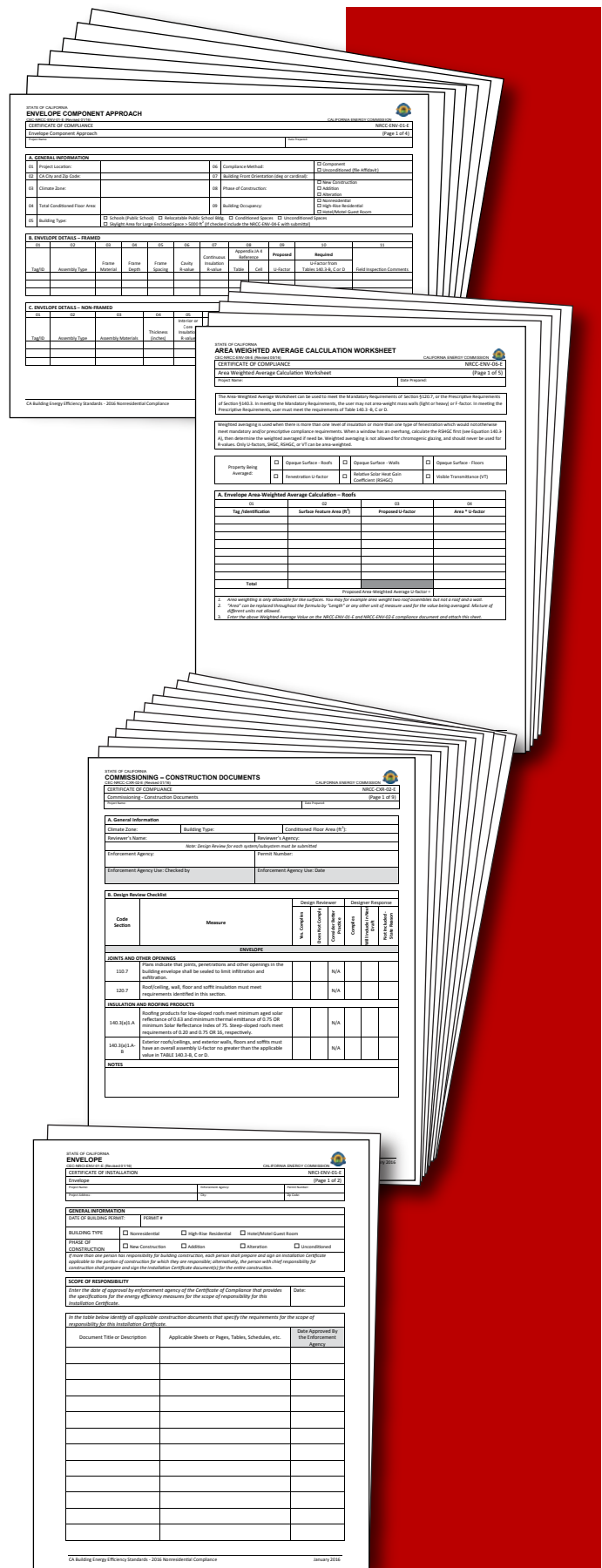
- **NRCC-CXR-02-E: Design Review Checklist**
 - Completed and signed by the design reviewer
 - Submitted to the building department during permit application

Why?: Section 120.8 of the Energy Standards requires a design review to be performed as part of the commissioning process for newly constructed buildings. This form is a checklist used for that design review, and includes two checks related to mandatory air sealing requirements from Section 110.7 and mandatory insulation requirements from Section 120.7 of the Energy Standards.

During Construction:

- **NRCI-ENV-01-E: Certification of Installation – Opaque Envelopes**
 - Completed by the installing contractor.
 - Made available for the Inspector when they are onsite.

Why?: To document the compliant installation of envelope components for inspectors. This form is used for both Prescriptive and Performance compliance methods.



For More Information

Primary Documents

- Energy Standards Section 110.7 – Mandatory Requirements to Limit Air Leakage
EnergyCodeAce.com/site/custom/public/reference-ace-2016/Documents/na78section1107mandatoryrequirementstolimitairleakage.htm
- Energy Standards Section 110.8 – Mandatory Requirements for Insulation, Roofing Products and Radiant Barriers
EnergyCodeAce.com/site/custom/public/reference-ace-2016/Documents/section1108mandatoryrequirementsforinsulationroofingproductsandr.htm
- Energy Standards Section 120.7 – Mandatory Insulation Requirements
EnergyCodeAce.com/site/custom/public/reference-ace-2016/Documents/na88section1207mandatoryinsulationrequirements.htm
- Energy Standards Section 140.3 – Prescriptive Requirements for Building Envelopes
EnergyCodeAce.com/site/custom/public/reference-ace-2016/Documents/na104section1403prescriptiverequirementsforbuildingenvelopes.htm
- Energy Standards Section 141.0(b)1 – Alterations to Existing Buildings
energycodeace.com/site/custom/public/reference-ace-2016/index.html#!Documents/sec1410additionsalterationsrepairoexistingbuildingsthatwillben.htm
- Energy Standards Nonresidential Compliance Manual Chapter 3.3, Envelope Assembly
energy.ca.gov/2015publications/CEC-400-2015-033/chapters/chapter_03_building_envelope.pdf
- Energy Standards Joint Appendix 4 (JA4):
energycodeace.com/site/custom/public/reference-ace-2016/index.html#!Documents/appendixja4ufactorfactorandthermalmassdata.htm
 - Provides data tables which contain effective U-factors for common roof/ceilings, walls, and floor assemblies.

California Energy Commission Information & Services

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

Additional Resources

- Energy Code Ace:
EnergyCodeAce.com
 - An online “one-stop-shop” providing free resources and training to help appliance and building industry professionals decode and comply with Title 24, Part 6 and Title 20. The site is administered by California’s investor-owned utilities.
- Of special interest:* Fact Sheets
(EnergyCodeAce.com/content/resources-fact-sheets) and Trigger Sheets
(EnergyCodeAce.com/content/resources-trigger-sheets):
 - Fenestration:
 - Nonresidential Fenestration Fact Sheet
 - Nonresidential Fenestration Trigger Sheet
 - Nonresidential Daylighting and Daylighting Controls Fact Sheet
 - Roof Reflectance & Emittance:
 - Nonresidential Cool Roofs Fact Sheet

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