2025

MULTIFAMILY COMPLIANCE MANUAL

FOR THE 2025 BUILDING ENERGY EFFICIENCY STANDARDS

ENERGY CONSERVATION MANUAL

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CALIFORNIA ENERGY COMMISSION
Gavin Newsom, Governor

CALIFORNIA ENERGY COMMISSION

California Energy Commission

STAFF REPORT

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California Energy Commission

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The Building Energy Efficiency Standards (Energy Code) were first adopted by the California Energy Commission and put into effect in 1978, and have been updated periodically as directed by statute. The Energy Code is a unique California asset that have placed the state on the forefront of energy efficiency, sustainability, energy independence, and climate change issues. These standards also have provided a template for national standards within the United States, as well as for other countries around the globe. They have benefitted from the conscientious involvement and enduring commitment to the public good of many persons and organizations along the way. The 2025 Energy Code development and adoption process continues a longstanding practice of maintaining the standards with technical rigor, challenging but achievable design and construction practices, public engagement, and full consideration of the views of stakeholders.

The 2025 Energy Code revision and the supporting documents were updated through the work of California Energy Commission (CEC) staff and consultants working under contract to the CEC. Support was provided by the utility-organized Codes and Standards Enhancement (CASE) Initiative. Input was also gained by the participation of stakeholders and the contribution of formal public comments.

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Gas and Electric Company, Southern California Edison, San Diego Gas & Electric, Sacramento Municipal Utility District, and Los Angeles Department of Water and Power.

ABSTRACT

California's Building Energy Efficiency Standards (Energy Code) were adopted by the California Energy Commission in 1976 and have been updated periodically as directed by statute. In 1975, the California Department of Housing and Community Development adopted rudimentary energy conservation standards under State Housing Law authority that were a precursor to the first generation of the standards. However, the Warren-Alquist Act was passed one year earlier with explicit direction to the California Energy Commission (CEC), formally titled the State Energy Resources Conservation and Development Commission, to adopt and implement the standards. The CEC's statute created separate authority and specific direction regarding what the standards are to address, what criteria are to be met in developing the Energy Code, and what implementation tools, aids, and technical assistance are provided.

The standards contain energy and water efficiency requirements (and indoor air quality requirements) for newly constructed buildings, additions to existing buildings, and alterations to existing buildings. Public Resources Code Sections 25402 subdivisions (a)-(b) and 25402.1 emphasize the importance of building design and construction flexibility by requiring the CEC to establish performance standards, in the form of an "energy budget" by building type in terms of the energy consumption per square foot of floor space. Public Resources Code Section 25402.1 requires the CEC to support the Energy Code with compliance tools for builders and building designers. The Compliance Manuals provide information supplemental to the Energy Code regulations. The manuals are intended to help plans examiners, inspectors, owners, designers, builders, and energy consultants comply with and enforce California's Building Energy Efficiency Standards.

Keywords:

California Energy Commission; mandatory; envelope insulation; California Building Code; prescriptive; HVAC; California Building Energy Efficiency Standards; performance; building commissioning; process load; Title 24, Part 6; valuation; refrigeration; 2025 Building Energy Efficiency Standards; data center; ducts in conditioned spaces; exhaust; Residential; high-performance attics; compressed air; Nonresidential; high-performance walls; acceptance testing; newly constructed; high-efficacy lighting; data collection; additions and alterations to existing buildings; water heating; cool roof; windows; on-site renewable; 2025 Energy Code; indoor air quality; field verification and diagnostic testing; swimming pool; photovoltaic; PV; battery; solar ready; electric-ready

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INTRODUCTION

Organization and Content

The 2025 Multifamily Compliance Manual is designed to help building owners, architects, engineers, designers, energy consultants, builders, enforcement agencies, contractors and installers, and manufacturers comply with and enforce the California Building Energy Efficiency Standards (Energy Code) for multifamily buildings. The manual is a reference and instructional guide for anyone involved in the design and construction of energy-efficient multifamily buildings.

Nine chapters make up the manual:

- Chapter 1 Introduction, Scope, and General Information
- Chapter 2 Compliance and Enforcement
- Chapter 3 Building Envelope
- Chapter 4 HVAC
- Chapter 5 Water Heating
- Chapter 6 Electrical and Lighting Systems
- Chapter 7 Solar Photovoltaic, Battery Energy Storage Systems, and Solar Readiness
- Chapter 8 Pool and Spa
- Chapter 9 Covered Process and Enclosed Parking Garage

This chapter uses a "code and commentary" style, which shows adopted Title 24, Part 6 code language followed by commentary that provides guidance on the corresponding code section, but that is not adopted code requirements. Table 1-1: Formatting Used in This Chapter to Differentiate Adopted Title 24, Part 6 Code Language From Commentary Provided for Guidance illustrates the formatting that has been used to differentiate between the adopted Title 24, Part 6 code language and the commentary guidance.

Table 1-1: Formatting Used in This Chapter to Differentiate Adopted Title 24, Part 6 Code Language From Commentary Provided for Guidance

Identifier	Example
Part 6 Code Language	3. **New construction in existing buildings (additions, alterations and repairs).** C. **Multifamily buildings.** Section 180.0 applies to new construction in existing multifamily buildings. New construction in existing buildings includes additions, alterations and repairs. Section 180.0 specifies requirements that uniquely apply to additions, alterations or repairs to existing buildings, and specifies which requirements in other sections also apply. For alterations that change the occupancy classification of the building, the requirements specified in Section 180.0 apply to the occupancy after the alterations.
Commentary Guidance	**«» Commentary for Section 100.0(e)3C:** An addition is any change to a building that increases floor area and conditioned volume. Additions involve the: Construction of new conditioned space and conditioned volume. Installation of space conditioning in a previously unconditioned space. Addition of unconditioned space. «Section 100.1»

Source: California Energy Commission

Related Documents

This compliance manual supplements several other documents from the California Energy Commission:

- *2025 California Administrative Code,* Title 24, Part 1. This manual explains and supplements the administrative requirements in Title 1 of the California Administrative Code. This manual does not replace or supersede the California Administrative code.
- *2025 Building Energy Efficiency Standards,* Title 24, Part 6 (Energy Code). This manual explains and supplements the Energy Code, the legal requirements for all covered buildings. This manual explains those requirements in simpler terms but does not replace or supersede the Energy Code. Readers should have a copy of the Energy Code as reference.
- 2025 Reference Appendices. Joint Appendices (JA) contain information common to residential and nonresidential buildings. Residential Appendices (RA) contain

information for residential buildings only. Nonresidential (NA) Appendices contain information for nonresidential buildings only.

- 2025 Alternative Calculation Method (ACM) Reference Manuals. The 2025 Single-Family ACM Reference Manual provides rules and specifications for single-family compliance software. The 2025 Nonresidential and Multifamily ACM Reference Manual provides rules and specifications for nonresidential and multifamily compliance software.
- The *2025 Single-Family Residential Compliance Manual* and *2025 Nonresidential Compliance Manual.* The 2025 Compliance Manuals provide information for stakeholders that are complying with or enforcing the Energy Code. The *2025 Single-Family Residential Compliance Manual* provides information for single-family building requirements. The *2025 Nonresidential Compliance Manual* provides information for nonresidential building requirements.

Material from these documents is not always repeated in this manual.

Why California Needs the Energy Code

Electricity Reliability and Demand

Buildings are a major contributor to electricity demand. The 2000 to 2001 California energy crisis and the East Coast blackout in the summer of 2003 illustrated the fragility of the electric distribution network. System overloads caused by excessive demand from buildings create unstable conditions. Blackouts disrupt business and cost the economy billions of dollars.

Since the California electricity crisis, the CEC has placed more emphasis on demand reduction.

Comfort

Comfort is an important benefit of energy-efficient buildings. Energy-efficient buildings include high-performance windows to reduce solar gains and heat loss, and properly designed HVAC systems, which improve air circulation. Poorly designed building envelopes result in buildings that are less comfortable. Oversized heating and cooling systems do not ensure comfort in older, poorly insulated, or leaky buildings.

Economics

Energy efficiency helps create a more profitable operation for building owners. More broadly, the less that California depends on depletable resources such as natural gas, coal, and oil, the stronger and more stable the economy will remain as energy costs increase. Investing in energy efficiency benefits everyone. It is more cost-effective to invest in saving energy than build new power plants.

Environment

The use of depletable energy has led to oil spills, acid rain, smog, and other forms of environmental pollution that threaten the natural beauty of the planet. California is not immune to these problems, but the Appliance Efficiency Regulations, the Energy Code, and utility programs that promote efficiency and conservation help maintain environmental quality. Other benefits include increased preservation of natural habitats, which protects animals, plants, and ecosystems.

Greenhouse Gas Emissions and Global Warming

Burning fossil fuel adds carbon dioxide (CO_2) to the atmosphere, a major contributor to global warming. Carbon dioxide and other greenhouse gases create an insulating layer that leads to global climate change. The CEC's research shows that most sectors of California economy face significant risk from climate change, including water resources (from reduced snowpack), agriculture, forests, and the natural habitats of indigenous plants and animals.

Energy efficiency is a far-reaching strategy to reducing greenhouse gases. The National Academy of Sciences has urged the United States to follow California's lead on such efforts, saying that conservation and efficiency should be the chief elements in energy and global warming policy. Its first efficiency recommendation was to adopt nationwide energy efficiency building codes.

The Energy Code is expected to significantly reduce greenhouse gas and other air emissions.

Building Decarbonization

California has nearly 14 million homes and 7.5 million square feet of commercial buildings. These buildings produce a quarter of the state's greenhouse gas (GHG) emissions, making homes and businesses a major factor in climate change. Reducing these emissions, also referred to as building decarbonization, is a key part of California's climate strategy. Of the many tools in the state's building decarbonization toolbox, the decarbonizing co-benefits of the California Energy Code stand out as a proven solution of significance.

Chapter 1 Introduction

This chapter covers general requirements for dwelling units and common use areas in multifamily buildings. The requirements cover newly constructed buildings and additions or alterations to existing buildings. Multifamily buildings include:

- A building of Occupancy Group R-2, other than a hotel/motel building or timeshare property.
- A building of Occupancy Group R-3 that is a non-transient congregate residence, other than boarding houses of more than six guests and alcohol or drug abuse recovery homes of more than six guests.
- A building of Occupancy Group R-4.

Single-family homes, duplexes and all townhouses (regardless of number of habitable stories) are subject to the single-family requirements and covered in the 2025 Single-family Residential Compliance Manual.

Occupancy groups are defined in Chapter 3 of the California Building Code (Title 24, Part 2, Volume I). Any buildings of occupancy group R that are not identified under the single-family or multifamily definitions above are considered hotel/motel buildings, covered in the Nonresidential Compliance Manual.

Spaces in multifamily buildings include both dwelling units and common use areas. Dwelling unit requirements apply to living, sleeping, eating, cooking, and sanitation spaces within a single unit. A single dwelling unit may include shared living spaces with multiple sleeping rooms, such as in a dormitory. Common use area requirements apply to spaces outside the dwelling unit that are shared by building owners, residents, and their guests. Spaces used by building managers and maintenance staff qualify as common use areas.

Guidance on administrative requirements is included in the Multifamily Compliance Manual Chapter 2: Compliance and Enforcement. Guidance on building system requirements is included in Chapters 3 through 9.

Table 1-2: Excerpt from Table 100.0-A Application of Standards provides an overview of the location of the general requirements that apply to multifamily buildings in the Energy Code, as covered in this chapter.

Table 1-2: Excerpt From Table 100.0-A Application of Standards

Application	Mandatory	Prescriptive	Performance	Additions/ Alterations
All Buildings-General	100.0, 100.1, 100.2, 110.0	N/A	N/A	N/A
Multifamily Buildings-General	160.0	170.0, 170.2	170.0, 170.1	180.0

Source: California Energy Commission

SECTION 100.0 – SCOPE

(a) Buildings Covered. The provisions of Part 6 apply to all buildings:

1. That are of Occupancy Group A, B, E, F, H, I, L, M, R, S, or U; and
2. For which an application for a building permit or renewal of an existing permit is filed (or is required by law to be filed) on or after the effective date of the provisions, or which are constructed by a governmental agency; and
3. That are:

   A. Unconditioned; or

   B. Indirectly or directly conditioned, or process spaces.

«» Commentary for Section 100.0(a):

Multifamily buildings, as referenced above, include:

1. A building of Occupancy Group R-2, other than a hotel/motel building or timeshare property.
2. A building of Occupancy Group R-3 that is a non-transient congregate residence, other than boarding houses of more than six guests and alcohol or drug abuse recovery homes of more than six guests.
3. A building of Occupancy Group R-4.

The Energy Code applies to any construction that requires a building permit, whether for newly constructed buildings, related outdoor lighting systems and signs, or additions or alterations to them. The primary enforcement mechanism is the building permitting process. The enforcement agency will only approve the building permit or occupancy permit once is satisfied that the building, outdoor lighting, or sign lighting complies with all applicable code requirements, including the Energy Code.

The Energy Code applies only to the construction subject to the building permit application. An existing space that is "conditioned" for the first time is an addition, and all the existing components, whether altered or not, must comply with the Energy Code. (See Section 100.1 for the definition of addition or newly conditioned space.) **«»**

Exception 1 to Section 100.0(a): Qualified historic buildings, as regulated by the California Historic Building Code (Title 24, Part 8). Lighting in qualified historic buildings shall comply with the applicable requirements in Section 140.6(a)3Q.

«» Commentary for Exception 1 to Section 100.0(a):

Exception 1 to Section 100.0(a) states that qualified historical buildings, as regulated by the California Historical Building Code Title 24, Part 8, or California Building Code, Title 24, Part 2, Volume I, Chapter 34, Division II, are not covered by the Energy Code.

Section 140.6(a)3Q and Exception 13 to Section 140.7(a) clarify that indoor and outdoor lighting systems in qualified historical buildings are exempt from the lighting power allowances only if they consist solely of historical lighting components or replicas of historical lighting components. If lighting systems in qualified historical buildings contain some historical lighting components or replicas of historical components, combined with other lighting components, only those historical or historical replica components are exempt.

The California Historical Building Code (CHBC) specifies that all nonhistorical additions must comply with the California Building Code, including the Energy Code. CHBC also specifies that when new nonhistorical mechanical, plumbing, or electrical (including lighting) equipment or appliances or a combination is installed in historic buildings, they must comply with the Energy Code and Appliance Efficiency Regulations unless historical significance or characteristic features are threatened.

The California State Historical Building Safety Board has final authority for interpreting the requirements of the CHBC and determining to what extent the requirements of the Energy Code apply to new and replacement equipment and other alterations to qualified historic buildings. In enacting the CHBC legislation, the Legislature wants to encourage energy conservation in alterations to historic buildings (Health and Safety Code Section 18951).

Additional information about the CHBC can be found at https://www.dgs.ca.gov/DSA/Resources/Page-Content/Resources-List-Folder/CHBC.«»

Exception 2 to Section 100.0(a): Building departments, at their discretion, may not require compliance for temporary buildings, temporary outdoor lighting or temporary lighting in an unconditioned building, or structures erected in response to a natural disaster. Temporary buildings or structures shall be completely removed upon the expiration of the time limit stated in the permit.

Exception 3 to Section 100.0(a): Buildings in Occupancy Group I-3 and I-4.

(b) Parts of Buildings Regulated. The provisions of Part 6 apply to the building envelope, space-conditioning systems, water-heating systems, pool and spas, solar ready buildings, indoor lighting systems of buildings, outdoor lighting systems, electrical power distribution systems, and signs located either indoors or outdoors, in buildings that are:

1. Covered by Section 100.0(a); and
2. Set forth in TABLE 100.0-A.

(c) Habitable stories.

1. All conditioned space in a story shall comply with Part 6 whether or not the story is a habitable space.

2. All unconditioned space in a story shall comply with the lighting requirements of Part 6 whether or not the story is a habitable space.

(d) Outdoor lighting and indoor and outdoor signs. The provisions of Part 6 apply to outdoor lighting systems and to signs located either indoors or outdoors as set forth in TABLE 100.0-A.

(e) Sections applicable to particular buildings. TABLE 100.0-A and this subsection list the provisions of Part 6 that are applicable to different types of buildings covered by Section 100.0(a).

1. **All buildings.** Sections 100.0 through 110.12 apply to all buildings.

   Exception to Section 100.0(e)1: Spaces or requirements not listed in TABLE 100.0-A.

2. **Newly constructed buildings.**

   A. **All newly constructed buildings.** Sections 110.0 through 110.12 apply to all newly constructed buildings within the scope of Section 100.0(a). In addition, newly constructed buildings shall meet the requirements of Subsections B, C, D or E, as applicable.

   E. **Multifamily Buildings**.

      i. Sections applicable. Sections 160.0 through 170.2 apply to newly constructed multifamily buildings.

      ii. Compliance approaches. In order to comply with Part 6 newly constructed multifamily buildings must meet the requirements of:

         a. Mandatory measures: The applicable provisions of Sections 110.0 through 110.10, and 160.0; and

         b. Either:

            (i) Performance approach: Section 170.1; or

            (ii) Prescriptive approach: Section 170.2(a) through (f).

3. **New construction in existing buildings (additions, alterations and repairs).**

   C. **Multifamily buildings.** Section 180.0 applies to new construction in existing multifamily buildings. New construction in existing buildings includes additions, alterations and repairs. Section 180.0 specifies requirements that uniquely apply to additions, alterations or repairs to existing buildings, and specifies which requirements in other sections also apply. For alterations that change the occupancy classification of the building, the requirements specified in Section 180.0 apply to the occupancy after the alterations.

«» Commentary for Section 100.0(e)3C:

Additions

An addition is any change to a building that increases floor area or conditioned volume. Additions involve the:

1. Construction of new conditioned space and conditioned volume.
2. Installation of space conditioning in a previously unconditioned space.
3. Addition of unconditioned space.

Mandatory requirements and either prescriptive or performance requirements apply. For conditioned space, the heating, lighting, envelope, and water-heating systems of additions are treated the same as those for new buildings.

Alterations to Existing Conditioned Spaces

An alteration is any change to the water heating system of a building, space-conditioning system, indoor lighting system, outdoor lighting system, sign lighting, or envelope that is not an addition. Alterations or renovations to existing conditioned spaces have separate rules for energy compliance.

In summary, the alteration rules are the following:

1. The Energy Code applies only to those portions or components of the systems being altered (altered component). Untouched portions or components need not comply with the standards.
2. Alterations must comply with the mandatory requirements for the altered components.
3. New systems in the alteration must comply with the current standards.
4. An existing unconditioned building, where evaporative cooling is added to the existing unaltered envelope and lighting, does not need to comply with current standards.
5. Mechanical system alterations are governed primarily by the mandatory requirements.

Beyond meeting all applicable mandatory requirements, alterations must also comply with applicable prescriptive requirements covered in Chapters 3 – 9 for each system type or use the performance approach.

Repairs

A repair is reconstructing or renewing any part of an existing building for maintaining it. Repairs shall not increase the preexisting energy consumption of the required component, system, or equipment. The Energy Code does not apply to repairs.

Change of Occupancy

A change of occupancy alone without any tenant improvements or other changes does not require any action under the Energy Code. If alterations are made to the building, then the rules for alterations or additions for the new occupancy apply.

If no changes are proposed for the building, consider the ventilation requirements of the new occupancy. For example, if a multifamily dwelling unit is converted to a hair salon, with new sources of indoor pollution, existing residential ventilation rates would likely be inadequate. The Energy Code does not require changes in this scenario, but if changes are made, then those alterations are required to comply with the Energy Code. «»

(f) Mixed occupancy. When a building is designed and constructed for more than one type of occupancy (residential and nonresidential), the space for each occupancy shall meet the provisions of Part 6 applicable to that occupancy.

«» Commentary for Section 100.0(f):

When a building includes both residential and nonresidential occupancies, the requirements may depend on the percentages of conditioned floor area for each occupancy type.

Mixed Occupancy

In a building with both residential and nonresidential occupancy, where neither occupancy is greater than 80 percent of the total conditioned floor area, the multifamily requirements apply to the dwelling units and common use areas while the nonresidential requirements apply to the nonresidential occupancy. Separate compliance for each occupancy is an option when one of the occupancies is a minor occupancy. «»

Exception 1 to Section 100.0(f): If one occupancy constitutes at least 80 percent of the conditioned floor area of the building, the entire building envelope, HVAC, and water heating may be designed to comply with the provisions of Part 6 applicable to that occupancy, provided that the applicable lighting requirements in Sections 140.6 through 140.8, 150.0(k), or 160.5 and 170.2(e) are met for each occupancy and space, and mandatory measures in Sections 110.0 through 130.5, 150.0, and 160.0 through 160.9 are met for each occupancy and space.

«» Commentary for Exception 1 to Section 100.0(f):

For a mixed occupancy where one of the occupancies is less than 20 percent of the total conditioned floor area, the smaller occupancy is considered a “minor” occupancy. In mixed use multifamily buildings, the nonresidential occupancy is typically a minor occupancy. Under this scenario, the applicant may choose to treat the entire building as if it is the major occupancy for envelope, HVAC, and water-heating compliance. Lighting requirements in Sections 140.6 through 140.8 or Section 160.5 must be met for each occupancy separately. Any mandatory requirements for the minor occupancy would still apply, if different from the mandatory requirements for the major occupancy. «»

Exception 2 to Section 100.0(f): If one occupancy constitutes at least 90 percent of the combined conditioned plus unconditioned floor area of the building, the entire building indoor lighting may be designed to comply with only the lighting provisions of Part 6 applicable to that occupancy.

(g) Administrative requirements. Administrative requirements relating to permit requirements, enforcement by the Commission, locally adopted energy standards, interpretations, claims of exemption, approved calculation methods, rights of appeal, and certification and labeling requirements of fenestration products and roofing products are specified in California Code of Regulations, Title 24, Part 1, Sections 10-101 to 10-114.

«» Commentary for Section 100.0(g):

See Multifamily Compliance Manual Chapter 2: Compliance and Enforcement for guidance on administrative requirements. **«»**

(h) Certification Requirements for Manufactured Equipment, Products, and Devices. Part 6 limits the installation of manufactured equipment, products, and devices to those that have been certified as specified by sections 110.0 and 110.1. Requirements for manufactured equipment, products, and devices, when not specified in Title 24 Part 6, are specified in California Code of Regulations, Title 20, Sections 1601-1609.

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

(a) Rules of Construction.

1. Where the context requires, the singular includes the plural and the plural includes the singular.
2. The use of "and" in a conjunctive provision means that all elements in the provision must be complied with, or must exist to make the provision applicable. Where compliance with one or more elements suffices, or where existence of one or more elements makes the provision applicable, "or" (rather than "and/or") is used.
3. "Shall" is mandatory and "may" is permissive.

(b) Definitions. Terms, phrases, words and their derivatives in Part 6 shall be defined as specified in Section 100.1. Terms, phrases, words and their derivatives not found in Section 100.1 shall be defined as specified in the "Definitions" chapters of Title 24, Parts 1 through 5 of the California Code of Regulations. Where terms, phrases, words and their derivatives are not defined in any of the references above, they shall be defined as specified in *Webster's Third New International Dictionary of the English Language, Unabridged* (1961 edition, through the 2002 addenda), unless the context requires otherwise.

«» Commentary for Section 100.1(b):

Refer to Section 100.1(b) for definitions that are specific to Title 24, Part 6. Definitions included in Title 24, Parts 1 through 5, also apply to Part 6 but are not repeated in Section 100.1(b). **«»**

SECTION 100.2 – CALCULATION OF ENERGY BUDGETS

Energy budgets are adopted by the Commission to establish the maximum energy consumption that a proposed building, or portion of a building, can be designed to consume. A building complies with the performance standards compliance approach if the energy consumption calculated for the proposed design building is no greater than the energy budget calculated for the standard design building using Commission-certified compliance software as specified by the Alternative Calculation Methods Reference Manual. The energy budget for newly constructed single-family, multifamily, and nonresidential buildings are expressed in terms of Long-Term System Cost (LSC) and Source Energy. The energy budget for additions and alterations for all building types are expressed in terms of LSC.

Long-term System Cost (LSC) is calculated by multiplying for each hour of the year, the site energy use (electricity kWh, natural gas therms, or fuel oil or LPG gallons) for each energy type by the applicable CEC-published LSC hourly factors. LSC hourly factors vary for each hour of the year and by energy type (electricity, natural gas, or propane), by Climate Zone and by building type (residential, nonresidential). LSC hourly factors are summarized in Reference Joint Appendix JA3. LSC hourly factors for propane are used for all energy obtained from depletable sources other than electricity and natural gas.

Source Energy is calculated by multiplying for each hour of the year, the site energy use (electricity kWh, natural gas therms, or fuel oil or LPG gallons) by Btu factors for fossil fuel consumed either directly at the building site or caused to be consumed to meet the electrical demand of the building considering the long-term marginal hourly resources of Commission-projected electric system resource procurement.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, *Public Resources Code*. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, *Public Resources Code*.

«» Commentary for Section 100.2:

Performance Concepts

The Warren-Alquist Act requires “performance standards” that establish an energy budget for the building in terms of energy consumption per square foot of floor space. This requires a complex calculation of the estimated energy consumption of the building. The Energy Commission has developed a compliance manager, public domain computer program for these calculations known as California Building Energy Code Compliance (CBECC). For compliance purposes, the Warren-Alquist Act also authorizes the use of privately developed computer programs that have been approved by the Energy Commission as alternatives to the public domain computer program. The term "compliance software" is used throughout this manual to refer to these programs.

Long-Term System Cost (LSC)

LSC is the CEC-projected present value of costs to California's energy system over a period of 30 years. LSC does not represent a prediction of individual utility bills.

LSC hourly factors are used to convert predicted site energy use to long-term dollar costs to California's energy system. Since the time that energy is used is as important as the amount of energy used, these factors are generated on an hourly basis for a representative year and created for each of the state's sixteen climate zones.

LSC consists of large data sets that convert electricity, gas and propane to LSC energy. The rate of conversion varies for each hour of the year, for each climate zone and for each energy type (electricity, natural gas and propane). The conversion factors also vary by building type. The complete LSC data can be downloaded from the Energy Commission's website at https://www.energy.ca.gov/files/2025-energy-code-hourly-factors.

Source Energy Metric

Source Energy is defined as the long run hourly marginal source energy of fossil fuels that are combusted as a result of building energy consumption either directly at the building site or caused to be consumed to meet the electrical demand of the building considering the long-term effects of Commission-projected energy resource procurement. For a given hour, the value in that hour for each forecasted year is averaged to establish a lifetime average source energy. «»

SECTION 110.0 – SYSTEMS AND EQUIPMENT—GENERAL

Sections 110.1 through 110.12 specify requirements for manufacturing, construction and installation of certain systems, equipment, appliances and building components that are installed in buildings within the scope of Section 100.0(a).

NOTE: The requirements of Sections 110.0 through 110.12 apply to newly constructed buildings. Sections 141.0 and 150.2 specify which requirements of Sections 110.1 through 110.12 also apply to additions and alterations to existing buildings.

(a) General Requirements. Systems, equipment, appliances and building components shall only be installed in a building within the scope of Section 100.0(a) regulated by Part 6 only if:

1. The manufacturer has certified that the system, equipment, appliances or building component complies with the applicable manufacturing provisions of Sections 110.1 through 110.12; and
2. The system, equipment, appliance or building component complies with all applicable installation provisions of Sections 110.1 through 110.12.

(b) Certification Requirements for Manufactured Systems, Equipment, Appliances and Building Components.

1. Appliances that are within the scope of Section 1601 of the Appliance Efficiency Regulations shall only be installed if they have been certified to the Energy Commission by the manufacturer, pursuant to the provisions of Title 20 California Code of Regulations, Section 1606; or
2. Systems, equipment, appliances and building components that are required by Part 6 or the Reference Appendices to be certified to the Energy Commission, which are not appliances that are within the scope of Section 1601 of the Appliance Efficiency Regulations, shall only be installed if they are certified by the manufacturer in a declaration, executed under penalty of perjury under the laws of the State of California, that:
   A. All the information provided pursuant to the certification is true, complete, accurate and in compliance with all applicable requirements of Part 6; and
   B. The equipment, product, or device was tested using the test procedure specified in Part 6 if applicable
3. The certification status of any system, equipment, appliance or building component shall be confirmed only by reference to:
   A. A directory published or approved by the Commission; or

B. A copy of the application for certification from the manufacturer and the letter of acceptance from the Commission staff; or

C. Written confirmation from the publisher of a Commission-approved directory that a device has been certified; or

D. A Commission-approved label on the device.

Note: Part 6 does not require a builder, designer, owner, operator, or enforcing agency to test any certified device to determine its compliance with minimum specifications or efficiencies adopted by the Commission.

Note**:** Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

«» Commentary for Section 110.0(b):

Manufacturer Certification for Equipment, Products, and Devices

During the permit application development phase, certain equipment, products, and devices must be selected for installation or use that are certified to be compliant with the Energy Code. These items are identified on the Certificates of Compliance (Nonresidential Certificates of Compliance [NRCC] or Low-rise Multifamily Certificate of Compliance [LMCC]) and are verified during inspection by the enforcement agency.

The equipment, products, and devices must be certified to the CEC by the manufacturer that it meets requirements under the Energy Code. The CEC makes no claim that the listed equipment, products, or devices meet the indicated requirements or, if tested, will confirm the indicated results. Inclusion on these lists confirms only that a manufacturer certification has been submitted to and accepted by the CEC. See the CEC's website for additional information about the required information for manufacturers to certify products and for lists of certified products, http://www.energy.ca.gov/title24/equipment_cert/. «»

SECTION 160.0 – GENERAL

Multifamily buildings shall comply with the applicable requirements of Sections 160.1 through 160.9. Sections 160.1 through 160.9 apply to dwelling units and common use areas in multifamily buildings. Nonresidential occupancies in a mixed occupancy building shall comply with nonresidential requirements in Sections 120.0 through 141.1.

Note: The requirements of Sections 160.1 through 160.9 apply to newly constructed buildings. Sections 180.1 through 180.4 specify which requirements of Sections 160.1 through 160.9 apply to additions or alterations.

Note: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

«» Commentary for Section 160.0:

For information on scope, see Commentary for Section 100.0(a), above. For information on and definitions of mixed occupancy buildings, see Commentary for Section 100.0(f), above. «»

SECTION 170.0 – GENERAL

Multifamily buildings shall comply with the applicable requirements of Sections 170.0 through 170.2. Sections 170.0 through 170.2 apply to dwelling units and common use areas in multifamily buildings. Nonresidential occupancies in mixed occupancy buildings shall comply with nonresidential requirements in Sections 120, 130, 140 and 141.

(a) Multifamily buildings shall meet all of the following:

1. The applicable requirements of Sections 110.0 through 110.10.
2. The applicable requirements of Section 160.0 (mandatory features).
3. Either the performance standards Section 170.1 or the prescriptive standards Section 170.2 set forth in this subchapter for the climate zone in which the building is located. Climate zones are shown in Reference Joint Appendix JA2—Weather/Climate Data.

    Exception to Section 170.0(a)3: If a single development falls in more than one climate zone, all buildings in the subdivision or tract may be designed to meet the performance or prescriptive standards for the climate zone that contains 50 percent or more of the dwelling units.

    NOTE: The Commission periodically updates, publishes and makes available to interested persons and local enforcement agencies precise descriptions of the climate zones, as specified in Reference Joint Appendix JA2—Weather/Climate Data.

NOTE: The requirements of Sections 170.1(a) through 170.2(e) apply to newly constructed buildings and Sections 180.1 and 180.2 specify changes to the requirements of Sections 170.1(a) through 170.2(e) that apply to additions or alterations.

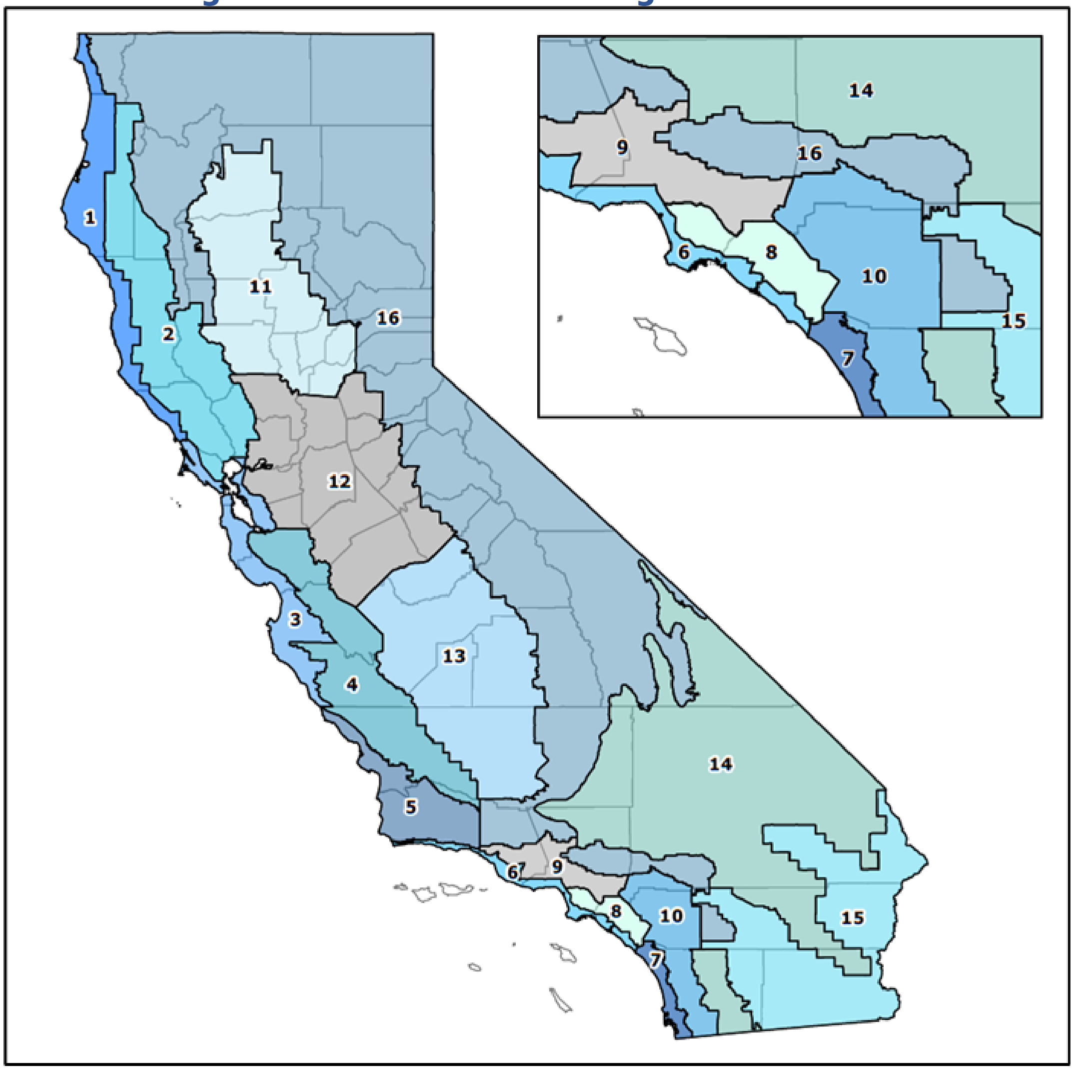
NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8 and 25943, Public Resources Code.

«» Commentary for Section 170.0:

Since energy use depends partly upon weather conditions, the CEC established 16 climate zones representing distinct climates within California. Information is available by zip code and in several formats (https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/climate-zone-tool-maps-and).

Cities may occasionally straddle two climate zones. In these instances, the exact building location and correct climate zone should be verified before any calculations are performed. In cases where a multibuilding development or subdivision crosses a climate zone boundary, the developer and designer may choose to design all of the buildings in the development to the requirements of the climate zone with 50 percent or more of the dwelling units, rather than designing individual buildings to the distinct prescriptive or performance requirements of each climate zone.

Figure 1-1: California Building Climate Zones



Source: California Energy Commission

«»

SECTION 170.1 – PERFORMANCE APPROACH

A building complies with the performance approach if the energy consumption calculated for the proposed design building is no greater than the energy budget calculated for the standard design building using Commission-certified compliance software as specified by Sections 10-109, 10-116 and the Alternative Calculation Method Reference Manual.

(a) Energy budget. The Energy budget is expressed in terms of long-term system cost (LSC) and source energy:

1. **Long-term system cost (LSC).** The LSC energy budget is determined by applying the mandatory and prescriptive requirements of the standard design to the proposed design building and has two components, the Efficiency LSC and the Total LSC.
   A. The Efficiency LSC energy is the sum of the LSC energy for space-conditioning, water heating, mechanical ventilation, lighting and the self-utilization credit.
   B. The Total LSC energy is the sum of the Efficiency LSC energy and LSC energy from the photovoltaic system, battery energy storage systems (BESS), and demand flexibility.
2. **Source energy.** The source energy budget is determined by applying the mandatory and prescriptive requirements of the standard design, except with a consumer gas or propane water heater, to the proposed design building.

Exception to Section 170.1(a): A community shared solar electric generation system, or other renewable electric generation system, and/or community shared BESS, that provides dedicated power, utility energy reduction credits or payments for energy bill reductions to the permitted building and is approved by the Energy Commission as specified in Title 24, Part 1, Section 10-115, may offset part or all of the solar electric generation system or BESS LSC energy required to comply with the standards, as calculated according to methods established by the Commission in the Nonresidential ACM Reference Manual.

«» Commentary for Section 170.1(a)1:

Under the performance approach, energy use of the building is modeled by compliance software approved by the Energy Commission. The compliance software simulates the LSC energy budget of the proposed building, including a detailed accounting of envelope heat transfers using the assemblies and fenestration input, and the precise geometry of any exterior overhangs or side fins. The most accurate tradeoffs between different envelope components — and among the envelope, the space-conditioning system, and the installed common area lighting — are accounted for and compared with the standard design version of the building. The proposed design must have LSC energy less than or equal to the standard design. As noted above, the LSC is the present value of costs over a 30-year period related to California's energy system. The LSC does not represent a prediction of individual utility bills. **«»**

(b) Compliance demonstration requirements for performance standards.

1. Certificate of Compliance and Application for a Building Permit. The application for a building permit shall include documentation pursuant to Sections 10-103(a)1 and 10-103(a)2 that demonstrates, using an approved calculation method, that the building has been designed so that its source energy and LSC energy consumption do not exceed the standard design energy budgets for the applicable climate zone.

«» Commentary for Section 170.1(b)1:

Some residential projects may not wish to use or do not meet the requirements for prescriptive compliance. The performance approach offers increased flexibility as well as compliance credits for certain assemblies, usually those requiring verification. The proposed design used under the performance approach is compared to the standard design, which is determined by the prescriptive requirements. When using the performance approach, all applicable mandatory requirements must still be met.

When applying for the building permit, certificate of compliance forms are required to be integrated into the drawing set per Title 24 Part 1, the Administrative Code and signed by the person who is eligible under Division 3 of the Business and Professions Code to accept responsibility for the building design (responsible person). If more than one person has responsibility for the building design, each person shall sign the Certificate of Compliance document(s) applicable to that portion of the design for which the person is responsible. Alternatively, the person with chief responsibility for the building design may sign the certificate of compliance for the entire building design.

The certificate of compliance shall contain compliance documentation for features consistent with the building design features identified on the other applicable compliance documents, worksheets, calculations, plans, and specifications submitted to the enforcement agency for approval with the building permit application. The performance approach certificate of compliance must support that the proposed design features included within the certificate of compliance is equal or better than those included within the design documents.

Multifamily buildings, including mixed use, with three or fewer habitable stories, use the LMCC-PRF-01-E Certificate of Compliance, to be registered with an Energy Code Compliance (ECC) Provider when there are field verification and diagnostic testing-supported measures associated with the project scope.

Multifamily buildings, including mixed use, with four or more habitable stories use the NRCC-PRF-01-E Certificate of Compliance and are not registered via an ECC provider even if there are ECC measures associated with the project scope.

When using the performance approach, the certificate of compliance can include all, or only some, of the building features supporting the conditioned areas of the building. Any features applicable to the scope of the project not included in the performance approach must show compliance via the prescriptive pathway and be documented with separate certificate of compliance forms. «»

2. Field verification of individual dwelling unit systems. When performance of installed features, materials, components, manufactured devices or systems above the minimum specified in Section 170.2 is necessary for the building to comply with Section 170.1, or is necessary to achieve a more stringent local ordinance, field verification shall be performed in accordance with the applicable requirements in the following subsections, and the results of the verification(s) shall be documented on applicable Certificates of Installation pursuant to Section 10-103(a)3 and applicable Certificates of Verification pursuant to Section 10-103(a)5.

«» Commentary for Section 170.1(b)2:

When using the performance approach, there are nonmandatory verification measures that can be used for compliance flexibility. If these verification measures are reported within the certificate of compliance, they will be required to be installed and tested by the contractor (documented with the certificate of installation) then verified by the ECC-Rater (documented with the certificate of verification), with the exception of thermal balancing valves, which is verified by the installing contractor. If the installed equipment or building feature is unable to meet the requirements supported in the certificate of compliance, the certificate of compliance must be revised, which may bring the project out of compliance. «»

A. EER2/SEER2/CEER/HSPF2 Rating. When performance compliance requires installation of a space-conditioning system with a rating that is greater than the minimum rating required by Table 170.2-K or specified for the standard design, the installed system shall be field verified in accordance with the procedures specified in the applicable sections of Reference Residential Appendix RA3.

«» Commentary for Section 170.1(b)2A:

Mechanical equipment efficiency greater than federal minimums, as is supported with the certified rating data from the AHRI Directory of Certified Product Performance (http://www.ahridirectory.org) or another directory of certified product performance ratings approved by the Energy Commission for determining compliance, can be used in the performance approach.

1. Heat pumps cooling efficiency (SEER2) and heating efficiency (HSPF2).
2. Central air conditioners cooling efficiency (SEER2 and EER2).
3. Window air conditioners cooling efficiency (CEER). «»

B. Variable capacity heat pump (VCHP) compliance option. When performance compliance requires installation of a heat pump system that meets all the requirements of the VCHP compliance option specified in the ACM Reference Manual, the system shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.4.4.3.

«» Commentary for Section 170.1(b)2B:

Variable-capacity heat pump (VCHP) can be used for dwelling unit mechanical equipment when the equipment and design meets the requirements of RA3.4.4.3 "Variable Capacity Heat Pump Performance Compliance Option Eligibility Verification," which includes ducted and ductless system component and wall-mounted thermostat zoning requirements. «»

C. Low leakage air handler. When performance compliance requires installation of a low leakage air-handling unit, the installed air handling unit shall be field verified in accordance with the procedures specified in Reference Residential Appendix RA3.1.4.3.9.

«» Commentary for Section 170.1(b)2C:

When low leakage air handlers are used, those systems must meet the qualification requirements of JA9. This includes being included in the CEC list of Low Leakage Air Handling Units https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment/low.

Additionally, the qualified air handler must be verified to leak less than or equal to the leakage rates specified on the Certificate of Compliance per RA3.1.4.3.1 to receive the credit. «»

D. Thermal Balancing Valve. When performance compliance requires installation of thermal balancing valves with variable speed circulation pump(s), the installation shall meet the procedures specified in Reference Residential Appendix RA4.4.3.

«» Commentary for Section 170.1(b)2D:

When a thermal balancing valve is incorporated into the water-heating distribution design and supported in the performance approach, then the design criteria of RA4.4.3 "Thermostatic Balancing Valve" will apply and must be verified by the installing contractor. This is not an ECC-verified measure. «»

E. Heat pump—rated heating capacity. When performance compliance requires installation of a heat pump system, the heating capacity values at 47°F and 17°F shall be field verified in accordance with the procedures specified in Reference Residential Appendix RA3.4.4.2.

«» Commentary for Section 170.1(b)2E:

When the performance approach includes heat pumps, those heat pumps must be verified by an ECC-Rater, confirming that the heating capacities at 47°F and at 17°F used in the certificate of compliance match the equipment installed in the field via the certified rating data referenced from the AHRI Directory of Certified Product Performance (http://www.ahridirectory.org) or another directory of certified product performance ratings approved by the Energy Commission for determining compliance.

The heating capacity at 17°F reflects how much of the heating load is supported by the heat pump equipment versus the supplemental heating source (which is typically electric resistance) on a cold day. «»

F. Dwelling unit enclosure air leakage. When performance compliance requires a building enclosure leakage rate that is lower than the standard design, the building enclosure shall be field verified in accordance with the procedures specified in Reference Residential Appendix RA3.8.

«» Commentary for Section 170.1(b)2F:

Dwelling unit enclosure air leakage testing is also referred to as compartment leakage or "blower door" testing. «»

G. Quality insulation installation (QII). When performance compliance requires field verification of QII, the building insulation system shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.5.

«» Commentary for Section 170.1(b)2G:

For multifamily buildings with three or fewer habitable stories, when the performance approach includes prescriptive Quality Insulation Installation (QII) verification, an ECC-Rater will be required to confirm the installed air barrier and insulation meets the requirements of RA3.5. See 2025 Multifamily Compliance Manual, Chapter 3 for more information. «»

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 170.2 – PRESCRIPTIVE APPROACH

Multifamily buildings, including both dwelling units and common use areas, that comply with the prescriptive standards shall be designed, constructed and equipped to meet all of the requirements for the appropriate climate zone shown in Table 170.2-A. In Table 170.2-A, NA (not allowed) means that feature is not permitted in a particular climate zone and NR (no requirement) means that there is no prescriptive requirement for that feature in a particular climate zone.

«» Commentary for Section 170.2:

Guidance on prescriptive requirements for building systems are included in Chapters 3–9 of this Compliance Manual. «»

SECTION 180.0 – GENERAL

Additions, alterations and repairs to existing attached dwelling units and common use areas in multifamily buildings, existing outdoor lighting for these occupancies, and internally and externally illuminated signs shall meet the requirements specified in Sections 100.0 through 110.10, 160.1, and 160.3 through 170.2 that are applicable to the building project, and either the performance compliance approach (energy budgets) in Section 180.1(b) (for additions) or 180.2(c) (for alterations), or the prescriptive compliance approach in Section 180.1(a) (for additions) or 180.2(b) (for alterations), for the climate zone in which the building is located. Climate zones are shown in Figure 100.1-A. Covered process requirements for additions, alterations and repairs to existing multifamily buildings are specified in Section 141.1. Nonresidential occupancies in mixed occupancy buildings shall comply with nonresidential requirements in Sections 120.0 through 141.1.

NOTE: For alterations that change the occupancy classification of the building, the requirements specified in Section 180.2 apply to the occupancy after the alterations.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8 and 25943, Public Resources Code.

«» Commentary for Section 180.0:

For information on definitions of Additions, Alterations, and Repairs, see the Commentary for Section 100.0(e)3C, above. **«»**

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INTRODUCTION

This chapter covers the major compliance and enforcement requirements of the Energy Code, primarily Title 24, Part 1, Section 10-103. This chapter helps the building construction industry during project development address compliance requirements ahead of plan check and inspections. Furthermore, the information provided in this chapter is to help authorities having jurisdiction (AHJ), or enforcement agencies, better understand how the Energy Code can be more effectively enforced.

SECTION 10-103 – PERMIT, CERTIFICATE, INFORMATIONAL, AND ENFORCEMENT REQUIREMENTS FOR DESIGNERS, INSTALLERS, BUILDERS, MANUFACTURERS, AND SUPPLIERS

Section 10-103(a) - Documentation

(a) Documentation. For all buildings other than healthcare facilities, the following documentation is required to demonstrate compliance with Part 6. This documentation shall meet the requirements of Section 10-103(a) or alternatives approved by the Executive Director. Healthcare facilities shall instead comply with the applicable provisions of Chapter 7.

«» Commentary for Section 10-103(a):

Section 10-103(a) refers to all buildings, but this chapter applies to multifamily buildings and will only give commentary for that application. Multifamily buildings are defined in the Energy Code and in many instances are still divided into low-rise and high-rise. Low-rise multifamily buildings are buildings with three or fewer habitable stories, and high-rise multifamily buildings are buildings with four habitable stories or more. These stories do not include parking structures. The residential dwelling units in low-rise multifamily buildings generally still use Energy Code Compliance (ECC)-Raters (formerly known as HERS Raters) for field verification and diagnostic testing and must still comply with many single-family residential requirements with some exceptions or differences. Typically referred to as "common use areas," spaces such as laundry rooms, meeting rooms, and halls must comply with the nonresidential requirements. For nonresidential requirements in low-rise multifamily buildings that address lighting controls or independent heating, ventilation, or air conditioning (HVAC), Acceptance Test Technicians (ATTs) must be used. High-rise multifamily may use ATTs or ECC-Raters to address some of the residential dwelling unit requirements.

The second sentence in this code section refers to the certificates of compliance or alternatives approved by the Energy Commission. «»

Section 10-103(a)1 – Certificate of Compliance

Certificate of Compliance. For all buildings, the Certificate of Compliance described in Section 10-103 shall be signed by the person who is eligible under Division 3 of the Business and Professions Code to accept responsibility for the building design (*responsible person*); and submitted in accordance with Sections 10-103(a)1 and 10-103(a)2 to certify conformance with Part 6. If more than one person has responsibility for the building design, each person shall sign the Certificate of

Compliance document(s) applicable to that portion of the design for which the person is responsible. Alternatively, the person with chief responsibility for the building design shall prepare and sign the Certificate of Compliance document(s) for the entire building design. Subject to the requirements of Sections 10-103(a)1 and 10-103(a)2, persons who prepare Certificate of Compliance documents (*documentation authors*) shall sign a declaration statement on the documents they prepare to certify the information provided on the documentation is accurate and complete. In accordance with applicable requirements of 10-103(a)1, the signatures provided by *responsible persons* and *documentation authors* shall be original signatures on paper documents or electronic signatures on electronic documents conforming to the electronic signature specifications in Reference Joint Appendix JA7.

For all Nonresidential buildings, the Design Review Kickoff Certificate(s) of Compliance and the Construction Document Design Review Checklist Certificate(s) of Compliance shall be reviewed and signed by a licensed professional engineer or licensed architect, or a licensed contractor representing services performed by or under the direct supervision of a licensed engineer or architect, as specified in the provisions of Division 3 of the Business and Professions Code. For buildings less than 10,000 square feet, this signer may be the engineer or architect of record. For buildings greater than 10,000 square feet but less than 50,000 square feet, this signer shall be a qualified in-house engineer or architect with no other project involvement or a third-party engineer, architect, or contractor. For buildings greater than 50,000 square feet and all buildings with complex mechanical systems serving more than 10,000 square feet, this signer shall be a third-party engineer, architect, or contractor.

«» Commentary for Section 10-103(a)1:

The applicable certificates of compliance have to be signed by the responsible person either with an original signature on paper or via electronic signatures on electronic documents consistent with JA7. The Certificates of Compliance can be completed by any person. That person must also sign as the documentation author. However, the certificates of compliance are not valid until it is signed by the responsible person.

To clarify who may sign as the responsible person, it is important to understand that the certificates of compliance are documentation of the intended design that must be approved by the authority having jurisdiction. As such, the responsible person must hold a credential to justify their signature on the certificates of compliance. The qualifications are specified in Division 3 of the Business and Professions Code. However, Division 3 will not speak to who may sign as a responsible person on the certificates of compliance. Division 3 specifies who, as a licensed individual, can design and build structures or building components in California.

For newly constructed buildings, this typically means that the architect responsible for overall design will likely act as the responsible person. For additions and alterations to existing buildings, the responsible person is typically the installing licensed contractor.

However, in many instances the responsible person can also be the general contractor, design engineer, or specialized contractor for specific components of the build. In general, whomever is signing the plans and specifications to be approved by the AHJ can also sign as the responsible person on the Certificates of Compliance for that building component.

It is very common for different aspects of the building to be designed by different licensed persons. For example, a structural engineer might sign the structural plans, while an HVAC engineer may independently design the HVAC system for the build. Similarly, different trades, such as lighting, electric, plumbing, photovoltaic, and others, may independently design other building components. It is permissible for each of these licensed trades to sign as the responsible person for their design component of the build and this can be the case for smaller projects. However, for larger projects, this approach is typically cumbersome. Therefore, it is also permitted for one person, appropriately licensed, who has chief responsibility for overall design or compliance to sign all of the Certificates of Compliance as the responsible person.

The Certificate of Compliance related to commissioning design review (i.e., the Design Review Kickoff Certificates of Compliance and the Construction Document Design Review Checklist Certificates of Compliance) only applies to newly constructed projects which require commissioning per Section 120.8. Commissioning is not required for additions and alterations to existing buildings. For a more detailed discussion of required and voluntary commissioning, please refer to Chapter 2 of the Nonresidential Compliance Manual. For multifamily projects, commissioning requirements apply only to the nonresidential spaces within the multifamily building. Such spaces include meeting rooms, laundry rooms, and any other such spaces that are not expected to be used as a residential space.

While it is very unlikely to apply to multifamily buildings, there are additional restrictions on who may sign as the responsible person under specific conditions. These restrictions are only covered here for the very unlikely event that they might apply to a multifamily building. These restrictions are shown in the last paragraph of Section 10-103(a)1, and are summarized in Table 2-1 Potential Additional Requirements for the Responsible Person.

Table 2-1 Potential Additional Requirements for the Responsible Person

Total Square footage of Nonresidential-Space in a Multifamily Building	Additional Requirements for the Responsible Person
Under 10,000	No additional requirements
10,000 and above but below 50,000	The responsible person is additionally restricted to be a qualified in-house engineer or architect with no other project involvement or a third-party engineer, architect, or contractor.
50,000 and above	The responsible person is additionally restricted to be a third-party engineer, architect, or contractor.
10,000 square feet and above and has complex mechanical systems (see definitions)	The responsible person is additionally restricted to be a third-party engineer, architect, or contractor.

Source: California Energy Commission

«»

Section 10-103(a)1A

A. All Certificate of Compliance documentation shall conform to a format and informational order and content approved by the Energy Commission.

These documents shall:

i. Identify the energy features, performance specifications, materials, components, and manufactured devices required for compliance with Part 6.

ii. Identify the building project name and location. The building project name and location identification on the Certificate of Compliance shall be consistent with the building project name and location identification given on the other applicable building design plans and specifications submitted to the enforcement agency for approval with the building permit application.

iii. Display the unique registration number assigned by the data registry if Section 10-103(a)1 requires the document to be registered.

iv. Include a declaration statement to the effect that the building energy features, performance specifications, materials, components, and manufactured devices for the building design identified on the Certificate of Compliance indicate the building is in compliance with the requirements of Title 24, Parts 1 and 6, and the building design features identified on the Certificate of Compliance are consistent with the building design features identified on the other applicable compliance documents, worksheets, calculations, plans, and specifications submitted to the enforcement agency for approval with the building permit application.

v. Be signed by the *documentation author* to certify the documentation is accurate and complete. When document registration is required by Section 10-103(a)1, the signature shall be an electronic signature on an electronic document in accordance with the electronic signature specifications in Reference Joint Appendix JA7.

vi. Be signed by the *responsible person* eligible under Division 3 of the Business and Professions Code to accept responsibility for the design to certify conformance with Part 6. When document registration is required by Section 10-103(a)1, the signature shall be an electronic signature on an electronic document in accordance with the electronic signature specifications in Reference Joint Appendix JA7.

«» Commentary for Section 10-103(a)1A:

Section 10-103(a)1A describes the requirements for the Certificates of Compliance, the requirements for them to be completed, and the required signatories. It specifically requires that they conform to a format, informational order, and content approved by the Energy Commission. This also allows the Energy Commission to approve alternative Certificates of Compliance. The responsible person and to a lesser extent, the documentation author are responsible to ensure that the Certificates of Compliance match or are at least consistent with the permit application (i.e., compliance documents, worksheets, calculations, plans, and specifications submitted to the AHJ for approval through the construction permit application process). Table 2-2: Certificates of Compliance by Application and Number of Stories shows the Certificates of Compliance documents available, based on the application and number of stories (low-rise vs. high-rise). When the performance approach is used for low-rise multifamily (LRMF) buildings, the LMCC-PRF-01 will report additional prescriptive Low-rise Multifamily Certificates of Compliance (LMCCs) that must also be completed.

LMCCs may be produced by completing the relevant forms on a number of platforms. These sources will be listed on the 2025 Building Energy Efficiency Standards web page. The options include using a residential data registry, a downloaded blank form, or a document generator. Which source may be used depends on the following: if the project does not require field verification and diagnostic testing (FV&DT), the documents may be produced without being registered in an Energy Commission approved residential data registry. Table 2-2: Certificates of Compliance by Application and Number of Stories shows compliance documents based on the application and number of stories. If no data registry is capable of producing registered certificates, the compliance documents must be generated using an alternative method as they are still necessary to facilitate FV&DT and the production of applicable compliance documents.

High-rise multi-family (HRMF) Certificates of Compliance use the Nonresidential Certificates of Compliance (NRCCs). They can be completed using compliance software.

Table 2-2: Certificates of Compliance by Application and Number of Stories

Application	Documentation Required for Buildings up to Three Habitable Stories when Applicable	Able to be registered in a Residential Data Registry[1]	Documentation Required for Buildings Four or more Habitable Stories when Applicable
Performance Approach	LMCC-PRF-01	Yes	NRCC-PRF-01
Electrical Power Distribution	LMCC-ELC-01-E	See note	NRCC-ELC-E
Envelope	LMCC-ENV-01-E	See note	NRCC-ENV-E
Commissioning	LMCC-CXR-01-E	See note	NRCC-CXR-E
Lighting – Indoor	LMCC-LTI-01-E	See note	NRCC-LTI-E
Lighting – Outdoor	LMCC-LTO-01-E	See note	NRCC-LTO-E
Lighting - Sign	LMCC-LTS-01-E	See note	NRCC-LTS-E
Mechanical Systems	LMCC-MCH-01-E	See note	NRCC-MCH-E
Prescriptive Alterations HVAC	LMCC-MCH-02-E	Yes	NRCC-MCH-E
Water Heating Systems/ Plumbing	LMCC-PLB-01-E	See note	NRCC-PLB-E
Covered Processes	LMCC-PRC-01-E	See note	NRCC-PRC-E
Solar and Battery	LMCC-SAB-01-E	See note	NRCC-SAB-E

Source: California Energy Commission

«»

Section 10-103(a)1B:

B. For all low-rise residential buildings for which compliance requires field verification, the person(s) responsible for the Certificate(s) of Compliance shall submit the Certificate(s) and their associated Compliance Registration Packages for registration and retention to an ECC-provider data registry in compliance with Section 10-103.3. The submittals to the ECC-provider data registry shall be made electronically in accordance with the specifications in Reference Joint Appendix JA7.

Contingent upon availability and approval of an electronic document repository by the Executive Director, Certificate of Compliance documents and their associated Compliance Registration Packages that are registered and retained by an ECC-provider data registry shall also be automatically transmitted by the data registry Section 10-103.3, to an electronic document repository for retention in accordance with the specifications in Reference Joint Appendix JA7.

«» Commentary for Section 10-103(a)1B:

Section 10-103(a)1B refers to low-rise residential buildings, which includes both single-family and multifamily buildings. For information on single-family residential buildings, please review the 2025 Single-family Residential Compliance Manual. LRMF projects that are also required to comply with the FV&DT regulations must register the one or more LMCCs with an Energy Commission-approved residential data registry (see Table 2-2). Note that different LMCC forms are available to address prescriptive new construction, additions, and alterations by category. These categories include mechanical systems, building envelope features, and water heating systems. Alternatively, a performance LMCC may be generated using approved compliance software. The LMCC-PRF-01-E will indicate if additional prescriptive LMCCs are required. These may include solar and battery systems, lighting and lighting controls, and others that apply more to the nonresidential-occupancy areas of the building.

The persons responsible for the LMCCs are also responsible for ensuring that this registration happens. This person is the responsible person as designated in Section 10-103(a)1. In the event that it is not possible to register the LMCC (see Table 2-2), the responsible person has the responsibility to ensure that the LMCCs are completed in compliance with the Energy Code requirements.

The remainder of Section 10-103(a)1B refers to a central document repository that is still in development at the time of this writing and does not impact the compliance or enforcement of the Energy Code. **«»**

Section 10-103(a)1C

C. For alterations to existing residential buildings for which field verification is not required, including but not limited to water heater and window replacements, and for additions to existing residential buildings that are less than 300 square feet for which field verification is not required, the enforcement agencies may at their discretion not require any Certificate of

Compliance documentation, or may develop simplified Certificate of Compliance documentation for demonstrating compliance with the Standards.

Allowances by enforcement agencies to not require compliance documentation shall not be deemed to grant authorization for any work to be done in any manner in violation of this code or other provisions of law.

«» Commentary for Section 10-103(a)1C:

Section 10-103(a)1C refers to existing residential buildings which includes both single-family and LRMF buildings. For information on single-family residential buildings please review the 2025 Single-family Residential Compliance Manual. For LRMF addition and alteration projects that do require FV&DT, Section 10-103(a)1C allows the AHJ, at its discretion, to either not require any LMCCs or develop its own Certificates of Compliance. The AHJ need not seek Energy Commission approval prior to implementing this option. If an AHJ develops its own Certificates of Compliance for these types of projects, it must ensure compliance with the Energy Code. **«»**

Section 10-103(a)1D

D. Contingent upon approval of data registry(s) by the Commission, all nonresidential buildings, high-rise residential buildings, and hotels and motels, when designated to allow use of an occupancy group or type regulated by Part 6 the person(s) responsible for the Certificate(s) of Compliance shall submit the Certificate(s) and their associated Compliance Registration Packages for registration and retention to a data registry approved by the Commission. The submittals to the approved data registry shall be made electronically in accordance with the specifications in Reference Joint Appendix JA7.

   Contingent upon availability and approval of an electronic document repository by the Executive Director, Certificate of Compliance documents and their associated Compliance Registration Packages that are registered and retained by an approved data registry shall also be automatically transmitted by the data registry to an electronic document repository for retention in accordance with the specifications in Reference Joint Appendix JA7.

«» Commentary for Section 10-103(a)1D:

Until a nonresidential data registry is approved by the California Energy Commission, there is no requirement to register compliance documents for high rise multifamily projects. A data registry could be approved mid-code cycle and, upon approval, registration of NRCC documents would be required. If a nonresidential data registry is approved, the California Energy Commission will issue a Regulatory Advisory. **«»**

Section 10-103(a)2 – Application for a Building Permit

2. **Application for a building permit.** Each application for a building permit subject to Part 6 shall contain at least one copy of the documents specified in Sections 10-103(a)2A, 10-103(a)2B, and 10-103(a)2C.

A. For all newly constructed buildings, additions, alterations, or repairs regulated by Part 6 the applicant shall submit the applicable Certificate(s) of Compliance to the enforcement agency for approval. The certificate(s) shall conform to the requirements of Section 10-103(a)1, and shall be approved by the local enforcement agency, in accordance with all applicable requirements of Section 10-103(d), by stamp or authorized signature prior to issuance of a building permit. A copy of the Certificate(s) of Compliance shall be included with the documentation the builder provides to the building owner at occupancy as specified in Section 10-103(b).

   For alterations to existing residential buildings for which field verification is required, and when the enforcement agency does not require building design plans to be submitted with the application for a building permit, the applicable Certificate of Compliance documentation specified in Section 10-103(a)1 is not required to be approved by the enforcement agency prior to issuance of a building permit, but shall be approved by the enforcement agency prior to final inspection of the dwelling unit, and shall be made available to the enforcement agency for all applicable inspections, or made available for viewing on an approved data registry.

   When the enforcement agency requires building design plans to be submitted with the application for a building permit, the applicable Certificate of Compliance documents shall be incorporated into the building design plans. When Section 10-103(a)1 requires document registration, the certificate(s) that are incorporated into the building design plans shall be copies of the registered Certificate of Compliance documents from an ECC-provider data registry, or a data registry approved by the Commission.

B. When the enforcement agency requires building design plans and specifications to be submitted with the application for a building permit, the plans shall conform to the specifications for the features, materials, components, and manufactured devices identified on the Certificate(s) of Compliance, and shall conform to all other applicable requirements of Part 6. Plans and specifications shall be submitted to the enforcement agency for any other feature, material, component, or manufactured device that Part 6 requires be indicated on the building design plans and specifications. Plans and specifications submitted with each application for a building permit for Nonresidential buildings, High-rise Residential buildings and Hotels and Motels shall provide acceptance requirements for code compliance of each feature, material, component or manufactured device when acceptance requirements are required under Part 6. Plans and specifications for Nonresidential buildings, High-rise Residential buildings and Hotels and Motels shall require, and indicate with a prominent note on the plans, that within 90 days after the Enforcement Agency issues a permanent final occupancy permit, record drawings be provided to the building owner.

For all buildings, if the specification for a building design feature, material, component, or manufactured device is changed before final construction or installation, such that the building may no longer comply with Part 6 the building must be brought back into compliance, and so indicated on amended plans, specifications, and Certificate(s) of Compliance that shall be submitted to the enforcement agency for approval. Such characteristics shall include the efficiency (or other characteristic regulated by Part 6) of each building design feature, material, component, or device.

C. The enforcement agency shall have the authority to require submittal of any supportive documentation that was used to generate the Certificate(s) of Compliance, including but not limited to the electronic input file for the compliance software tool that was used to generate performance method Certificate(s) of Compliance; or any other supportive documentation that is necessary to demonstrate that the building design conforms to the requirements of Part 6.

«» Commentary for Section 10-103(a)2 – Application for a Building Permit:

Section 10-103(a)2 is the first point at which the Certificates of Compliance are required to be submitted to the AHJ for approval. The scope for this action includes newly constructed buildings as well as additions, alterations, and repairs to existing buildings. In general, when the AHJ requires a permit to construct for a project and that project includes elements regulated by the Energy Code, the responsible person must submit the required Certificates of Compliance with the permit application. The responsible person must incorporate the Certificates of Compliance into the plans with an application for a permit to construct. Additionally, the responsible person must submit a registered copy of the Certificates of Compliance, when they are required to be registered with an Energy Commission approved data registry.

Once the permit application is reviewed and approved by the AHJ, the Certificates of Compliance are approved as well. It is at this approval that the Certificates of Compliance are considered to have met all of the Energy Code requirements pertaining to the filling out the Certificate of Compliance. Only an agent of the AHJ, such as a field inspector, can overturn that approval. ECC-Raters and ATTs do not have the authority to declare an AHJ approved Certificate of Compliance does not meet all of the form requirements of the Energy Code. ECC-Raters and ATTs can only pass or fail a project regarding the Energy Code required FV&DT or acceptance testing. A copy of the AHJ approved Certificates of Compliance is also required to be given to the building owner within 90 days following the AHJ issuance of the certificate of occupancy.

In some instances the AHJ might not require building design plans to be submitted with the permit application; this is typically limited to small alteration projects at existing buildings, such as an HVAC change out. However, when these projects require FV&DT, the appropriate Certificates of Compliance must still be completed and approved by the AHJ. In such a case, the Certificates of Compliance are not required to be approved by the AHJ until the AHJ is ready to issue the certificate of occupancy, as opposed to the permit to construct. The Certificates of Compliance must be completed and made available to the AHJ during all inspections. This is, of course, augmented by the ultimate authority of the AHJ to require the submittal of all compliance documents, including supporting documents, at any point during the permitting process, including at the application for a permit to construct. Therefore, it is highly recommended that project proponents discuss the submission requirements with the AHJ directly.

The AHJ is intended to review and verify that all elements (specifications for the features, materials, components, and manufactured devices) of the Certificates of Compliance are included correctly in the plans and specifications submitted for the permit application. This would typically be done at plan review. The AHJ Plan Review must also review the permit application for compliance with the Energy Code for elements that are not included on the Certificates of Compliance as well. The plans and specifications that are submitted for the permit application must include indications where FV&DT and/or acceptance testing is required by the Energy Code for the project.

Change-Orders

If a change from the original design is still compliant with the Energy Code, then there is no requirement to make changes to the Certificate(s) of Compliance. The issue arises when the change is not in compliance with the Energy Code. In that case, the project design must be brought back into compliance, the Certificate(s) of Compliance must be updated with the project plans, and the plans must be re-approved by the AHJ. The AHJ may have a specific process for handling change-orders, which should be followed and will generally address the Energy Code requirements. **«»**

Section 10-103(a)3 – Certificate of Installation

3. **Certificate of Installation.** For all buildings, the person in charge of the construction or installation, who is eligible under Division 3 of the Business and Professions Code to accept responsibility for the construction or installation of features, materials, components, or manufactured devices regulated by Part 6 or the Appliance Efficiency Regulations (*responsible person*) shall sign and submit Certificate of Installation documentation as specified in Section 10-103(a)3 to certify conformance with Part 6. If more than one person has responsibility for the construction or installation, each person shall sign and submit the Certificate of Installation documentation applicable to the portion of the construction or installation for which they are responsible; alternatively, the person with chief responsibility for the construction or installation shall sign and submit the Certificate of Installation documentation for the entire construction or installation scope of work for the project. Subject to the requirements of Section 10-103(a)3, persons who prepare Certificate of Installation documentation (*documentation authors*) shall sign a declaration statement on the documents they prepare to certify the information provided on the documentation is accurate and complete. In accordance with applicable requirements of 10-103(a)3, the signatures provided by *responsible persons* and *documentation authors* shall be original signatures on paper documents or electronic signatures on electronic documents

conforming to the electronic signature specifications in Reference Joint Appendix JA7.

«» Commentary for Section 10-103(a)3:

The responsible person indicated under Section 10-103(a)3 to sign the Certificate of Installation is not typically the same as person that signs on the Certificates of Compliance, unless that person is qualified for that trade under Division 3 of the Business and Professions Code. The installing contractor or technician in the employ of the contractor typically acts as the responsible person for the Certificates of Installation. The Energy Commission may refer to the Certificates of Installation responsible person signatory as the installing contractor signatory. **«»**

Section 10-103(a)3A – Delegation of Signature Authority

A. **Delegation of Signature Authority.** Except where prohibited by law, including but not limited to any requirements under Division 3 of the Business and Professions Code, the *Responsible Person* may delegate signature authority to third parties (*Authorized Representatives*) provided that there is a written agreement:

   i. Between the *Responsible Person* and the person to be designated as the *Authorized Representative*.

   ii. Specifying that the *Authorized Representative* may sign Certificates of Installation on behalf of the *Responsible Person*.

   iii. Specifying that the legal responsibility for construction or installation in the applicable classification for the scope of work specified on the Certificate of Installation document(s) remains with the Responsible Person.

   iv. That is signed by both the *Responsible Person* and the *Authorized Representative*.

   v. That is retained by the ECC-provider to which all compliance documents are submitted for the building to which the Certificate of Installation documentation pertains.

   vi. That is maintained in the ECC-provider data registry such that it is accessible for verification by, including but not limited to, the Energy Commission and enforcement agencies.

«» Commentary for Section 10-103(a)3A:

The delegation of signature authority was originally set up to encourage the completion of the Certificates of Installation by allowing the Rater to complete the form. The Certificates of Installation were generally being ignored by installing contractors and AHJs and, when completed, were generally completed incorrectly. This was most often the case for when FV&DT was required and very consistently the case when sampling was used. To combat this issue, it was decided that the Rater would be allowed to complete the Certificates of Installation for the installing contractors, with some restrictions. It had to be a written agreement between the contractors acting as the Certificate of Installation responsible person and the ‘Authorized Representative, in almost all case, the Rater. However, the responsibility for the scope of work remains with the responsible person. Both parties must sign the agreement, and the agreement must be retained by the Provider where the Certificates of Installation are registered. To date, only Raters have acted as Authorized Representatives for Certificates of Installation responsible persons. «»

Section 10-103(a)3B – Format of Certificate of Installation

B. **Format.** All Certificate of Installation documentation shall conform to a format and informational order and content approved by the Energy Commission.

These documents shall:

i. Identify the features, materials, components, manufactured devices, and system performance diagnostic results required to demonstrate compliance with Part 6 and the Appliance Efficiency Regulations.

ii. State the number of the building permit under which the construction or installation was performed.

iii. Display the unique registration number assigned by the data registry if Section 10-103(a)3 requires the document to be registered.

iv. Include a declaration statement indicating that the constructed or installed features, materials, components or manufactured devices (the installation) identified on the 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.

v. Be signed by the *documentation author* to certify the documentation is accurate and complete. When document registration is required by Section 10-103(a)3, the signature shall be an electronic signature on an electronic document in accordance with the electronic signature specifications in Reference Joint Appendix JA7.

vi. Be signed by the *Responsible Person* eligible under Division 3 of the Business and Professions Code to accept responsibility for construction or installation in the applicable classification for the scope of work specified on the Certificate of Installation document(s), or shall be signed by their *Authorized Representative*. When document registration is required by Section 10-103(a)3, the signature shall be an electronic signature on an electronic document in accordance with the electronic signature specifications in Reference Joint Appendix JA7.

«» Commentary for Section 10-103(a)3B:

Section 10-103(a)3B describes the requirements for the Certificates of Installation which includes the low-rise multifamily Certificate of Installation (LMCI) and nonresidential

Certificate of Installation (NRCI). It specifically requires that they conform to a format, informational order, and content approved by the Energy Commission. This also allows the Energy Commission to approve alternative compliance documents. The responsible person, and to a lesser extent the documentation author, are responsible to ensure that the compliance documents match or are at least consistent with the permit application (i.e., compliance documents, worksheets, calculations, plans, and specifications submitted to the AHJ for approval through the construction permit application process).

Construction Phase Documentation

The Certificates of Installation are separated into envelope, lighting, mechanical, plumbing, and solar categories. Most compliance features have a separate Certificate of Installation form that is specific to a particular trade (e.g. electrical, plumbing, HVAC, etc.). The Certificates of Installation forms are completed during the construction or installation phase by the contractors responsible for installing regulated energy features such as fenestration, air distribution ducts and other requirements that affect building energy performance. The Certificates of Installation must be posted at the job site, kept with the building permit, or otherwise submitted to the enforcement agency.

Certificates may be produced using a residential data registry, using a downloaded blank form, or by using a document generator. **«»**

Section 10-103(a)3C

C. For all low-rise residential buildings, the person(s) responsible for the Certificate(s) of Installation, or their *Authorized Representative(s)*, shall submit the following Certificate of Installation documentation and their associated Compliance Registration Packages that is applicable to the building to an ECC-provider data registry for registration and retention in accordance with Section 10-103.3 and procedures specified in Reference Residential Appendix RA2:

   i. All Certificates of Installation for which compliance requires field verification.

   ii. All other Certificates of Installation, except those not required by the Energy Commission.

   The submittals to the ECC-provider data registry shall be made electronically in accordance with the specifications in Reference Joint Appendix JA7.

   Contingent upon availability and approval of an electronic document repository by the Executive Director, Certificate of Installation documents and their associated Compliance Registration Packages that are registered and retained by an ECC-provider data registry in compliance with Section 10-103.3 shall also be automatically transmitted by the data registry to an electronic document repository for retention in accordance with the specifications in Reference Joint Appendix JA7.

«» Commentary for Section 10-103(a)3C:

Section 10-103(a)3C refers to low-rise residential buildings, which includes both single-family and LRMF buildings. For a discussion on single-family residential buildings please review the Single Family Residential Compliance Manual. LRMF projects that are also required to comply with the FV&DT regulations must register the associated LMCIs with an Energy Commission approved residential data registry. When field verification of a feature is required, the builder or subcontractor performs the diagnostic test (Reference Residential Appendix RA3) of the installation to confirm compliance with the approved design requirements and the Energy Code. The Certificates of Installation for multifamily buildings with three or fewer habitable stories are registered with an ECC-Provider's data registry and made available to the enforcement agency. Table 2-3: Certificates of Installation by Application and Number of Stories shows compliance documents based on the application and number of stories.

Table 2-3: Certificates of Installation by Application and Number of Stories

Application	Documentation Required for Buildings up to Three Habitable Stories when Applicable	Able to be registered in a Residential Data Registry[1]	Documentation Required for Buildings Four or more Habitable Stories when Applicable
Electric Ready Requirements	LMCI-ELC-01-E	Yes	NRCI-ELC-E
Electrical Power Distribution	LMCI-ELC-E	See note	NRCI-ELC-E
Envelope – Non-FV&DT	LMCI-ENV-E	See note	NRCI-ENV-E
Envelope – QII	LMCI-ENV-21-H LMCI-ENV-22-H	Yes	Not Applicable
Indoor Lighting	LMCI-LTI-E	No	NRCI-LTI-E
Outdoor Lighting	LMCI-LTO-E	No	NRCI-LTO-E
Sign Lighting	LMCI-LTS-E	No	NRCI-LTS-E
Mechanical – Common Spaces	LMCI-MCH-E	No	NRCI-MCH-E
Mechanical – FV&DT	LMCI-MCH-01(a-d)-E LMCI-MCH-(20-29)-H LMCI-MCH-(32-33)-H	Yes, except for LMCI-MCH-01c-E (See note)	NRCI-MCH-20(a-e)-F NRCI-MCH-(22-23)-F NRCI-MCH-25(a-c, f)-F

Application	Documentation Required for Buildings up to Three Habitable Stories when Applicable	Able to be registered in a Residential Data Registry[1]	Documentation Required for Buildings Four or more Habitable Stories when Applicable
Plumbing – Multifamily central hot water system distribution	LMCI-PLB-21-H LMCI-PLB-22-H	Yes	NRCI-PLB-E
Plumbing – Non-FV&DT	LMCI-PLB-01-E LMCI-PLB-02-E	Yes	NRCI-PLB-E
Plumbing – Non-FV&DT Domestic Water	LMCI-PLB-E	No	NRCI-PLB-E
Plumbing – Pools and Spas	LMCI-PLB-03-E	Yes; Not required to be registered	Not Applicable
Covered Process	LMCI-PRC-E	No	NRCI-PRC-E
Solar and Battery	LMCI-SRB-E	No	NRCI-SAB-E

Source: California Energy Commission

«»

Section 10-103(a)3D – Certificate of Installation - Alterations

D. For alterations to existing residential buildings for which field verification is not required, including but not limited to water heater and window replacements, and for additions to existing residential buildings that are less than 300 square feet for which field verification is not required, the enforcement agencies may, at their discretion, not require any Certificate of Installation documentation, or may develop simplified Certificate of Installation documentation for demonstrating compliance with the Standards.

Allowances by enforcement agencies to not require compliance documentation shall not be deemed to grant authorization for any work to be done in any manner in violation of this code or other provisions of law.

«» Commentary for Section 10-103(a)3D:

Section 10-103(a)3D refers to existing residential buildings which includes both single-family and LRMF buildings. For a discussion on single-family residential buildings please review the Single Family Residential Compliance Manual. For LRMF addition and alteration projects that do require FV&DT, Section 10-103(a)3D allows the AHJ, at its discretion, to either not require any LMCIs or develop its own Certificates of Instillation. The AHJ need not seek Energy Commission approval prior to implementing this option. If an AHJ develops its own Certificates of Installation for these types of projects, it must ensure compliance with the Energy Code. **«»**

Section 10-103(a)3E – Nonresidential Data Registry

E. Contingent upon approval of data registry(s) by the Commission, all nonresidential buildings, high-rise residential buildings, and hotels and motels, when designated to allow use of an occupancy group or type regulated by Part 6 the person(s) responsible for the Certificate(s) of Installation, except those documents not required by the Energy Commission, shall submit the Certificate(s) and their associated Compliance Registration Packages for registration and retention to a data registry approved by the Commission. The submittals to the approved data registry shall be made electronically in accordance with the specifications in Reference Joint Appendix JA7.

Contingent upon availability and approval of an electronic document repository by the Executive Director, Certificate of Installation documents and their associated Compliance Registration Packages that are registered and retained by an approved data registry shall also be automatically transmitted by the data registry to an electronic document repository for retention in accordance with the specifications in Reference Joint Appendix JA7.

«» Commentary for Section 10-103(a)3E:

Until a nonresidential data registry is approved by the California Energy Commission, there is no requirement to register multifamily buildings with four or more habitable stories, compliance documents. A data registry could be approved mid-code cycle, and upon approval registration of NRCI documents would be required. If a nonresidential data registry is approved, the California Energy Commission will issue a Regulatory Advisory. **«»**

Section 10-103(a)3F - Availability

F. **Availability.** For all buildings, a copy of the Certificate(s) of Installation shall be posted, or made available with the building permit(s) issued for the building, or made available for viewing on an approved data registry, and shall be made available to the enforcement agency for all applicable inspections. When document registration is required by Section 10-103(a)3, registered copies of the Certificate(s) of Installation from an ECC-provider data registry or a data registry approved by the Commission shall be posted or made available with the building permit(s) issued for the building, and shall be made available to the enforcement agency for all applicable inspections. If construction on any portion of the building subject to Part 6 will be impossible to inspect because of subsequent construction, the enforcement agency may require the Certificate(s) of Installation to be posted upon completion of that portion. A copy of the Certificate(s) of Installation shall be included with the documentation the builder provides to the building owner at occupancy as specified in Section 10-103(b).

«» Commentary on Section 10-103(a)3F:

Section 10-103(a)3F is a simple requirement to make the completed Certificates of Installation available to the AHJ. This can be done in many ways and when a data registry is involved, it can include a link to the registered documents within the registry. For compliance with this section, we advise that the builder discuss the preferred options with the AHJ. «»

Section 10-103(a)4A

4. **Certificate of Acceptance.** For all nonresidential buildings, high-rise residential buildings, and hotels and motels, when designated to allow use of an occupancy group or type regulated by Part 6 the person in charge of the acceptance testing, who is eligible under Division 3 of the Business and Professions Code to accept responsibility for the applicable scope of system design, or construction, or installation of features, materials, components, or manufactured devices regulated by Part 6 or the Appliance Efficiency Regulations (*responsible person*), shall sign and submit all applicable Certificate of Acceptance documentation in accordance with Section 10-103(a)4 and Reference Nonresidential Appendix NA7 to certify conformance with Part 6. If more than one person has responsibility for the acceptance testing, each person shall sign and submit the Certificate of Acceptance documentation applicable to the portion of the construction or installation, for which they are responsible; alternatively, the person with chief responsibility for the system design, construction, or installation, shall sign and submit the Certificate of Acceptance documentation for the entire construction or installation scope of work for the project. Subject to the requirements of Section 10-103(a)4, persons who prepare Certificate of Acceptance documentation (*documentation authors*) shall sign a declaration statement on the documents they prepare to certify the information provided on the documentation is accurate and complete. Persons who perform acceptance test procedures in accordance with the specifications in Reference Nonresidential Appendix NA7, and report the results of the acceptance tests on the Certificate of Acceptance (*field technicians*) shall sign a declaration statement on the documents they submit to certify the information provided on the documentation is true and correct. In accordance with applicable requirements of Section 10-103(a)4, the signatures provided by *responsible persons*, *field technicians*, and *documentation authors* shall be original signatures on paper documents or electronic signatures on electronic documents conforming to the electronic signature specifications in Reference Joint Appendix JA7.

   A. All Certificate of Acceptance documentation shall conform to a format and informational order and content approved by the Energy Commission.

   These documents shall:

i. Identify the features, materials, components, manufactured devices, and system performance diagnostic results required to demonstrate compliance with the acceptance requirements to which the applicant must conform as indicated in the plans and specifications submitted under Section 10-103(a)2, and as specified in Reference Nonresidential Appendix NA7.

ii. State the number of the building permit under which the construction or installation was performed.

iii. Display the unique registration number assigned by the data registry if Section 10-103(a)4 requires the document to be registered.

iv. Include a declaration statement indicating that the features, materials, components or manufactured devices identified on the Certificate of Acceptance conform to the applicable acceptance requirements as indicated in the plans and specifications submitted under Section 10-103(a), and with applicable acceptance requirements and procedures specified in the Reference Nonresidential Appendix NA7, and confirms that Certificate(s) of Installation described in Section 10-103(a)3 has been completed and is posted or made available with the building permit(s) issued for the building, or made available for viewing on an approved data registry.

v. Be signed by the *documentation author* to certify the documentation is accurate and complete. When document registration is required by Section 10-103(a)4, the signature shall be an electronic signature on an electronic document in accordance with the electronic signature specifications in Reference Joint Appendix JA7.

vi. Be signed by the *field technician* who performed the acceptance test procedures and reported the results on the Certificate of Acceptance. When document registration is required by Section 10-103(a)4, the signature shall be an electronic signature on an electronic document in accordance with the electronic signature specifications in Reference Joint Appendix JA7.

vii. Be signed by the *responsible person* in charge of the acceptance testing who is eligible under Division 3 of the Business and Professions Code to accept responsibility for the system design, construction or installation in the applicable classification for the scope of work identified on the Certificate of Acceptance, or shall be signed by their authorized representative. When document registration is required by Section 10-103(a)4, the signature shall be an electronic signature on an electronic document in accordance with the electronic signature specifications in Reference Joint Appendix JA7.

«» Commentary for Section 10-103(a)4A:

The Energy Code requires specific acceptance testing for lighting controls, HVAC controls, air distribution ducts, envelope features, and special purpose equipment, referred to as covered processes. The Energy Code allows the installing contractor to perform this acceptance testing if they are certified as described below. However, the Energy Code acceptance testing procedures do not alleviate the installing contractor from performing any manufacturer required startup and commissioning tests for the installed energy efficiency feature.

Certified technicians who conduct acceptance testing for lighting and mechanical systems are required to be trained and certified by a CEC-approved Acceptance Test Technician Certification Provider (ATTCP). These certified technicians are referred to as acceptance test technicians (ATTs). The CEC verifies that the ATTCP provides the required classroom and hands-on training to perform the required acceptance tests and complete the required documentation (Section 10-103.1 or Section 10-103.2). Builders and installers will need to ensure that an ATT conducts the required acceptance testing and completes the required Nonresidential Certificates of Acceptance (NRCA) for lighting controls and mechanical systems. For this purpose, the ATTCPs provide publicly available lists of ATTs certified by the ATTCP. Enforcement agency field inspectors can verify that the submitted NRCAs are signed by an ATT using the same public lists and by inspection of the NRCA itself. Each NRCA is watermarked by the ATTCP that certified the ATT for authentication. The NRCA itself can also be verified by the ATTCP as valid by contacting the ATTCP by phone or email. The CEC maintains a link to all ATTCPs at its ATTCP web page (https://www.energy.ca.gov/programs-and-topics/programs/acceptance-test-technician-certification-provider-program/acceptance). Table 2-4: Nonresidential Certificate of Acceptance lists the Energy Code required NRCAs and indicates which are to be completed by ATTs through the ATTCP program. For more information on the ATTCP program, see Chapter 14 of the Nonresidential Compliance Manual.

Table 2-4: Nonresidential Certificate of Acceptance

Certificate of Acceptance	Description	ATTCP Required	ATT-Alternative to Rater FV&DT
NRCA-ENV-02-A	Envelope – Fenestration	No	No
NRCA-ENV-03-A	Envelope – Daylight PAFs	No	No
NRCA-LTI-02-A	Lighting Controls - Shutoff	Yes	No
NRCA-LTI-03-A	Lighting Controls – Daylighting	Yes	No
NRCA-LTI-04-A	Lighting Controls – Demand Response	Yes	No

Certificate of Acceptance	Description	ATTCP Required	ATT-Alternative to Rater FV&DT
NRCA-LTI-05-A	Lighting Controls – Institutional Tuning	Yes	No
NRCA-LTO-02-A	Lighting Controls – Outdoor	Yes	No
NRCA-MCH-02-A	Mechanical – Outdoor Air	Yes	No
NRCA-MCH-03-A	Mechanical – Constant Volume	Yes	No
NRCA-MCH-04-A	Mechanical – Duct Leakage	Yes	No
NRCA-MCH-05-A	Mechanical – Economizer	Yes	No
NRCA-MCH-06-A	Mechanical – Demand Control	Yes	No
NRCA-MCH-07-A	Mechanical – Supply Control	Yes	No
NRCA-MCH-08-A	Mechanical -Valve Leakage	Yes	No
NRCA-MCH-09-A	Mechanical – Supply Water	Yes	No
NRCA-MCH-10-A	Mechanical – Hydronic System	Yes	No
NRCA-MCH-11-A	Mechanical – Demand Shed Control	Yes	No
NRCA-MCH-12-A	Mechanical – FDD Package Direct	Yes	No
NRCA-MCH-13-A	Mechanical – FDD AHU/ZTU	Yes	No
NRCA-MCH-14-A	Mechanical – Energy Storage	Yes	No
NRCA-MCH-15-A	Mechanical – Thermal Energy Storage	Yes	No
NRCA-MCH-16-A	Mechanical – Supply Air Temp.	Yes	No
NRCA-MCH-17-A	Mechanical – Condenser Water Temp.	Yes	No
NRCA-MCH-18-A	Mechanical — EMCS	Yes	No
NRCA-MCH-19-A	Mechanical – Occupancy Sensor	Yes	No
NRCA-MCH-20a-H	Mechanical – Multi-Family Dwelling Inspection	Yes	Alternative
NRCA-MCH-20b-H	Mechanical – MF Kitchen Exhaust	Yes	Alternative
NRCA-MCH-20c-H	Mechanical – MF IAQ System	Yes	Alternative

Certificate of Acceptance	Description	ATTCP Required	ATT-Alternative to Rater FV&DT
NRCA-MCH-20d-H	Mechanical – MF Dwelling HRV/ERV System	Yes	Alternative
NRCA-MCH-21-H	Mechanical – MF Dwelling Leakage	Yes	Alternative
NRCA-MCH-22-A	Mechanical – MF Duct Leakage	Yes	No
NRCA-MCH-23-A	Mechanical – MF HRV/ERV Verification	Yes	No
NRCA-MCH-24-A	Cooling Tower Conductivity Controls	Yes	No
NRCA-PRC-01-F	Covered Process – Compressed Air	No	No
NRCA-PRC-02-F	Covered Process – Kitchen Exhaust	No	No
NRCA-PRC-03-F	Covered Process – Garage Exhaust	No	No
NRCA-PRC-04-F	Covered Process – Refrigerated Warehouse Evaporator and Fan Controls	No	No
NRCA-PRC-05-F	Covered Process – RW Evaporator Controls	No	No
NRCA-PRC-06-F	Covered Process — Air Cooled Condensers	No	No
NRCA-PRC-07-F	Covered Process — Variable Speed Condensers	No	No
NRCA-PRC-08-F	Covered Process - RW Underslab Heating	No	No
NRCA-PRC-12-F	Covered Process – Elevator Lighting and Ventilation	No	No
NRCA-PRC-13-F	Covered Process – Escalator Speed Control	No	No
NRCA-PRC-14(a-c3)-F	Covered Process – Lab Exhaust	No	No
NRCA-PRC-15-F	Covered Process – Fume Hood	No	No
NRCA-PRC-16-F	Covered Process – Adiabatic Condenser	No	No

Certificate of Acceptance	Description	ATTCP Required	ATT-Alternative to Rater FV&DT
NRCA-PRC-17-F	Transcritical Refrigeration	No	No

Source: California Energy Commission

«»

Section 10-103(a)4B

B. Contingent upon approval of data registry(s) by the Commission, for all nonresidential buildings, high-rise residential buildings, and hotels and motels, when designated to allow use of an occupancy group or type regulated by Part 6 the person(s) responsible for the Certificate(s) of Acceptance shall submit the Certificate(s) and their associated Compliance Registration Packages for registration and retention to a data registry approved by the Commission, excluding all Certificates of Acceptance recorded by an acceptance test technician certification provider (10-103.1 and 10-103.2). The submittals to the approved data registry shall be made electronically in accordance with the specifications in Reference Joint Appendix JA7.

Contingent upon availability and approval of an electronic document repository by the Executive Director, Certificate of Acceptance documents and their associated Compliance Registration Packages that are registered and retained by an approved data registry shall also be automatically transmitted by the data registry, to an electronic document repository for retention in accordance with the specifications in Reference Joint Appendix JA7.

«» Commentary for Section 10-103(a)4B:

Until a nonresidential data registry is approved by the California Energy Commission, there is no requirement to register high rise multifamily buildings with four or more habitable stories compliance documents. A data registry could be approved mid-code cycle, and upon approval registration of NRCA documents would be required. If a nonresidential data registry is approved, the California Energy Commission will issue a Regulatory Advisory. «»

Section 10-103(a)4C

C. A copy of the Certificate(s) of Acceptance shall be posted, or made available with the building permit(s) issued for the building, and shall be made available to the enforcement agency for all applicable inspections. If construction on any portion of the building subject to Part 6 will be impossible to inspect because of subsequent construction, the enforcement agency may require the Certificate(s) of Acceptance to be posted upon completion of that portion. A copy of the Certificate(s) of Acceptance shall be included with the documentation the builder provides to the building owner at occupancy as specified in Section 10-103(b).

«» Commentary for Section 10-103(a)4C:

Section 10-103(a)4C is similar to Section 10-103(a)3F, a simple requirement to make the completed Certificate(s) of Acceptance available to the AHJ. In the case of high rise multifamily buildings, this may also involve acceptance tests from the ATTCPs when lighting controls or HVAC acceptance testing is required. The ATTCP uses a central system to verify and normalize the NRCAs completed by the ATTs. Each page of the NRCAs produced by the ATTCPs will include the ATTCP-Logo, as well as a watermark. The NRCAs are published in a PDF format and can be submitted to the AHJ either hardcopy or e-copy. It is strongly recommended that the ATT verify exactly how the NRCA are to be made available to the AHJ. **«»**

Section 10-103(a)5 – Certificates of Verification

5. **Certificate of Field Verification and Diagnostic Testing (Certificate of Verification).** For all buildings for which compliance requires field verification, a certified ECC-Rater shall conduct all required field verification and diagnostic testing in accordance with applicable procedures specified in Reference Appendices RA2, RA3, NA1, and NA2. All applicable Certificate of Verification documentation shall be completed, signed, and submitted by the certified ECC-Rater who performed the field verification and diagnostic testing services (*responsible person*) in accordance with the requirements of Section 10-103(a)5, and Reference Appendices RA2, and NA1, to certify conformance with Part 6. If more than one rater has responsibility for the verification for the building, each rater shall sign and submit the Certificate of Verification documentation applicable to the portion of the building for which they are responsible. Subject to the requirements of Section 10-103(a)5, persons who prepare Certificate of Verification documentation (*documentation authors*) shall sign a declaration statement on the documents they prepare to certify the information provided on the documentation is accurate and complete. The signatures provided by *responsible persons* and *documentation authors* shall be electronic signatures on electronic documents.

   A. **Format.** All Certificate of Verification documentation shall conform to a format and informational order and content approved by the Energy Commission.

      These documents shall:

      i. Identify the installed features, materials, components, manufactured devices, or system performance diagnostic results that require verification for compliance with Part 6 as specified on the Certificate(s) of Compliance for the building.

      ii. State the number of the building permit under which the construction or installation was performed,

iii. Display the unique registration number assigned by the ECC-provider data registry, and provide any additional information required by Reference Appendices RA2, RA3, NA1, and NA2.

iv. Include a declaration statement indicating that the installed features, materials, components or manufactured devices requiring verification conform to the applicable requirements in Reference Appendices RA2, RA3, NA1, NA2, and the requirements specified on the Certificate(s) of Compliance approved by the local enforcement agency, and confirms the same features, materials, components or manufactured devices are identified on the applicable Certificate(s) of Installation signed and submitted by the person(s) responsible for the construction or installation as described in Section 10-103(a)3.

v. Be signed by the *documentation author* to certify the documentation is accurate and complete. The signatures shall be electronic signatures on electronic documents in accordance with the electronic signature specifications in Reference Joint Appendix JA7.

vi. Be signed by the ECC-Rater who performed the field verification and diagnostic testing services (*responsible person)*. The signatures shall be electronic signatures on electronic documents in accordance with the electronic signature specifications in Reference Joint Appendix JA7.

B. For all buildings for which compliance requires field verification, the certified ECC-Rater responsible for the Certificate(s) of Verification shall submit the Certificates and their associated Compliance Registration Packages for registration and retention to a ECC-provider data registry in accordance with the applicable procedures in Reference Appendices RA2 and NA1, and in compliance with Section 10-103.3.

The submittals to the ECC-provider data registry shall be made electronically in accordance with the specifications in Reference Joint Appendix JA7.

Contingent upon availability and approval of an electronic document repository by the Executive Director, Certificate of Verification documents and their associated Compliance Registration Packages that are registered and retained by an ECC-provider data registry in accordance with Section 10-103.3 shall also be automatically transmitted by the data registry, to an electronic document repository for retention in accordance with the specifications in Reference Joint Appendix JA7.

C. **Availability.** For all buildings, a copy of the registered Certificate(s) of Verification shall be posted, or made available with the building permit(s) issued for the building, or made available for viewing on an approved data registry, and shall be made available to the enforcement agency for all applicable inspections. If construction on any portion of the building subject to Part 6 will be impossible to inspect because of subsequent construction, the enforcement agency may require the Certificate(s) of Verification to be posted upon completion of that portion. A copy of the registered Certificate(s) of Verification shall be included with the documentation the builder provides to the building owner at occupancy as specified in Section 10-103(b).

EXCEPTION to Section 10-103(a): Enforcing agencies may not require nonresidential buildings that have no more than 1,000 square feet of conditioned floor area in the entire building and an occupant load of 49 persons or less to comply with the documentation requirements of Section 10-103(a), provided a statement of compliance with Part 6 is submitted and signed by a licensed engineer or the licensed architect with chief responsibility for the design.

«» Commentary for Section 10-103(a)5:

Section 10-103(a)5 makes a slightly different statement of scope concerning the building projects that require FV&DT. Prior sections (10-103(a)1 and 3) made reference to “residential buildings,” which include single-family as well as LRMF buildings. Section 10-103(a)5 makes reference to “all buildings,” which include not only single-family and LRMF, but HRMF, hotel/motels, and nonresidential buildings. That is because the Energy Code requires select FV&DT on nonresidential construction and for the results to be registered and the appropriate certificates of verification completed. For a discussion on single-family residential buildings, please review the *2025 Single-Family Residential Compliance Manual.*

Section 10-103(a)5A identifies the requirements that must be followed to create the LRMF Certificates of Verification (LMCV), nonresidential certificates of Verification (NRCV) and nonresidential Certificates of Acceptance (NRCA). This section also requires that the LMCV be completed and signed by the documentation author as well as the Rater that completed the work regarding specific projects. Table 2-5: Certificates of Verification shows compliance documents based on the application.

Table 2-5: Certificates of Verification

Application (Residential)	LRMF Compliance Documents	HRMF Compliance Documents	HRMF Alternative Certificate of Acceptance Documents
MF Envelope Leakage	Not Applicable	NRCA-MCH-21-A	Not Applicable
QII Air infiltration sealing – Frame Stage	LMCV-ENV-21-H	Not Applicable	None
QII Insulation Installation	LMCV-ENV-22-H	Not Applicable	None

Application (Residential)	LRMF Compliance Documents	HRMF Compliance Documents	HRMF Alternative Certificate of Acceptance Documents
Duct Leakage Testing	LMCV-MCH-20(a-e)-H	NRCV-MCH-04(a-e)-H	
Duct Location	LMCV-MCH-21-H	Not Applicable	Not Applicable
Space Conditioning System Fan Efficacy	LMCV-MCH-22(a,b)-H LMCV-MCH-23(a-d)-H	Not Applicable	Not Applicable
Dwelling Unit Air Leakage Diagnostic Test Worksheet	LMCV-MCH-24(a,b)-H	NRCV-MCH-24(a,b)-H	Not Applicable
Refrigerant Charge Verification	LMCV-MCH-25(a-d)-H	Not Applicable	Not Applicable
Rated Space Conditioning System Equipment Verification	LMCV-MCH-26-H	Not Applicable	Not Applicable
Indoor Air Quality and Mechanical Ventilation – Total Vent Rate Method	LMCV-MCH-27b-H	NRCV-MCH-27-H	NRCA-MCH-20-H
Return Duct Design and Filter Device Sizing	LMCV-MCH-28-H	Not Applicable	Not Applicable
Duct Surface Area Reduction; R-Value, Buried Ducts Compliance Credit	LMCV-MCH-29-H	Not Applicable	Not Applicable
Local Mechanical Exhaust	LMCV-MCH-32-H	NRCV-MCH-32-H	NRCA-MCH-20-H

Application (Residential)	LRMF Compliance Documents	HRMF Compliance Documents	HRMF Alternative Certificate of Acceptance Documents
Variable Capacity Heat Pump Compliance Credit	LMCV-MCH-33-H	Not Applicable	Not Applicable
Verified Multifamily Central Hot Water System Distribution	LMCV-PLB-21-H LMCV-PLB-22-H	NRCV-PLB-21-H NRCV-PLB-22-H	None

Source: California Energy Commission

Registration of certificates of compliance, installation, and verification is required for all multifamily buildings up to three habitable stories (low rise multifamily buildings) for which compliance requires field verification. When registration is required, compliance documents are electronically completed using an approved ECC-Provider's residential data registry for registration and retention.

Compliance documents completed on an ECC-Provider data registry must be certified, by electronic signature, by the appropriate responsible person (Section 10-103). The registry will assign a unique registration number to each document when completed. The ECC-Provider data registry will retain the registered documents, which are available via secure internet access to authorized users. This allows authorized users to provide copies of registered documents for enforcement agencies or other purposes, as needed.

ECC-Raters produce a registered certificate of verification for each ECC-verified measure in each dwelling unit that the ECC-Rater determines has met the verification and/or diagnostic requirements for compliance. The ECC-Rater must not sign a certificate of verification for a measure that does not have a registered certificate of installation. If the installer placed a dwelling unit into a sample group, the certificates of verification will include additional information that identifies whether the measures were tested or not tested. The registry will indicate which dwelling unit was randomly selected by the ECC-Rater for testing. The certificates of verification for the tested measures will include the field verification results, while the certificates of verification for nontested measure will not include the field verification results. Refer to Reference Residential Appendix RA2 for more details on the field verification and certificate of verification documentation procedures.

Table 2-5: Certificates of Verification lists certificates of verification by the application and number of habitable stories. **«»**

Section 10-103(b) – Information Provided by the Builder

(b) Compliance, Operating, Maintenance, and Ventilation Information to be provided by Builder.

1. **Compliance information.**

   A. For low-rise residential buildings, at final inspection, the enforcement agency shall require the builder to leave in the building, copies of the completed, signed, and submitted compliance documents for the building owner at occupancy. For low-rise residential buildings, such information shall, at a minimum, include copies of all Certificate of Compliance, Certificate of Installation, and Certificate of Verification documentation submitted. These documents shall be in paper or electronic format and shall conform to the applicable requirements of Section 10-103(a).

   B. For nonresidential buildings, high-rise residential buildings and hotels and motels, at final inspection, the enforcement agency shall require the builder to leave in the building, copies of the completed, signed, and submitted compliance documents for the building owner at occupancy. For nonresidential buildings, high-rise residential buildings and hotels and motels, such information shall include copies of all Certificate of Compliance, Certificate of Installation, Certificate of Acceptance and Certificate of Verification documentation submitted. These documents shall be in paper or electronic format and shall conform to the applicable requirements of Section 10-103(a).

2. **Operating information.** At final inspection, the enforcement agency shall require the builder to leave in the building, for the building owner at occupancy, operating information for all applicable features, materials, components, and mechanical devices installed in the building. Operating information shall include instructions on how to operate the features, materials, components, and mechanical devices correctly and efficiently. The instructions shall be consistent with specifications set forth by the Executive Director. For low-rise residential buildings, such information shall be contained in a folder or manual which provides all information specified in Section 10-103(b). This operating information shall be in paper or electronic format.

   For dwelling units, buildings or tenant spaces that are not individually owned and operated, or are centrally operated, such information shall be provided to the person(s) responsible for operating the feature, material, component or mechanical device installed in the building. This operating information shall be in paper or electronic format.

3. **Maintenance information.** At final inspection, the enforcement agency shall require the builder to leave in the building, for the building owner at occupancy, maintenance information for all features, materials, components, and manufactured devices that require routine maintenance for efficient operation. Required routine maintenance actions shall be clearly stated and incorporated on a readily accessible label. The label may be limited to identifying, by title and/or

publication number, the operation and maintenance manual for that particular model and type of feature, material, component or manufactured device. For low-rise residential buildings, this information shall include a schedule of all interior luminaires and lamps installed to comply with Section 150.0(k).

For dwelling units, buildings or tenant spaces that are not individually owned and operated, or are centrally operated, such information shall be provided to the person(s) responsible for maintaining the feature, material, component or mechanical device installed in the building. This information shall be in paper or electronic format.

4. **Ventilation information.**

A. For low-rise and high-rise residential buildings, the enforcement agency shall require the builder to leave the following information in the building, for the building owner at occupancy:

i. A description of the quantities of outdoor air that the whole-dwelling unit ventilation system(s) are designed to provide to the building's conditioned space, and instructions for proper operation and maintenance of the ventilation system.

ii. Instructions for proper operation and maintenance of local exhaust systems, including instructions for conditions for which any occupant-controlled systems such as kitchen range hoods and bathroom exhaust fans should be used.

iii. For systems in buildings or tenant spaces that are not individually owned and operated by the dwelling unit occupants, the building's owner or their representative shall provide a copy of the ventilation system information to dwelling occupants at the beginning of their occupancy. For systems in buildings or tenant spaces that are centrally operated, all applicable ventilation system information shall be provided to the person(s) responsible for operating and maintaining the feature, material, component, or mechanical ventilation device installed in the building. This information shall be in paper or electronic format.

B. For nonresidential buildings, hotels, and motels, the enforcement agency shall require the builder to provide the building owner at occupancy a description of the quantities of outdoor and recirculated air that the ventilation systems are designed to provide to each area. For buildings or tenant spaces that are not individually owned and operated, or are centrally operated, such information shall be provided to the person(s) responsible for operating and maintaining the feature, material, component or mechanical device installed in the building. This information shall be in paper or electronic format.

Section 10-103(c) – Information Provided by the Manufacturer

(c) Equipment Information to be Provided by Manufacturer or Supplier. The manufacturer or supplier of any manufactured device shall, upon request, provide to building designers and installers information about the device. The information shall include the efficiency (and other characteristics regulated by Part 6). This information shall be in paper or electronic format.

Section 10-103(d) – Enforcement Agency Requirements

(d) Enforcement Agency Requirements.

1. **Permits.** An enforcement agency shall not issue a building permit for any construction unless the enforcement agency determines in writing that the construction is designed to comply with the requirements of Part 6 that are in effect on the date the building permit was applied for. The enforcement agency determination shall confirm that the documentation requirements of Sections 10-103(a)1 and 10-103(a)2 have been met.

   If a building permit has been previously issued, there has been no construction under the permit, and the permit has expired, the enforcement agency shall not issue a new permit unless the enforcement agency determines in writing that the construction is designed to comply with the requirements of Part 6 in effect on the date the new permit is applied for. The enforcement agency determination shall confirm that the documentation requirements of Sections 10-103(a)1 and 10-103(a)2 have been met.

   "Determines in writing" includes, but is not limited to, approval of a building permit with a stamp normally used by the enforcement agency.

2. **Inspection.** The enforcement agency shall inspect newly constructed buildings and additions, and alterations to existing buildings to determine whether the construction or installation is consistent with the agency's approved plans and specifications, and complies with Part 6. Final certificate of occupancy shall not be issued until such consistency and compliance is verified. For Occupancy Group R-3, final inspection shall not be complete until such consistency and compliance is verified.

   Such verification shall include determination that:

   A. All installed features, materials, components, or manufactured devices, regulated by the Appliance Efficiency Regulations or Part 6 are indicated, when applicable, on the Certificate(s) of Installation, Certificate(s) of Acceptance and Certificate(s) of Verification, and are consistent with such features, materials, components, or manufactured devices given in the plans and specifications and the Certificate(s) of Compliance approved by the local enforcement agency.

   B. All required Certificates of Installation are posted, or made available with the building permit(s) issued for the building, or made available for viewing on an approved data registry, and are made available to the enforcement agency for all applicable inspections, and that all required Certificates of Installation conform to the specifications of Section 10-103(a)3.

C. All required Certificates of Acceptance are posted, or made available with the building permit(s) issued for the building, and are made available to the enforcement agency for all applicable inspections, and that all required Certificates of Acceptance conform to the specifications of Section 10-103(a)4.

D. All required Certificates of Verification are posted, or made available with the building permit(s) issued for the building, or made available for viewing on an approved data registry, and are made available to the enforcement agency for all applicable inspections, and that all required Certificates of Verification conform to the specifications of Section 10-103(a)5.

«» Commentary for Section 10-103(d):

Section 10-103(d) relies on the building inspector to review all certificates of compliance to some degree throughout the permit process. Registered certificates are available on the registry or can be shared electronically. Electronic copies are easily authenticated by inspecting the digital signature of a document. The ECC-Provider offers verification methods for paper copies.

In addition, the data registry produces and updates the project status report of a building to outline required compliance documents per dwelling unit and per mechanical system and indicates whether the documents are registered, pending completion, and if any tested measures failed compliance. This project status report is intended to supplement field inspections. Certificates that have form numbers ending with an -H or -A have been tested by installers, raters, and testers. Certificates with form numbers that end with -E are completed by the builder or installer.

The building inspector should compare the contents of these documents with field conditions during construction and before final inspection. Inconsistencies that would present noncompliance without rework or revision to the certificates of compliance is intended be used to delay issuance of the certificate of occupancy. **«»**

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INTRODUCTION

Chapter 3 Introduction

This chapter covers envelope requirements for all dwelling units and common use areas in multifamily buildings for newly constructed buildings and additions or alterations to existing buildings.

Guidance on general requirements is included in the Multifamily Compliance Manual Chapter 1: General Requirements. Guidance on administrative requirements is included in the Multifamily Compliance Manual Chapter 2: Compliance and Enforcement. This chapter includes guidance on covered process system requirements.

Table 3-2: Excerpt from Table 100.0-A Application of Standards provides an overview of the location of the envelope requirements that apply to multifamily occupancies in the Energy Code.

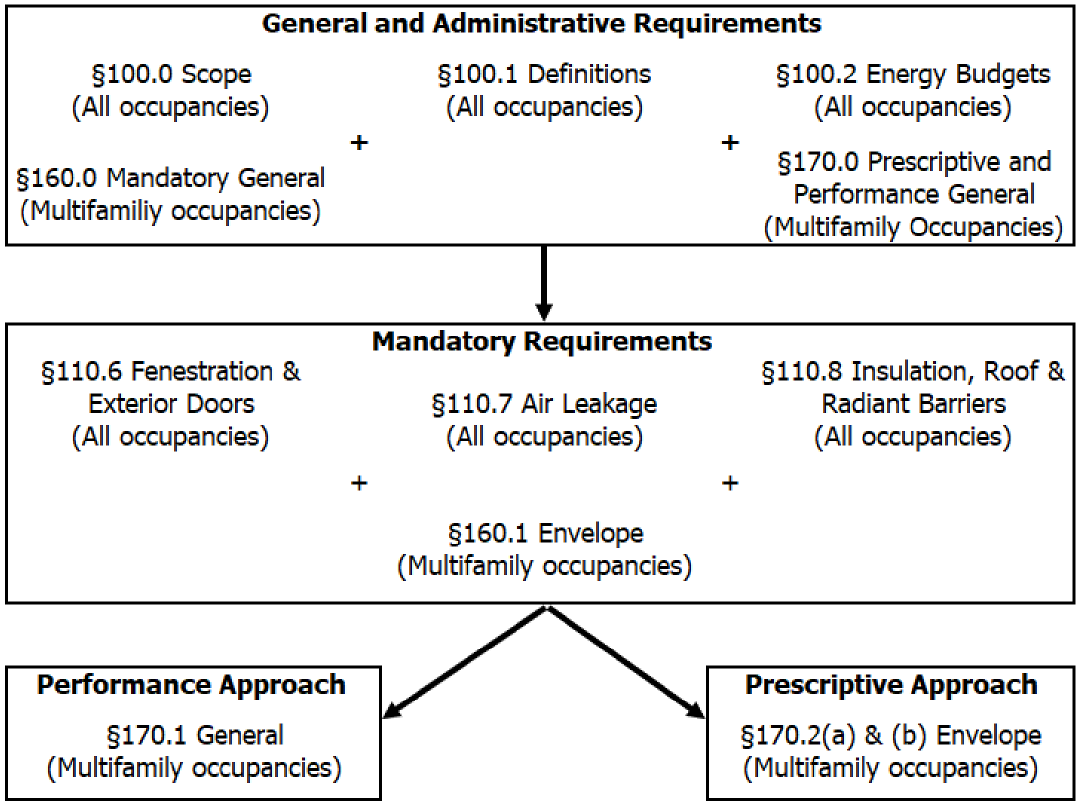
Table 3-2: Excerpt From Table 100.0-A Application of Standards

Application	Mandatory	Prescriptive	Performance	Additions/ Alterations
General[1]	160.0	170.0	170.0	180.0
Envelope (conditioned)	110.6, 110.7, 110.8, 160.1	170.2(a), 170.2(b)	170.1	180.1, 180.2

1. Guidance on General Requirements from Sections 160.0, 170.0 and 180.0 are included in the Multifamily Compliance Manual Chapter 1 General Requirements. Guidance specific to multifamily envelopes is included in this chapter.

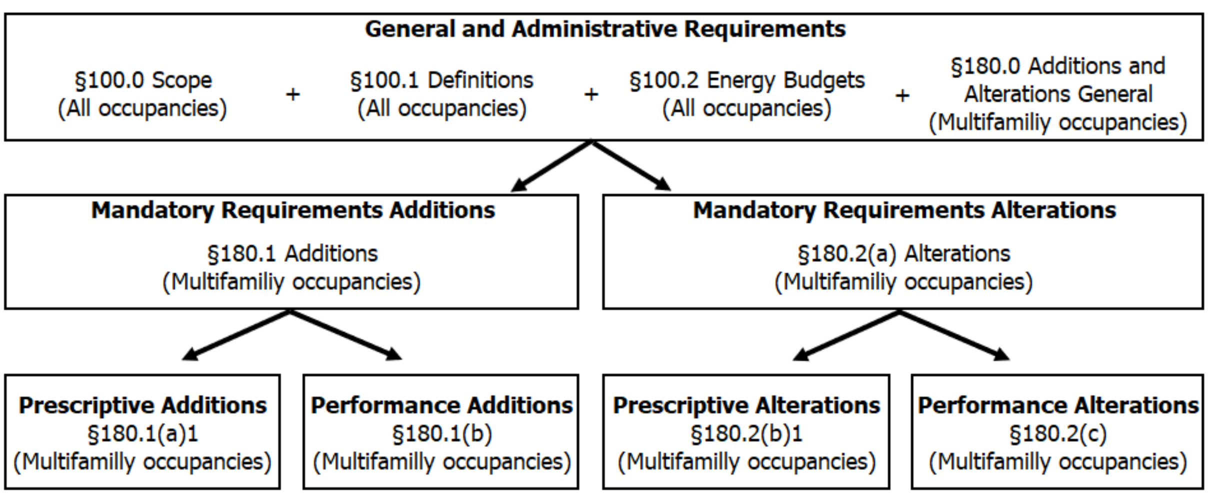
Figure 3-1: Flowchart Guidance for Application of New Construction Multifamily Envelope (Conditioned) Requirements and Figure 3-2: Flowchart Guidance for Application of Addition or Alteration Multifamily Envelope (Conditioned) Requirements below illustrate the applicable sections for newly constructed buildings and additions or alterations to existing buildings.

Figure 3-1: Flowchart Guidance for Application of New Construction Multifamily Envelope (Conditioned) Requirements



Newly Constructed Buildings Compliance Approaches

Figure 3-2: Flowchart Guidance for Application of Addition or Alteration Multifamily Envelope (Conditioned) Requirements



Addition, Alteration Compliance Approaches

Source: California Energy Commission

SECTION 110.6 – MANDATORY REQUIREMENTS FOR FENESTRATION PRODUCTS AND EXTERIOR DOORS

(a) Certification of fenestration products and exterior doors other than field-fabricated. Any fenestration product and exterior door, other than field-fabricated fenestration products and field-fabricated exterior doors, may be installed only if the manufacturer has certified to the Commission, or if an independent certifying organization approved by the Commission has certified, that the product complies with all of the applicable requirements of this subsection.

«» Commentary for Section 110.6(a):

Manufactured fenestration is a fenestration product constructed of materials that 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.

Site-built fenestration is designed to be field-glazed or field-assembled units, using specific factory-cut or other factory-formed framing and glazing units that are manufactured with the intention of being assembled at the construction site. These include storefront systems, curtain walls or large-track sliding glass walls, and atrium roof systems.

Field-fabricated fenestration is when the windows are fabricated at the building site from elements that are not sold together as a fenestration product (that is, 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). «»

1. **Air leakage.** Manufactured fenestration products and exterior doors shall have air infiltration rates not exceeding 0.3 cfm/ft^2 of window area, 0.3 cfm/ft^2 of door area for residential doors, 0.3 cfm/ft^2 of door area for nonresidential single doors (swinging and sliding), and 1.0 cfm/ft^2 for nonresidential double doors (swinging), when tested according to NFRC-400 or ASTM E283 at a pressure differential of 75 pascals (or 1.57 pounds/ft^2), incorporated herein by reference.

   NOTES TO SECTION 110.6(a)1: Pet doors must meet 0.3 cfm/ft^2 when tested according to ASTM E283 at 75 pascals (or 1.57 pounds per square foot). AAMA/WDMA/CSA 101/I.S.2/A440-2011 specification is equivalent to ASTM E283 at a pressure differential of 75 pascals (or 1.57 pounds per square foot) and satisfies the air leakage certification requirements of this section.

Exception to Section 110.6(a)1: Field-fabricated fenestration and field-fabricated exterior doors.

«» Commentary for Section 110.6(a)1:

Manufactured and site-built fenestration such as doors and windows must be tested and shown to have infiltration rates not exceeding the values shown in Table 3-2: Maximum Air Infiltration Rates. For field-fabricated products or exterior doors, the Energy Code requires that the unit be caulked, gasketed, weather stripped, or otherwise sealed. Unframed glass doors and fire doors are the two exceptions to these air leakage requirements.

Table 3-2: Maximum Air Infiltration Rates

Class	Type	Rate
Windows (cfm/ft^2) of window area	All	0.3
Residential Doors (cfm/ft^2) of door area	Swinging, Sliding	0.3
All Other Doors (cfm/ft^2) of door area	Sliding, Swinging (single door)	0.3
All Other Doors (cfm/ft^2) of door area	Swinging (double door)	1.0

Source: California Energy Commission, see Section 110.6(a)1

«»

2. **U-factor.** The fenestration product and exterior door's U-factor shall be rated in accordance with NFRC 100, or use the applicable default U-factor set forth in Table 110.6-A.

   Exception 1 to Section 110.6(a)2: If the fenestration product is a skylight in a building covered by the nonresidential standards with less than 200 square feet of skylight area, the default U-factor may be calculated as set forth in Reference Nonresidential Appendix NA6.

   Exception 2 to Section 110.6(a)2: If the fenestration product is an alteration consisting of any area replacement of glass in a skylight product in a building covered by the nonresidential standards, the default U-factor may be calculated as set forth in Reference Nonresidential Appendix NA6.

«» Commentary for Section 110.6(a)2:

U-Factor

A measure of how much heat can pass 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 square foot (ft^2) of window area per degree Fahrenheit (°F) of temperature difference (Btu/hr-ft^2-°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 fenestration products, the frame losses can be significant. **«»**

3. **Solar heat gain coefficient SHGC.** The fenestration product's SHGC shall be rated in accordance with NFRC 200, or use the applicable default SHGC set forth in TABLE 110.6-B.

   EXCEPTION 1 to Section 110.6(a)3: If the fenestration product is a skylight in a building covered by the nonresidential standards with less than 200 square feet of skylight area, the default SHGC may be calculated as set forth in Reference Nonresidential Appendix NA6.

   EXCEPTION 2 to Section 110.6(a)3: If the fenestration product is an alteration consisting of any area replacement of glass in a skylight product in a building covered by the nonresidential standards, the default SHGC may be calculated as set forth in Reference Nonresidential Appendix NA6.

«» Commentary for Section 110.6(a)3:

Solar Heat Gain Coefficient (SHGC)

The solar heat gain coefficient (SHGC) is a measure of the relative amount of heat gain from sunlight that passes through a fenestration product. The 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. The SHGC or $SHGC_t$ is the SHGC for the total fenestration product and is the value used for compliance with the standards. **«»**

4. **Visible transmittance (VT).** The fenestration product's VT shall be rated in accordance with NFRC 200 or ASTM E972, for tubular daylighting devices VT shall be rated using NFRC 203**.**

   Exception 1 to Section 110.6(a)4: If the fenestration product is a skylight in a building covered by the nonresidential standards with less than 200 square feet of skylight area, the default VT may be calculated as set forth in Reference Nonresidential Appendix NA6.

   Exception 2 to Section 110.6(a)4: If the fenestration product is an alteration consisting of any area; replacement of glass in a skylight product in a building covered by the nonresidential standards, the default VT may be calculated as set forth in Reference Nonresidential Appendix NA6.

«» Commentary for Section 110.6(a)4:

Visible Transmittance (VT)

Visible transmittance is the ratio of visible light transmitted through the fenestration. The higher the VT rating, the more light is allowed through a window. «»

5. **Labeling.** Fenestration products and exterior doors shall:

   A. Have a temporary label for manufactured fenestration products and exterior doors or a label certificate when the Component Modeling Approach (CMA) is used and for site-built fenestration meeting the requirements of Section 10-111(a)1. The temporary label shall not be removed before inspection by the enforcement agency; and

   B. Have a permanent label or label certificate when the Component Modeling Approach (CMA) is used and for site-built fenestration meeting the requirements of Section 10-111(a)2 if the product is rated using NFRC procedures.

«» Commentary for Section 110.6(a)5:

Certification and Labeling

The Administrative Regulations Section 10-111 and Section 110.6 require that fenestration products have labels that list the U-factor, SHGC, VT, and the method used to determine those values. The label must also certify that the fenestration product meets the requirements for air leakage from Section 110.6(a)1.

Manufactured (Factory-Assembled) Fenestration Label Certificates

Each manufactured (factory-assembled) fenestration product must have a clearly visible temporary label attached to it (Figure 3-3: NFRC Manufactured Label), which is not to be removed before inspection by the enforcement agency. The manufacturer rates and labels its fenestration products for U-factor, SHGC and VT.

The manufacturer can choose to have the fenestration product rated and labeled in accordance with the NFRC Rating Procedure (NFRC 100 for U-factors and NFRC 200 for SHGC and VT). If the manufactured fenestration product is rated using the NFRC rating procedure, it must also be permanently labeled in accordance with NFRC procedures.

Figure 3-3: NFRC Manufactured Label

Source: California Energy Commission

Component Modeling Approach (CMA)

The NFRC has developed a performance base calculation, the component modeling approach (CMA), to make the rating process quick and simple. This approach serves as an energy ratings certification program for fenestration products used in nonresidential and multifamily projects. The CMA allows users to assemble fenestration products in a virtual environment. The CMA draws data for NFRC-approved components from online libraries choosing from preapproved glazing, frame, and spacer components. CMA users are able to obtain preliminary ratings for various configurations of their designs. The CMA is a fair, accurate, and credible method based on NFRC 100 and 200 program documents, which are verified by third-party rating procedures. This tool helps users to:

1. Design energy-efficient windows, curtain wall systems, and skylights for high-performance building projects.
2. Determine whether a product meets the specifications for a project and local/state building energy codes.
3. Model different fenestration designs to compare energy performance.

Once the user is satisfied with the product, they create a bid report containing the data for all fenestration products to be reviewed. The windows are then built, either on-site or in a factory. The final products are reviewed and are rated by an NFRC-approved calculation entity (ACE) and a license agreement is signed with the NFRC. Then the NFRC issues a CMA label certificate (Figure 3-4: NFRC — CMA Label Certificate, Page

1) for the project. This label certificate is a document that lists the certified fenestration ratings at the NFRC standard testing size for the entire building project. Once approved, the CMA label certificate (Figure 3-5: NFRC — CMA Label Certificate, Page 2) is available online immediately. This certificate serves as code compliance documentation for fenestration energy performance, and the certified products may be applied to future projects without repeating the certification process.

Figure 3-4: NFRC — CMA Label Certificate, Page 1

NATIONAL FENESTRATION RATING COUNCIL
LABEL CERTIFICATE

PROJECT INFORMATION

LABEL CERTIFICATE ID: ***XYZ-001*** Issuance Date: mm/dd/yyyy

This is to be completed by an NFRC Approved Calculation Entity (ACE), based on information provided by the Specifying Authority and calculated in accordance with NFRC procedures.

PROJECT LOCATION:

Address: __________

City: ______, State, ______, Zip code: ______

Contact person: ______, Title: ______

Phone: ______, Facsimile: ______, Email: ______

Project name (optional): ______, Designer (optional): ______

Source: California Energy Commission

Figure 3-5: NFRC — CMA Label Certificate, Page 2

PRODUCT LISTING

FOR CODE COMPLIANCE

LABEL CERTIFICATE ID: ***XYZ-001*** Issuance Date: mm/dd/yyyy

NFRC CERTIFIED PRODUCT RATING INFORMATION:*

The NFRC Certified Product Rating Information listed here is to be used to verify that the ratings meet applicable energy code requirements.

PRODUCT LISTING:

						CERTIFIED Performance Rating at NFRC Model Size		
CPD ID	Total Area	Name	Framing Ref	Glazing Ref	Spacer Ref	U**	SHGC**	VT**
	ft^2					Btu/ $hr \cdot ft^2 \cdot °F$	-	-
P-PL-010	88.89	PL-2200 / PL-2210	FA-PL2210	GA-TT-001	SA-AM-001	0.53	0.58	0.66
P-PL-005	192.67	PL-3400 / PL-3401	FA-PL3401	GA-TT-001	SA-AM-002	0.56	0.57	0.65
P-PL-012	382.22	PL-5700 / PL-5720	FA-PL5720	GA-TO-002	SA-AM-001	0.52	0.21	0.30
P-PL-002	60.00	PL-1100 / PL-1152	FA-PL1152	GA-TT-001	SA-AM-001	0.42	0.51	0.62
P-PL-022	525.00	PL-9900 / PL-9915	FA-PL9915	GA-TO-003	SA-AM-002	0.45	0.15	0.19

Source: California Energy Commission

Benefits of CMA

The CMA provides facility managers, specifiers, building owners, and design teams with a simple method for designing and certifying the energy performance of fenestration systems for their buildings without having to test every possible variation of glazing and framing. This is significantly less expensive than building sample wall sections and testing them in a large test enclosure. There are several additional advantages gained by using the CMA:

1. CMA's online tool has the ability to output a file with values for use in building energy analysis software programs.
2. The program can export detailed information for angular-dependent SHGC and VT values, seamlessly transferring the data to the analytical software.
3. A 2010 study conducted in California demonstrated that fenestration modeled with the CMA program can provide an increase in compliance margins by as much as 11.7 percent over the Energy Code default calculation methods.
4. CMA can help demonstrate above-code performance, which is useful for environmental rating programs such as Leadership in Energy and Environmental Design (LEED™) or local green building programs.

Use of the CMA can lead to a more efficient building and enable cost savings due to more accurate fenestration performances and potential energy benefits from above-code utility incentives. Details are available at www.NFRC.org.

Site-Built Label Certificates

Site-built fenestration is field-assembled using specific factory-cut or factory-formed framing and glazing units that are manufactured with the intention of being assembled at the construction site or glazing contractor's shop.

1. For site-built skylight fenestration in low-rise multifamily buildings totaling 250 ft^2 or 5 percent of floor area or greater, or in high-rise multifamily buildings totaling 200 ft^2 or greater, or for site-built vertical fenestration being used in newly constructed buildings, the glazing contractor or specifier must generate an NFRC label certificate from either approach listed below:
2. A NFRC label certificate generated by the CMA computer program.
   - Default to the U-factor values from Table 110.6-A, the SHGC values from 110.6-B, and for VT values, use the method specified in NA6.
3. For site-built skylight fenestration in low-rise multifamily buildings totaling less than 250 ft^2, or in high-rise multifamily buildings totaling less than 200 ft^2, or for site-built vertical fenestration being used in an alteration, the glazing contractor or specifier must comply with one of the following:
   - An NFRC label certificate generated by the CMA computer program.
   - The center-of-glass values from the manufacturer's product literature to determine the total U-factor, SHGC and VT. (See Reference Nonresidential Appendix NA6 — the Alternative Default Fenestration Procedure).
   - The U-factor values from Table 110.6-A and SHGC values from Table 110.6-B. For VT values, use the method specified in NA6.

NA6 calculations are based on center-of-glass (COG) values from the manufacturer. For example, when using a manufacturer's SHGC center-of-glass specification of 0.27, the NA6 calculation results in an overall SGHC value of 0.312, which may be rounded to 0.31. Rounding to the nearest hundredth decimal place is acceptable to determine the overall fenestration efficiency value with either the prescriptive or performance approach.

Site-built certificates should be filed at the contractor's project office during construction or in the building manager's office. Site-built fenestration has multiple responsible parties. The steps of producing site-built fenestration are as follows:

1. Architects and/or engineers design the basic glazing system by specifying the components, the geometry of the components, and, sometimes, the assembly method.
2. An extrusion manufacturer provides the mullions and frames that support the glazing and is responsible for thermal breaks.
3. A glazing manufacturer provides the glazing units, cut to size and fabricated as insulated glass (IG) units. The glazing manufacturer is responsible for tempering or heat strengthening, the tint of the glass, any special coatings, the spacers, and the sealants.
4. A glazing contractor (usually a subcontractor to the general contractor) puts the system together at the construction site, or the contractor's shop and is responsible for many quality aspects. Predetermining the energy performance of site-built fenestration as a system is more challenging than for manufactured units.
5. One of the parties (architect, glazing contractor, extrusion manufacturer, IG fabricator, or glass manufacturer) must take responsibility for testing and labeling of the site-built fenestration system under the most recent NFRC 100 procedure. The responsible party must obtain a label certificate as described in Section 10-111.
6. The glazing contractor or other appropriate party assumes responsibility for acquiring the NFRC label certificate. Each label certificate has the same information as the NFRC temporary label for manufactured products but includes other information specific to the project, such as the name of the glazing manufacturer, the extrusion contractor, the places in the building where the product line is used, and other details.

It is typical for the glazing contractor to assume responsibility and coordinate the certification and labeling process. The design team may include language in the contract with the general contractor that requires that the general contractor be responsible. The general contractor typically assigns this responsibility to the glazing contractor once the responsible party has established a relationship with the NFRC.

It is not necessary to complete the NFRC testing and labeling prior to completing the building permit application. Designers should specify the type of glass and whether the frame has a thermal break or is thermally improved. Plans examiners should verify that the fenestration performance shown in the plans and used in the compliance calculations is reasonable and achievable, by consulting the default values for U-factor and SHGC in the NA6. «»

6. **Fenestration acceptance requirements.** Before an occupancy permit is granted site-built fenestration products in other than single-family buildings shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified in the Reference Nonresidential Appendix NA7 to ensure that site-built fenestration meets Standards requirements, including a matching label certificate for product(s) installed and be readily accessible at the project location. A certificate of acceptance certifying that the fenestration product meets the acceptance requirements shall be completed, signed and submitted to the enforcement agency.

   Exception to Section 110.6(a): Fenestration products removed and reinstalled as part of a building alteration or addition.

«» Commentary for Section 110.6(a)6:

Acceptance tests are required for newly installed fenestration, window film, and dynamic glazing in new construction, additions, and alterations for all buildings except single-family residential per Section 110.6(a)6.

These fenestration products must be tested according to NA7.4 to verify that the NFRC label certificate or CEC fenestration certificate is provided for each fenestration product being installed. These certificates identify the thermal performance of the fenestration product (for example, U-factor, solar heat gain coefficient, and visible transmittance).

This test also verifies that the thermal performance of installed fenestration products match the label certificate, energy compliance documentation, and plan specifications. «»

(b) Installation of field-fabricated fenestration and exterior doors. Field-fabricated fenestration and field-fabricated exterior doors may be installed only if the compliance documentation has demonstrated compliance for the installation using U-factors from Table 110.6-A and SHGC values from Table 110.6-B. Field-fabricated fenestration and field-fabricated exterior doors shall be caulked between the fenestration products or exterior door and the building, and shall be weatherstripped.

Exception to Section 110.6(b): Unframed glass doors and fire doors need not be weatherstripped or caulked.

TABLE 110.6-A DEFAULT FENESTRATION PRODUCT U-FACTORS

Frame	Product Type	Single Pane [3, 4] U-Factor	Double Pane [1, 3, 4] U-Factor	Glass Block [2,3] U-Factor
Metal	Operable	1.28	0.79	0.87
Metal	Fixed	1.19	0.71	0.72
Metal	Greenhouse/Garden Window	2.26	1.40	N.A.
Metal	Glazed Doors	1.25	0.77	N.A.
Metal	Skylight	1.98	1.30	N.A.
Metal, Thermal Break	Operable	N.A.	0.66	N.A.
Metal, Thermal Break	Fixed	N.A.	0.55	N.A.
Metal, Thermal Break	Greenhouse/Garden Window	N.A.	1.12	N.A.
Metal, Thermal Break	Glazed Doors	N.A.	0.59	N.A.
Metal, Thermal Break	Skylight	N.A.	1.11	N.A.
Nonmetal	Operable	0.99	0.58	0.60
Nonmetal	Fixed	1.04	0.55	0.57
Nonmetal	Glazed Doors	0.99	0.53	N.A.
Nonmetal	Greenhouse/Garden Windows	1.94	1.06	N.A.
Nonmetal	Skylight	1.47	0.84	N.A.

1. For all dual-glazed fenestration products, adjust the listed U-factors as follows:

a. Add 0.05 for products with dividers between panes if spacer is less than 7/16 inch wide.

b. Add 0.05 to any product with true divided lite (dividers through the panes).

2. Translucent or transparent panels shall use glass block values when not rated by NFRC 100.

3. Visible Transmittance (VT) shall be calculated by using Reference Nonresidential Appendix NA6.

4. Windows with window film applied that is not rated by NFRC 100 shall use the default values from this table.

TABLE 110.6-B DEFAULT SOLAR HEAT GAIN COEFFICIENT (SHGC)

FRAME TYPE	PRODUCT	GLAZING	FENESTRATION PRODUCT SHGC Single Pane[2,3] SHGC	FENESTRATION PRODUCT SHGC Double Pane[2,3] SHGC	FENESTRATION PRODUCT SHGC Glass Block[1,2] SHGC
Metal	Operable	Clear	0.80	0.70	0.70
Metal	Fixed	Clear	0.83	0.73	0.73
Metal	Operable	Tinted	0.67	0.59	N.A.
Metal	Fixed	Tinted	0.68	0.60	N.A.
Metal, Thermal Break	Operable	Clear	N.A.	0.63	N.A.
Metal, Thermal Break	Fixed	Clear	N.A.	0.69	N.A.
Metal, Thermal Break	Operable	Tinted	N.A.	0.53	N.A.
Metal, Thermal Break	Fixed	Tinted	N.A.	0.57	N.A.
Nonmetal	Operable	Clear	0.74	0.65	0.70
Nonmetal	Fixed	Clear	0.76	0.67	0.67
Nonmetal	Operable	Tinted	0.60	0.53	N.A.
Nonmetal	Fixed	Tinted	0.63	0.55	N.A.

1. Translucent or transparent panels shall use glass block values when not rated by NFRC 200.

2. Visible Transmittance (VT) shall be calculated by using Reference Nonresidential Appendix NA6.

3. Windows with window film applied that is not rated by NFRC 200 shall use the default values from this table.

«» Commentary for Section 110.6(b):

Field-fabricated fenestration is fenestration assembled on site that does not qualify as site-built fenestration. It includes windows where wood frames are constructed from raw materials at the building site, salvaged windows that do not have an NFRC label or rating, and other similar fenestration items.

No attached labeling is required for field-fabricated fenestration products; only the appropriate compliance documentation with the default values is required (i.e. Prescriptive LMCC-ENV-E or Performance LMCC-PRF-01-E for low-rise; Prescriptive NRCC-ENV-E or Performance NRCC-PRF-01-E for high-rise). Field-fabricated fenestration and field-fabricated exterior doors may be installed only if the documentation has demonstrated compliance with the Energy Code. **«»**

SECTION 110.7 – MANDATORY REQUIREMENTS TO LIMIT AIR LEAKAGE

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 exfiltration.

Note**:** Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.8, and 25943, Public Resources Code.

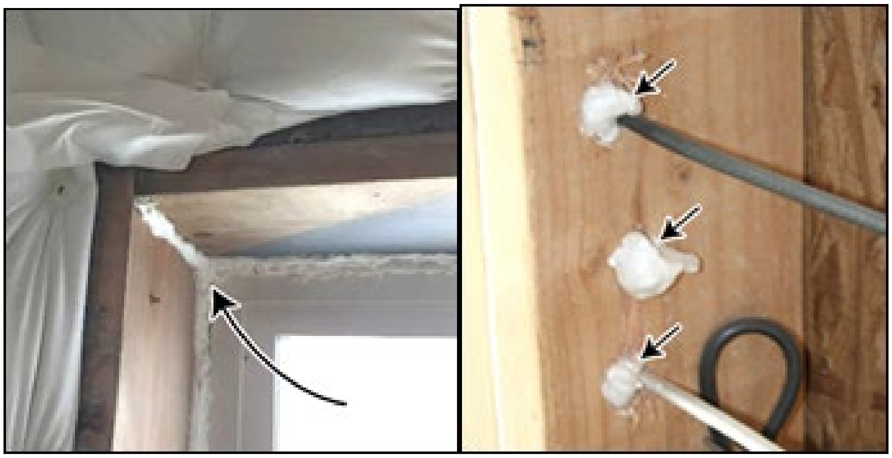
«» Commentary for Section 110.7:

All joints and other openings in the building envelope that are potential sources of air leakage must be caulked, gasketed, weatherstripped, or otherwise sealed to limit air leakage. This requirement applies to roof penetrations and penetrations for pipes and conduits, ducts, vents, and other openings in the building envelope. Particular attention should be paid to the junctures where assemblies meet and all gaps between wall panels, around doors, and other construction joints. Ceiling joints, lighting fixtures, and rough openings for doors and windows should all be considered potential sources of unnecessary energy loss due to infiltration. No special construction requirements are necessary for suspended (T-bar) ceilings, provided they meet the requirements of Section 110.7.

Air leakage through joints, penetrations, cracks, holes, openings around windows, doors, walls, roofs, and floors can result in higher energy use. The following openings in the building envelope shall be caulked, gasketed, weatherstripped, or otherwise sealed:

1. Exterior joints around window and door frames, including doors between a dwelling unit and a garage, between interior HVAC closets and conditioned space, between attic access and conditioned space, between wall sill plates and the floor, exterior panels, and all siding materials.
2. Openings for plumbing, electricity, and gas lines in exterior and interior walls, ceilings, and floors.
3. Openings in the attic floor, such as where ceiling panels meet interior walls, exterior walls, and masonry fireplaces.
4. Openings around exhaust ducts, such as those for clothes dryers.
5. All other such openings in the building envelope.

Figure 3-6: Air Sealing



Source: Sierra Building Science

«»

SECTION 110.8 – MANDATORY REQUIREMENTS FOR INSULATION, ROOFING PRODUCTS AND RADIANT BARRIERS

(a) Insulation certification by manufacturers. All insulation shall be certified by Department of Consumer Affairs, Bureau of Household Goods and Services that the insulation conductive thermal performance is approved pursuant to the California Code of Regulations, Title 24, Part 12, Chapters 12-13, Article 3, "Standards for Insulating Material."

«» Commentary for Section 110.8:

Manufacturers must certify that insulating materials comply with the California Quality Standards for Insulating Materials, which became effective January 1, 1982. It ensures that insulation sold or installed in the state performs according to the stated R-value and meets minimum quality, health, and safety standards.

Builders may not install insulating materials unless the product has been certified by the Department of Consumer Affairs, Bureau of Household Goods and Services. Builders and enforcement agencies shall use the Department of Consumer Affairs Directory of Certified Insulation Materials to verify certification of the insulating material (https://bhgs.dca.ca.gov/consumers/ti_directory.pdf). If an insulating product is not listed in the most recent edition of the directory, contact the Department of Consumer Affairs, Bureau of Household Goods and Services, using the contact information at https://www.bhgs.dca.ca.gov/about_us/contact_us.shtml. **«»**

(b) Installation of urea formaldehyde foam insulation. Urea formaldehyde foam insulation may be applied or installed only if:

1. It is installed in exterior side walls; and
2. A 4-mil-thick plastic polyethylene vapor retarder or equivalent plastic sheathing vapor retarder is installed between the urea formaldehyde foam insulation and the interior space in all applications.

«» Commentary for Section 110.8(b):

The mandatory requirements restrict the use of urea formaldehyde foam insulation 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 barrier must be placed in the wall construction to isolate the insulation from the interior of the space. The barrier must be 4-mil (0.1 mm) thick, polyethylene or equivalent. **«»**

(c) Flame spread rating of insulation. All insulating material shall be installed in compliance with the flame spread rating and smoke density requirements of the CBC.

«» Commentary for Section 110.8(c):

The California Quality Standards for Insulating Materials requires that all exposed installations of faced mineral fiber and mineral aggregate insulations use fire-retardant facings that have been tested and certified not to exceed a flame spread index of 25 and a smoke development index of 450. Insulation facings that do not touch a ceiling, wall, floor surface, and faced batts on the underside of roofs with an air space between the ceiling and facing are considered exposed applications. Flame spread index and smoke density index are shown on the insulation or packaging material or may be obtained from the manufacturer. **«»**

(d) Installation of insulation in existing buildings. Insulation installed in an existing attic, or on an existing duct or water heater, shall comply with the applicable requirements of Subsections 1, 2 and 3 below. If a contractor installs the insulation, the contractor shall certify to the customer, in writing, that the insulation meets the applicable requirements of Subsections 1, 2 and 3 below.

1. **Attics.** If insulation is installed in the existing attic of a low-rise residential building, the R-value of the total amount of insulation (after addition of insulation to the amount, if any, already in the attic) shall meet the requirements of Section 150.0(a) for single-family buildings and Section 180.2(a)1 for multifamily buildings three habitable stories or less.

   Exception to Section 110.8(d)1: Where the accessible space in the attic is not large enough to accommodate the required R-value, the entire accessible space shall be filled with insulation, provided such installation does not violate Section 1202.2 of Title 24, Part 2 or Section 806 of Title 24, Part 2.5.

2. **Water heaters.** If external insulation is installed on an existing unfired water storage tank or on an existing back-up tank for a solar water-heating system, it shall have an R-value of at least R-3.5, or the heat loss of the tank surface based on an 80°F water-air temperature difference shall be less than 6.5 Btu per hour per square foot.

3. **Ducts.** If insulation is installed on an existing space-conditioning duct, it shall comply with Section 605.0 of the CMC.

(g) Insulation requirements for heated slab floors. Heated slab floors shall be insulated according to the requirements in Table 110.8-A.

1. Insulation materials in ground contact must:

   A. Comply with the certification requirements of Section 110.8(a); and

B. Have a water absorption rate for the insulation material alone without facings that is no greater than 0.3 percent when tested in accordance with Test Method A – 24 Hour-Immersion of ASTM C272.

C. Water vapor permeance no greater than 2.0 perm/ inch when tested in accordance with ASTM E96.

2. Insulation installation must:

A. Be covered with a solid guard that protects against damage from ultraviolet radiation, moisture, landscaping operation, equipment maintenance and wind; and

B. Include a rigid plate, which penetrates the slab and blocks the insulation from acting as a conduit for insects from the ground to the structure above the foundation.

TABLE 110.8-A SLAB INSULATION REQUIREMENTS FOR HEATED SLAB FLOOR

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 16	5 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 16	5 10 vertical and 7 horizontal

«» Commentary for Section 110.8(g)2:

Slab Insulation Products

The mandatory requirements state that the insulation material must be suitable for the application. Insulation material in direct contact with soil, such as perimeter insulation, must have 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.

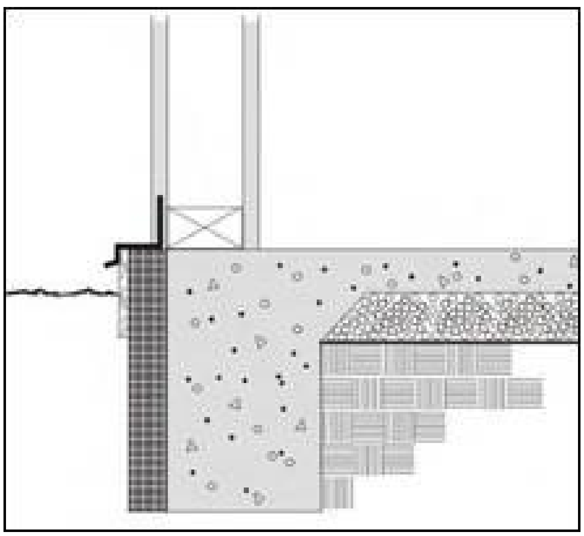
The insulation must be protected from physical and UV degradation by either installing a water-resistant protection board, extending sheet metal flashing below grade, choosing an insulation product that has a hard durable surface on one side, or using other suitable means.

The top of the insulation must be protected with a rigid material to prevent intrusion of insects into the building foundation.

A common location for the slab insulation is on the foundation perimeter (Figure 3-7: Perimeter Slab Insulation). 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.

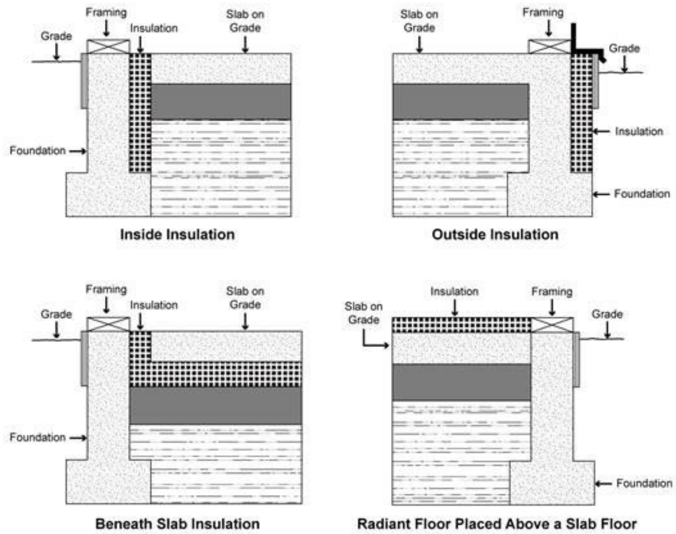
Figure 3-7: Perimeter Slab Insulation



Source: California Energy Commission

One option is to install the insulation between the heated slab and foundation wall. In this case, insulation must extend downward to the top of the footing and then extend horizontally inward 4 feet toward 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 3-8: Allowed Slab Edge Insulation Placement



Source: California Energy Commission

«»

(h) Wet insulation systems. When insulation is installed on roofs above the roofing membrane or layer used to seal the roof from water penetration, the effective R-value of the insulation shall be as specified in Reference Joint Appendix JA4.

«» Commentary for Section 110.8(h):

Wet insulation systems are roofing systems where the insulation is installed above the waterproof membrane of the roof. Water can penetrate this insulation material and affect 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 waterproof membrane of the roof must be multiplied by 0.8, and installers must use the resulting value in choosing the table column in Reference Appendices, 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 Appendices, Joint Appendix JA4. «»

(i) Roofing products solar reflectance and thermal emittance.

1. In order to meet the requirements of Sections 140.1, 140.2, 140.3(a)1, 141.0(b)2B, 150.1(c)11, 150.2(b)1I or 150.2(b)2, a roofing product's thermal emittance and an aged solar reflectance shall be certified and labeled according to the requirements of Section 10-113.

   Exception 1 to Section 110.8(i)1: Roofing products that are not certified according to Section 10-113 shall assume the following default aged solar reflectance/thermal emittance values:

   For asphalt shingles: 0.08/0.75

For all other roofing products: 0.10/0.75

2. If CRRC testing for an aged solar-reflectance is not available for a roofing product, the aged values shall be derived from the CRRC initial values using the 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 in Table 110.8-B.

TABLE 110.8-B 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

3. Solar Reflectance Index (SRI), calculated as specified by ASTM E1980-11 (2019), may be used as an alternative to thermal emittance and an aged solar reflectance when complying with the requirements of Sections 140.2, 140.3(a)1, 141.0(b)2B, 150.1(c)11, 150.2(b)1I or 150.2(b)2. SRI calculations shall be based on approach I from Section 6.1.1 of ASTM E1980-11 (2019) using only equation 1 and 3 and a moderate wind velocity of 2–6 meters per second. The SRI shall be calculated based on the aged solar reflectance value of the roofing products.

«» Commentary for Section 110.8(i)3:

Roofing Products: Aged Solar Reflectance (SR) and Thermal Emittance (TE)

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. The Energy Code prescribes cool roof radiative properties for low-sloped and steep-sloped roofs. Low-sloped roofs receive more solar radiation than steep-sloped roofs in the summer when the sun is higher in the sky.

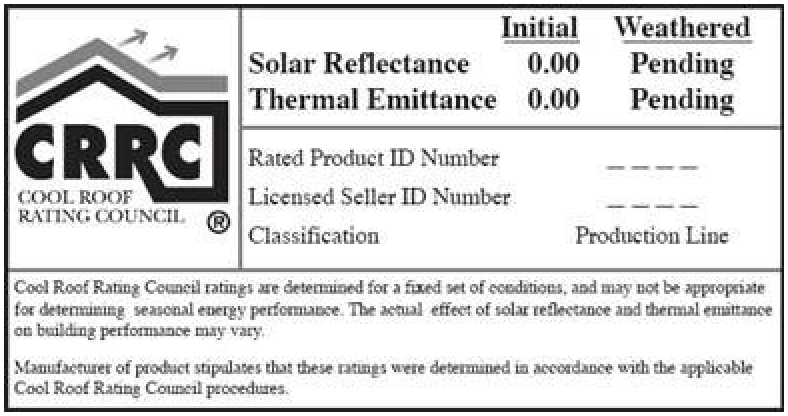
Roofing products must be tested and labeled by the Cool Roof Rating Council (CRRC), and liquid-applied products must meet minimum standards for performance and durability per Section 110.8(i)4. When installing cool roofs, the aged solar reflectance (SR) and thermal emittance (TE) of the roofing product must be tested and certified according to CRRC procedures. The SR and TE properties are rated and listed by the Cool Roof Rating Council at https://www.coolroofs.org/.When a CRRC rating is not obtained for the roofing products, the Energy Code default values for solar reflectance and TE must be used.

Rating and Labeling

When a cool roof is installed to meet the prescriptive requirement or when it is used for compliance credit, the products must be tested and labeled by the CRRC as specified in Section 10-113. The CRRC is the supervisory entity responsible for certifying cool roof products. The CRRC test procedure is documented in CRRC-1, the *CRRC Product Rating Program Manual.* This test procedure includes tests for both solar reflectance and TE.

See Figure 3-9: Sample CRRC Product Label and Information for an example of an approved CRRC product label.

Figure 3-9: Sample CRRC Product Label and Information



CRRC COOL ROOF RATING COUNCIL ®

	Initial	Weathered
Solar Reflectance	0.00	Pending
Thermal Emittance	0.00	Pending

Rated Product ID Number	_ _ _ _
Licensed Seller ID Number	_ _ _ _
Classification	Production Line

Cool Roof Rating Council ratings are determined for a fixed set of conditions, and may not be appropriate for determining seasonal energy performance. The actual effect of solar reflectance and thermal emittance on building performance may vary.

Manufacturer of product stipulates that these ratings were determined in accordance with the applicable Cool Roof Rating Council procedures.

Source: Cool Roof Rating Council

Solar Reflectance, Thermal Emittance, and Solar Reflectance Index (SRI)

Both solar reflectance and TE 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 adequate cool roof properties. Excess heat can increase the air-conditioning load of a building, resulting in increased air-conditioning energy needed for maintaining occupant comfort. High-emitting roof surfaces reject absorbed heat more quickly (upward and out of the building) than roof surfaces with low-emitting properties.

There are three measurements of solar reflectance:

1. Initial solar reflectance
2. Three-year SR
3. Accelerated SR

All requirements of the Energy Code are based on the three-year SR. 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 value or an accelerated testing process. Until the appropriate age-rated value for the reflectance is posted in the directory, or a new method of testing is used to find the accelerated solar reflectance, the equation below can be used to calculate the aged rated solar reflectance.

$$Aged\ Reflectance_{calculated} = (0.2 + \beta[\rho_{inital} - 0.2])$$

Where,

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

β= 0.65 for field-applied coating, or 0.70 for not a field-applied coating

Thermal Emittance

The Energy Code does not distinguish between initial and aged TE, meaning that either value can be used to demonstrate compliance with the Energy Code.

Default Values

If a manufacturer fails to obtain CRRC certificate for its roofing products, the following default SR and TE values must be used for compliance:

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

Solar Reflectance Index (SRI)

The temperature of a surface depends on the solar radiation incidence, surface reflectance, and emittance. The SRI measures the relative steady-state surface temperature with respect to standard white (SRI=100) and standard black (SRI=0) under the standard solar and ambient condition. A calculator has been produced that calculates the SRI by designating the solar reflectance and TE of the desired roofing material. The calculator can be found at https://www.energy.ca.gov/filebrowser/download/5237. The linked calculator does not work in a web browser and should be downloaded. To calculate the SRI, either the initial or the three-year SR value of the roofing product may be used. By using the SRI calculator, a cool roof may comply with a lower emittance, as long as the SR is higher and vice versa. **«»**

4. Liquid-applied roof coatings applied to low-sloped roofs in the field as the top surface of a roof covering shall:

   A. Be applied across the entire roof surface to meet the dry mil thickness or coverage recommended by the coating manufacturer, taking into consideration the substrate on which the coating is applied; and

   B. Meet the minimum performance requirements listed in Table 110.8-C or the minimum performance requirements of ASTM C836, D3468, D6083 or D6694, whichever are appropriate to the coating material.

   Exception 1 to Section 110.8(i)4B: Aluminum- pigmented asphalt roof coatings shall meet the requirements of ASTM D2824 and be installed as specified by ASTM D3805.

   Exception 2 to Section 110.8(i)4B: Cement- based roof coatings shall contain a minimum of 20 percent cement and shall meet the requirements of ASTM C1583, ASTM D822 and ASTM D5870.

TABLE 110.8-C MINIMUM PERFORMANCE REQUIREMENTS FOR LIQUID APPLIED ROOF COATINGS

Physical Property	ASTM Test Procedure	Requirement
Initial percent elongation (break)	D2370	Minimum 200% @ 73° F (23° C)
Initial percent elongation (break) OR Initial Flexibility	D2370 D522, Test B	Minimum 60% @ 0° F (-18° C) Minimum pass 1” mandrel @ 0° F (-18° C)
Initial tensile strength (maximum stress)	D2370	Minimum 100 psi (1.38 Mpa) @ 73° F (23° C)
Initial tensile strength (maximum stress) OR Initial Flexibility	D2370 D522, Test B	Minimum 200 psi (2.76 Mpa) @ 0° F (-18° C) Minimum pass 1” mandrel @ 0° F (-18° C)
Final percent elongation (break) after accelerated weathering 1000 h	D2370	Minimum 100% @ 73° F (23° C)
Final percent elongation (break) after accelerated weathering 1000 h OR Flexibility after accelerated weathering 1000 h	D2370 D522, Test B	Minimum 40% @ 0° F (-18° C) Minimum pass 1” mandrel @ 0° F (-18° C)
Permeance	D1653	Maximum 50 perms
Accelerated weathering 1000 h	D4798	No cracking or checking[1]

1. Any cracking or checking visible to the eye fails the test procedure.

«» Commentary for Section 110.8(i)4:

Field-Applied Liquid Coatings

There are several liquid products, including elastomeric coatings and white acrylic coatings that qualify for field-applied liquid coatings. The Energy Code specifies minimum performance and durability requirements for field-applied liquid coatings in Table 110.8-C, depending on the type of coating. 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.

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 surface of the coating and provides a shiny, surface. Because of the shiny surface and the physical properties of aluminum, these coatings have a TE below 0.75, which is the minimum rating for prescriptive compliance. The performance approach is typically used to achieve compliance with these coatings.

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. Also, the aluminum-pigmented asphalt roof coatings shall be manufactured in accordance with ASTM D2824. Standard specification is also required for aluminum-pigmented asphalt roof coatings, nonfibered, asbestos-fibered, and fibered without asbestos that are suitable for applying 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.

Cement-Based Roof Coatings

- This class of coatings consists of a layer of cement and has been used for several years in California’s Central Valley and 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 percent Portland cement and meet the requirements of ASTM D822, ASTM C1583, and ASTM D5870.

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 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 performance and durability requirements as specified in Table 110.8-C of the Energy Code or the minimum performance requirements of ASTM C836, D3468, D6083, or D6694, whichever are appropriate to the coating material. «»

(j) Radiant barrier. A radiant barrier shall have an emittance of 0.05 or less, tested in accordance with ASTM C1371 or ASTM E408, and shall be certified to the Department of Consumer Affairs as required by Title 24, Part 12, Chapter 12-13, Standards for Insulating Material.

«» Commentary for Section 110.8(j):

The radiant barrier is a reflective material that reduces radiant heat transfer into the attic from solar heat gain in the roof. Radiant barriers must have an air space next to the foil side to provide its energy benefit. When a radiant barrier is installed, the product must meet mandatory requirements in Section 110.8(j). The radiant barrier must have an emittance of 0.05 or less. The product must be tested according to ASTM C1371 or ASTM E408 and must be certified by the California Department of Consumer Affairs, Bureau of Household Goods and Services and listed in its Consumer Guide and Directory of Certified Insulation Material, at https://bhgs.dca.ca.gov/consumers/ti_directory.pdf. **«»**

Note**:** Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.8, and 25943, Public Resources Code

SECTION 160.1 – MANDATORY REQUIREMENTS FOR BUILDING ENVELOPES

(a) Ceiling and roof insulation. The opaque portions of ceilings and roofs separating conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of Item 1 or 2, and 3 below:

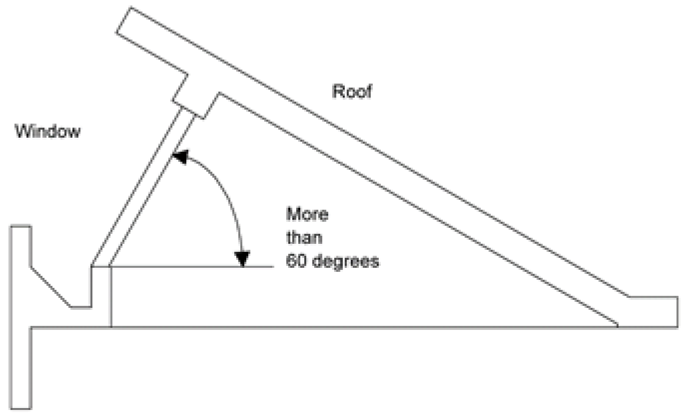
«» Commentary for Section 160.1(a):

Opaque Envelope Definitions

Opaque elements of the building envelope significantly contribute to the related energy efficiency. Components of the building envelope include walls, floors, soffits, roofs, and ceilings. Envelope and other building components definitions are listed in Section 100.1(b) of the Energy Code and the Reference Appendices, Joint Appendix JA1 and several relevant definitions are included here for ease of use.

1. The exterior partition is an opaque, translucent, or transparent solid barrier that separates conditioned space from ambient air or unconditioned space.
2. The demising partition is a wall, fenestration, floor, or ceiling that separates conditioned space from enclosed unconditioned space.
3. The conditioned space is an enclosed space within a building that is either directly conditioned or indirectly conditioned.
4. Unconditioned space is enclosed space within a building that is neither directly conditioned nor indirectly conditioned.
5. Plenum is an air compartment or chamber, including uninhabited crawl space, areas above a ceiling or below a floor, or attic spaces, to which one or more ducts are connected and that forms part of either the supply-air, return-air, or exhaust-air system, other than the occupied space being conditioned.
6. Attic is an enclosed space directly below the roof deck and above the ceiling.
7. Sloping surfaces are considered either a wall or a roof, depending on the slope. (See Figure 3-10: Slope of a Wall or Window [Roof or Skylight Slope Is Less Than 60°].) 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 in roofs.

Figure 3-10: Slope of a Wall or Window (Roof or Skylight Slope Is Less Than 60°)



Source: California Energy Commission

8. The exterior roof is an exterior partition that has a slope less than 60 degrees from horizontal, that has conditioned space below, and that is not an exterior door or skylight.
9. The roof deck is the surface that supports the roofing material. Typically made of plywood or OSB, it is supported by the roof framing members such as rafters or trusses.
10. Exterior floor/soffit is a horizontal exterior partition, or a horizontal demising partition, under conditioned space.
11. Vapor retarder or vapor barrier is a material or assembly designed to limit the amount of vapor moisture that passes through that material or assembly.
12. Roofing products are the top layer of the roof that is exposed to the outside, which has properties including, but not limited to, solar reflectance, TE, and mass.
13. Cool roof is a roofing material with high TE and high solar reflectance, or low TE and exceptionally high solar reflectance, as specified in Part 6, that reduces heat gain through the roof.
14. Solar reflectance is the fraction of solar energy that is reflected by the roof surface.
15. TE is the fraction of thermal energy that is emitted from the roof surface.
16. A low-sloped roof is a surface with a pitch less than 2:12 (less than 9.5 degrees from the horizontal).
17. A steep-sloped roof is a surface with a pitch greater than or equal to 2:12 (9.5 degrees or greater from the horizontal).
18. Air leakage is a measurement of heat loss and gain by infiltration and exfiltration through gaps and cracks in the envelope.
19. 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. Infiltration can occur through holes and cracks in the building envelope and around doors and fenestration framing areas.
20. Reducing infiltration in the building envelope can result in significant energy savings, especially in climates with severe winter and summer conditions. It also can result in improved occupant comfort, reduced moisture intrusion, and fewer air pollutants.
21. Exfiltration is uncontrolled outward air leakage from inside a building, including leakage through cracks, joints, and intersections, around windows and doors, and through any other exterior partition or duct penetration.
22. Ventilation is the intentional replacement of conditioned air with unconditioned air through open windows and skylights or mechanical systems. **«»**

1. Attic roof. Roofs with an attic space shall meet the requirements of A through C below:

A. Shall be insulated to achieve an area-weighted average U-factor not exceeding U-0.043 or shall be insulated between wood-framing members with insulation resulting in an installed thermal resistance of R-22 or greater for the insulation alone. For vented attics, the mandatory insulation shall be installed at the ceiling level; for unvented attics, the mandatory insulation shall be placed at either ceiling or roof level;

B. Attic access doors shall have permanently attached insulation using adhesive or mechanical fasteners. The attic access shall be gasketed to prevent air leakage; and

C. When loose-fill insulation is installed, the minimum installed weight per square foot shall conform with the insulation manufacturer's installed design weight per square foot at the manufacturer's labeled R-value.

«» Commentary for Section 160.1(a)1C:

Attic Roof

Roof/ceiling construction assemblies with an attic space must have at least R-22 insulation between wood framing members or a maximum U-factor of 0.043. Some areas of the roof/ceiling can be greater than the maximum U-factor if other areas have lower U-factors such that the weighted average U-factor for the overall ceiling/roof is 0.043 or less. Metal framed assemblies must also have a weighted U-factor of 0.043 or less.

If insulation is not penetrated by framing, such as rigid insulation laid over a structural deck, then the rigid insulation can 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.

Loose-fill insulation must be blown in evenly and insulation levels must be documented on the certificate of installation. 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 also must meet the manufacturer’s specified minimum weight per square foot for the corresponding R-value. **«»**

2. Non-attic roof. Roofs without attic spaces shall meet the applicable requirements of A through C below:

   A. Metal building — The area-weighted average U-factor of the roof assembly shall not exceed 0.098.

   B. Wood framed and others — The area-weighted average U-factor of the roof assembly shall not exceed 0.075.

   C. Insulation placement — When insulation is installed at the roof, fixed vents or openings to the outdoors or to unconditioned spaces shall not be installed. When the space between the ceiling and the roof is either directly or indirectly conditioned space, it shall not be considered an attic for the purposes of complying with CBC attic ventilation requirements.

      Exception to Section 160.1(a)2C: Vents that do not penetrate the roof deck and are instead designed for wind resistance for roof membranes are not within the scope of Section 160.1(a)2C.

«» Commentary for Section 160.1(a)2C:

Non-Attic Roof

For roof/ceiling construction assemblies without an attic space, the maximum weighted average U-factor is 0.098 for metal building and 0.075 for wood framing and others. If insulation is installed at the roof, vents or openings that penetrate the roof deck to the outdoor are prohibited. **«»**

3. Insulation shall be installed in direct contact with a roof or ceiling that is sealed to limit infiltration and exfiltration as specified in Section 110.7, including but not limited to placing insulation either above or below the roof deck or on top of a drywall ceiling.

«» Commentary for Section 160.1(a)3:

Regardless of whether or not there is an attic space, insulation must be installed in direct contact with the air barrier. **«»**

(b) Wall insulation. Opaque portions of above grade walls separating conditioned spaces from unconditioned spaces or ambient air shall meet the following applicable requirements:

1. Metal building—The area-weighted average U-factor of the wall assembly shall not exceed 0.113.

2. Metal framed—The area-weighted average U-factor of the wall assembly shall not exceed 0.151.

3. Wood framed and others—

   A. Nominal 2x4 inch framing shall have an area-weighted average U-factor of the wall assembly not exceeding 0.095.

   B. Nominal 2x6 inch framing shall have an area-weighted average U-factor of the wall assembly not exceeding 0.069.

C. Other wall assemblies shall have an area-weighted average U-factor of the wall assembly not exceeding 0.102.

4. **Light mass walls**—A 6 inch or greater hollow core concrete masonry unit shall have a U-factor not to exceed 0.440.
5. **Heavy mass walls**—An 8 inch or greater hollow core concrete masonry unit shall have a U-factor not to exceed 0.690.
6. **Spandrel panels and curtain wall**—The area-weighted average U-factor of the spandrel panels and curtain wall assembly shall not exceed 0.280.
7. **Demising walls**—The opaque portions of framed demising walls shall meet the requirements of Item A or B below:

   A. Wood framed walls shall be insulated to meet a U-factor not greater than 0.099.

   B. Metal framed walls shall be insulated to meet a U-factor not greater than 0.151.
8. Bay or bow window roofs and floors shall be insulated to meet the wall insulation requirements of Table 170.2-A.

«» Commentary for Section 160.1(a)3:

Wall Insulation Mandatory Requirements:

1. Above-grade walls separating conditioned spaces from other spaces must adhere to maximum area-weighted U-factor requirements based on the material, size, and location of the wall assemblies. The mandatory maximum U-factor requirements for wood-framed walls have been updated in 2025 code cycle to align with requirements for single family residential and reflect increased availability of cost-effective strategies to meet the insulation requirements. The wall insulation requirements listed below include cavity insulation suggestions for wood-framed wall applications. See Reference Joint Appendix JA 4.3 wall tables for more details.
2. The 2x4-inch wood-framed walls above grade must have a U-factor not exceeding 0.095. This requirement could be met with at least R-15 insulation installed in the cavities between framing members, such as a compressed fiber glass batt product that is manufactured to retain an R-15 value in a 3.5″ cavity 16″ on-center.
3. The 2x6-inch or greater wood-framed walls above grade must have a U-factor not exceeding 0.069. This requirement could be met with at least R-21 insulation installed in the cavities between framing members, such as a compressed fiber glass batt product that is manufactured to retain an R-21 value in a 5.5″ cavity 16″ on center.
4. Demising and knee walls must not exceed minimum U-factor requirements of 0.099 for wood framing and 0.151 for metal framing. This requirement could be met with at least R-15 compressed fiber glass batt in 3.5″ cavity 16″ on center.
5. Metal building, mass walls, and spandrel panels and curtain wall construction types must not exceed the U-factor requirement in Table 3-3: Wall Construction U-Factor Requirements.
6. All other wall types (not listed) above grade must meet a maximum U-factor of 0.102.
7. When determining envelope requirements for bay or bow window roofs and floors in Table 170.2-A, the requirements for walls of the same climate zone and material should be used.

Table 3-3: Wall Construction U-Factor Requirements

Wall Construction	Maximum U-Factor
2x4 inch wood-framed walls above grade	0.095
2x6 inch or greater wood-framed walls above grade	0.069
Demising partitions and knee walls – wood framing	0.099
Demising partitions and knee walls – metal framed	0.151
Metal Building	0.113
Metal Framed	0.151
Light Mass Wall	0.440
Heavy Mass Wall	0.690
Spandrel Panel and Curtain Wall	0.280

Source: California Energy Commission

«»

(c) Floor and soffit insulation. The opaque portions of floors and soffits that separate conditioned spaces from unconditioned spaces or ambient air shall meet the applicable requirements of Items 1 through 3 below:

1. Raised mass floors shall have a minimum of 3 inches of lightweight concrete over a metal deck or the area-weighted average U-factor of the floor assembly shall not exceed 0.269.
2. Raised wood floor shall have an overall assembly U-factor not exceeding 0.037. In a wood framed assembly, compliance with the U-factor may be demonstrated by installing insulation with an R-value of 19 or greater.
3. Other floors—The area-weighted average U-factor of the floor assembly shall not exceed 0.071.
4. Heated slab on grade floor—A heated slab on grade floor shall be insulated to meet the requirements of Section 110.8(g).

Exception to Section 160.1(c): A building with a controlled ventilation or unvented crawl space may omit raised floor insulation if all of the following are met:

A. The foundation walls are insulated to meet the wall insulation minimums as shown in Table 170.2-A; and
B. A Class I or Class II vapor retarder is placed over the entire floor of the crawl space; and
C. Vents between the crawl space and outside air are fitted with automatically operated louvers that are temperature actuated; and
D. The requirements in Reference Residential Appendix RA4.5.1.

(d) Vapor retarder.

1. In Climate Zones 1–16, the earth floor of unvented crawl space shall be covered with a Class I or Class II vapor retarder. This requirement shall also apply to controlled ventilation crawl space for buildings complying with the Exception to Section 160.1(c).
2. In Climate Zones 14 and 16, a Class I or Class II vapor retarder shall be installed on the conditioned space side of all insulation in all exterior walls, vented attics and unvented attics with air-permeable insulation.

«» Commentary for Section 160.1(d)2:

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

Buildings with unvented or controlled-ventilation crawl spaces in all climate zones must have a Class I or Class II vapor retarder placed over the earth floor of the crawl space to reduce moisture entry and protect insulation from condensation in accordance with RA4.5.1.

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

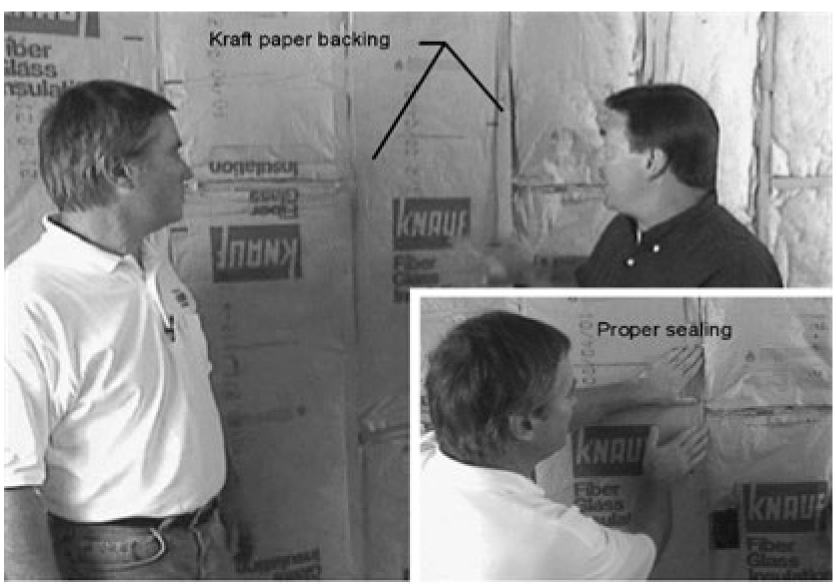
1. Class I: 0.1 perm or less
2. Class II: 0.1 < perm < 1.0 perm
3. Class III: 1.0 < perm < 10 perm

The following are common vapor retarder product types:

1. Foil and other facings on gypsum board can provide moisture resistance, and product literature shows conformance to ASTM E96.
2. Kraft paper facing on thermal batt insulation material is typically a Class II vapor retarder. Faced batts may 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 installation integrity through friction-fitting within the cavity of framed assemblies. In all cases, the insulation must be installed properly.
3. Interior painted surfaces may also serve as vapor retarders if the paint product has been tested and shown to comply with the vapor retarder requirements. The effectiveness of vapor retarder paint depends upon the installed thickness (in mils). These products often require more than one layer to achieve the tested perm rating. Installers of the paint, and building officials at inspection, must ensure proper application to comply with requirements.
4. Closed-cell spray polyurethane foam (ccSPF) products can provide Class I or Class II vapor retarder performance, depending on thickness.

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

Figure 3-11: Typical Kraft-Faced Vapor Retarder Facing



Source: California Energy Commission

«»

(e) Fenestration products. Fenestration separating conditioned space from unconditioned space or outdoors shall meet the requirements of either Item 1 or 2 below:

1. Fenestration, including skylight products, must have a maximum U-factor of 0.58.

   Exception 1 to Section 160.1(e)1: Up to 0.5 percent of the conditioned floor area is not required to comply with the maximum U-factor requirement.

   Exception 2 to Section 160.1(e)1: For dual-glazed greenhouse or garden windows, up to 30 square feet of fenestration area per dwelling unit is not required to comply with the maximum U-factor requirement.

2. The area-weighted average U-factor of all fenestration, including skylight products, shall not exceed 0.58.

Exception to Section 160.1(e): Fenestration installed in buildings meeting Part 7 of the California Building Code, California Wildland-Urban Interface Code, where the building is located in Fire Hazard Severity Zones or Wildland-Urban Interface (WUI) Fire Areas as designated by the local enforcement agency.

«» Commentary for Section 160.1(e)2:

The preferred methods for determining fenestration U-factor are those in NFRC 100 for manufactured windows and for site-built fenestration. The default U-factors in Table 110.6-A must be used when a NFRC label for the U-factor is not available. The U-factors in Table 110.6-A represent the least efficient possible values, thereby encouraging designers to obtain ratings through NFRC test procedures, when they are available. **«»**

(f) Installation of fireplaces, decorative gas appliances and gas logs. If a masonry or factory-built fireplace is installed, it shall comply with Section 110.5, Section 4.503 of Part 11, and shall have the following:

1. Closable metal or glass doors covering the entire opening of the firebox; and
2. A combustion air intake to draw air from the outside of the building, which is at least 6 square inches in area and is equipped with a readily accessible, operable and tight-fitting damper or combustion-air control device; and

   Exception to Section 160.1(f)2: An outside combustion-air intake is not required if the fireplace will be installed over concrete slab flooring and the fireplace will not be located on an exterior wall.

3. A flue damper with a readily accessible control.

   Exception to Section 160.1(f)3: 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 CMC or the manufacturer's installation instructions.

«» Commentary for Section 160.1(f)3:

Closeable metal or glass doors must cover the entire firebox opening for fireplaces, decorative gas appliances, and gas logs in dwelling unit and common use areas. A combustion air intake no smaller than 6 square inches in area, with a tight-fitting damper or combustion-air control must also be installed. A flue damper with accessible control is also required. **«»**

(g) Slab edge Insulation. Slab edge insulation shall meet the following minimum specifications:

1. Insulation material alone without the facing shall have a water absorption rate no greater than 0.3 percent when tested in accordance with ASTM C272, Test Method A – 24-Hour-Immersion; and
2. Water vapor permeance no greater than 2.0 perm/inch when tested in accordance with ASTM C272; and
3. Concrete slab perimeter insulation shall be protected from physical damage and ultraviolet light deterioration; and
4. Insulation for a heated slab floor shall meet the requirements of Section 110.8(g).

«» Commentary for Section 160.1(g):

The Energy Code includes mandatory requirements for multifamily buildings to ensure that materials used for slab perimeter insulation are suitable for the application, including minimum specifications regarding water absorption rate, water vapor permeance, damage protection, and ultraviolet protection. Insulation material in direct contact with soil, such as perimeter insulation, must have 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. Several types of insulation are widely available in the market that are appropriate for ground contact and for slab edge insulation, such as extruded polystyrene (XPS), rigid fiberglass, and rock wool.

The insulation must 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 using other suitable means. **«»**

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 170.1 – PERFORMANCE APPROACH

A building complies with the performance approach if the energy consumption calculated for the proposed design building is no greater than the energy budget calculated for the standard design building using Commission-certified compliance software as specified by Sections 10-109, 10-116 and the Alternative Calculation Method Reference Manual.

«» Commentary for Section 170.1

Performance approach information is included in Chapter 10. **«»**

(a) Energy budget. The Energy budget is expressed in terms of long-term system cost (LSC) and source energy:

1. **Long-term system cost (LSC).** The LSC energy budget is determined by applying the mandatory and prescriptive requirements of the standard design to the proposed design building and has two components, the Efficiency LSC and the Total LSC.
   A. The Efficiency LSC energy is the sum of the LSC energy for space-conditioning, water heating, mechanical ventilation, lighting and the self-utilization credit.
   B. The Total LSC energy is the sum of the Efficiency LSC energy and LSC energy from the photovoltaic system, battery energy storage systems (BESS), and demand flexibility.
2. **Source energy.** The source energy budget is determined by applying the mandatory and prescriptive requirements of the standard design, except with a consumer gas or propane water heater, to the proposed design building.

Exception to Section 170.1(a): A community shared solar electric generation system, or other renewable electric generation system, and/or community shared BESS, that provides dedicated power, utility energy reduction credits or payments for energy bill reductions to the permitted building and is approved by the Energy Commission as specified in Title 24, Part 1, Section 10-115, may offset part or all of the solar electric generation system or BESS LSC energy required to comply with the standards, as calculated according to methods established by the Commission in the Nonresidential ACM Reference Manual.

(b) Compliance demonstration requirements for performance standards.

1. Certificate of Compliance and Application for a Building Permit. The application for a building permit shall include documentation pursuant to Sections 10-103(a)1 and 10-103(a)2 that demonstrates, using an approved calculation method, that the building has been designed so that its source energy and LSC energy consumption do not exceed the standard design energy budgets for the applicable climate zone.
2. Field verification of individual dwelling unit systems. When performance of installed features, materials, components, manufactured devices or systems above the minimum specified in Section 170.2 is necessary for the building to comply with Section 170.1, or is necessary to achieve a more stringent local ordinance, field verification shall be

performed in accordance with the applicable requirements in the following subsections, and the results of the verification(s) shall be documented on applicable Certificates of Installation pursuant to Section 10-103(a)3 and applicable Certificates of Verification pursuant to Section 10-103(a)5.

F. Dwelling unit enclosure air leakage. When performance compliance requires a building enclosure leakage rate that is lower than the standard design, the building enclosure shall be field verified in accordance with the procedures specified in Reference Residential Appendix RA3.8.

G. Quality insulation installation (QII). When performance compliance requires field verification of QII, the building insulation system shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.5.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 170.2 – PRESCRIPTIVE APPROACH

Multifamily buildings, including both dwelling units and common use areas, that comply with the prescriptive standards shall be designed, constructed and equipped to meet all of the requirements for the appropriate climate zone shown in Table 170.2-A. In Table 170.2-A, NA (not allowed) means that feature is not permitted in a particular climate zone and NR (no requirement) means that there is no prescriptive requirement for that feature in a particular climate zone. Installed components shall meet the following requirements:

(a) **Envelope component requirements**.

1. **Exterior roofs and ceilings**. Exterior roofs and ceilings shall comply with each of the applicable requirements in this subsection:

   A. Roofing products. All roofing products shall meet the requirements of Section 110.8 and the applicable minimum aged solar reflectance and thermal emittance requirements of Table 170.2-A.

   Exception 1 to Section 170.2(a)1A: Roof area covered with building integrated photovoltaic panels and building integrated solar thermal panels are not required to comply with the minimum requirements for solar reflectance and thermal emittance or SRI.

   Exception 2 to Section 170.2(a)1A: Roof constructions with a weight of at least 25 lb/ft² are not required to comply with the minimum requirements for solar reflectance and thermal emittance or SRI.

«» Commentary for Section 170.2(a)1A:

Energy-efficient cool roofs are prescriptively required. The prescriptive requirements are defined based on three-year SR and TE, or SRI, as summarized in Table 3-4: Prescriptive Cool Roof Requirements. The requirements differ depending on roof slope, climate zone, and whether roof/ceiling Option B, C, or D (as defined below in Section 170.2(a)1B) is selected. These distinctions are used to maximize energy savings for specific roofing structures in climate zones with high solar heat gain. Climate Zones 10, 11, 13 and 15 have higher requirements for steep-slope Option B roof types, and the requirements for low-sloped roof Option D have been expanded to most climate zones. If a cool roof is being installed to comply with the Energy Code, it must meet the mandatory product and labeling requirements of Section 110.8(i) of the Energy Code. See Section 180.1 for additions and Section 180.2 for alterations.

Table 3-4: Prescriptive Cool Roof Requirements

Roof Type[1]	Climate Zone	Minimum Three-Year Solar Reflectance	Minimum Thermal Emittance	Minimum SRI
Steep-sloped, Option B	12, and 14	0.20	0.75	16
Steep-sloped, Option B	10-11, 13, and 15	0.25	0.75	23
Steep-sloped, Option C	10-15	0.20	0.75	16
Steep-sloped Option D	2-15	0.20	0.75	16
Low-sloped Option B and C	13, and 15	0.63	0.75	75
Low-sloped Option D	2, 4, and 6-15	0.63	0.75	75

[1] Low-sloped roof is defined as having a surface with a pitch less than 2:12 (less than 9.5 degrees from the horizon). A steep-sloped roof is a surface with a pitch greater than or equal to 2:12 (9.5 degrees or greater from the horizontal).

Source: California Energy Commission

There are two exceptions to meeting these prescriptive requirements:

1. Roof area covered with building-integrated photovoltaic panels or building-integrated solar thermal panels. Building integrated-photovoltaics are photovoltaic materials that are used to replace conventional building materials in parts of the building envelope such as the roof, skylights, or facades. These materials refer to roofing material that is a photovoltaic or solar thermal panel. Any roof area that is not building-integrated photovoltaic or solar thermal panel must still meet applicable roofing material requirements, including any roof area that has a photovoltaic or solar thermal system above it. **OR**
2. Roof constructions that have a weight of at least 25 pounds per square foot, including EPDM with stone ballast and slate roofing.**«»**

B. Roof insulation. Roofs shall have an overall assembly U-factor no greater than the applicable value in Table 170.2-A, meeting i, ii, iii or iv below. Where required by Sections 110.8 and 160.1(a), insulation shall be placed in direct contact with a continuous roof or drywall ceiling.

i. Option A: Reserved.

ii. Option B: A minimum R-value of insulation installed between the roof rafters in contact with the roof deck and an additional layer of ceiling insulation located between the attic and the conditioned space when meeting Section 170.2(c)3Biia; or

iii. Option C: A minimum R-value of ceiling insulation located between the attic and the conditioned space when meeting Section 170.2(c)3Biib.

iv. Option D: A minimum U-factor for roof assemblies above conditioned space without attic space.

«» Commentary for Section 170.2(a)1B:

The Energy Code is designed to offer flexibility to builders and designers of multifamily newly constructed buildings in terms of achieving the intended energy efficiency targets. Thus, the Energy Code offers several compliance options for roof insulation in multifamily buildings, as summarized in Table 3-5: Summary of Multifamily Roof Insulation Options.

Table 3-5: Summary of Multifamily Roof Insulation Options

Roof / Ceiling Insulation Option	Attic Space	Below Roof Deck Insulation	Ceiling Insulation	Radiant Barrier	Duct and Air Handler Location
B	Yes, ventilated	Required in climate zones 4 and 8-16	Yes	Required in climate zones 2-3, 5-7	Allowed in ventilated attic
C	Yes, ventilated	Not required	Yes	Required in climate zones 2-15	Within conditioned space
D	No	As needed to meet assembly U-factor requirements	As needed to meet assembly U-factor requirements	Not required	Within conditioned space

Source: California Energy Commission

Option B has a vented attic space and uses a combination of ceiling insulation and below-roof deck insulation.

Option C also has a vented attic space but uses ceiling insulation only.

Option D has no attic space and uses U-factor requirements instead of insulation levels.

The prescriptive requirements for Option B and Option C assume that the building is built with the following construction practices:

1. The attic is ventilated with an appropriate free vent area as described below.
2. The roof is constructed with standard wood rafters and trusses.
3. For Option B, the outermost layer of the roof construction is either tiles or a roofing product installed with an air gap between it and the roof deck.
4. The air handler and ducts are in the ventilated attic for Option B and are otherwise in conditioned space for Option C.
5. The air barrier is located at the ceiling (except cathedral and sealed attic roof/ceiling systems).

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

Section 170.2 requires different values of roof and ceiling insulation, depending on whether Option B or Option C is chosen. Table 3-6: Prescriptive Insulation Options shows a prescriptive requirements checklist for each option based on Table 170.2-A.

Table 3-6: Prescriptive Insulation Options

Ventilated Attics	Ventilated Attics With Ducts in Conditioned Space	No Attic
Option B	**Option C**	**Option D**
¨ Vented attic ¨ R-19 (CZ 4, 8-9, 11-15) or R-13 (CZ 10, 16) **below roof deck** batt, spray in cellulose/fiberglass secured with netting, or spray foam ¨ R-38 (CZ 1, 2, 4, 8-16) ceiling insulation or R-30 (CZ 3 and 5-7) ¨ Radiant barrier (CZ 2, 3, 5-7) ¨ Air space between roofing and the roof deck	¨ Vented attic ¨ R-38 (CZ 1, 11-16) ceiling insulation or R-30 (CZ 2-10) ¨ R-6 or R-8 ducts (climate zone-specific) ¨ Radiant barrier (CZ 2-15)	¨ No attic space ¨ Maximum U-factor of 0.041 for metal buildings ¨ Maximum U-factor of 0.028 (CZ 1-2, 4, 8-16) or 0.034 (CZ 3, 5-6) or 0.039 (CZ7)

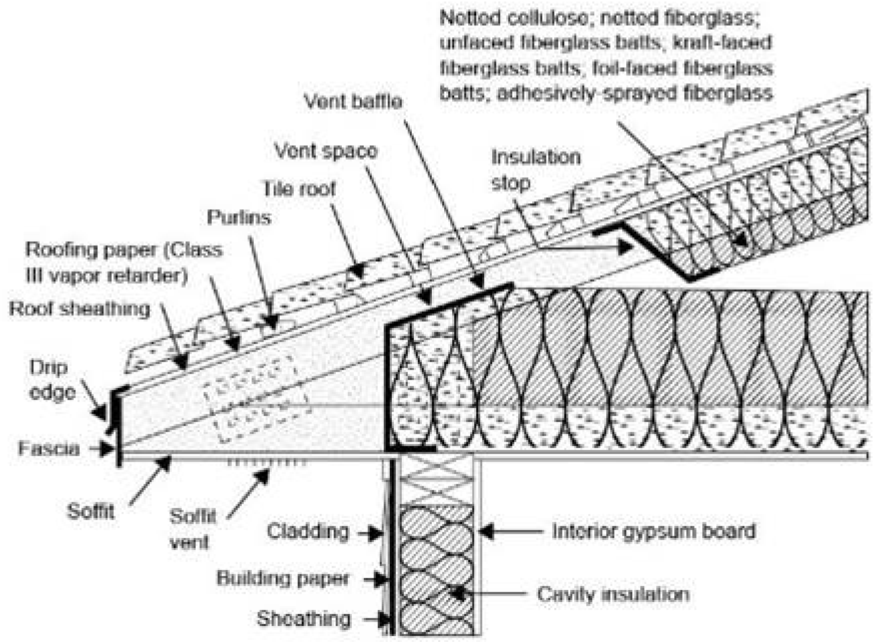
Source: California Energy Commission

Below Roof Deck Insulation (Option B)

In a vented attic, air-permeable or air-impermeable insulation (batt, spray foam, loose-fill cellulose, or fiberglass) should be placed directly below the roof deck between the truss members and secured in place to provide a thermal break. Figure 3-12: Details of Option B Assembly shows an example of insulation details in an Option B attic. Insulation must be in direct contact with the roof deck and secured by the insulation adhesion, facing, mechanical fasteners, wire systems, a membrane material, or netting. Batts supported with cabling or other mechanical methods from below must have supports that are less than or equal to 16" apart and no further than 8" from the end of the batt. Figure 3-13: Placement of Insulation Below the Roof Deck shows the placement and provides example attachment methods for below-deck insulation.

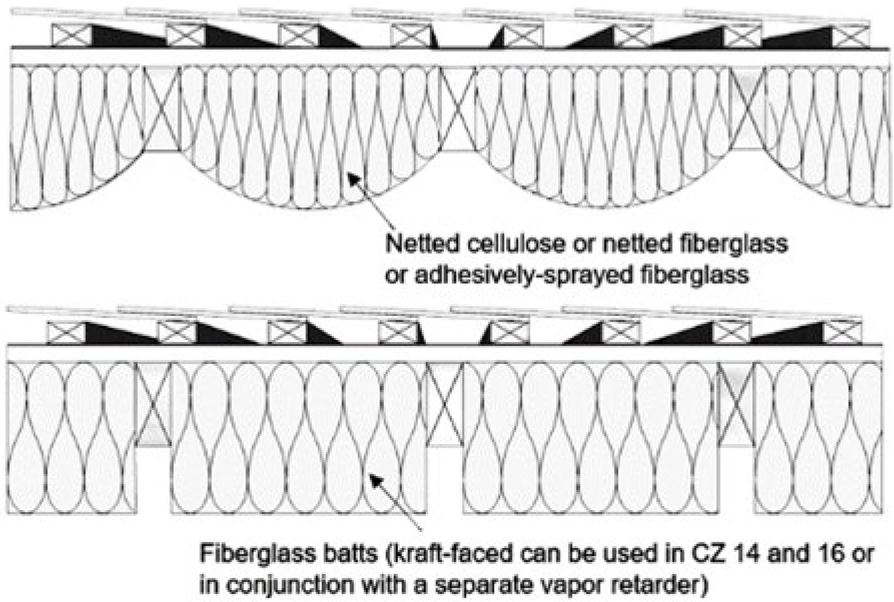
When batt thickness exceeds the depth of the roof framing members, full-width batts must be used to fit snugly and allow batts to expand beyond the framing members. Full coverage of the top chord framing members by insulation is recommended as best practice but is not required.

Figure 3-12: Details of Option B Assembly



Source: California Energy Commission

Figure 3-13: Placement of Insulation Below the Roof Deck



Source: California Energy Commission

When insulation is installed below the roof deck to meet the prescriptive requirements of Option B, a radiant barrier is not required.

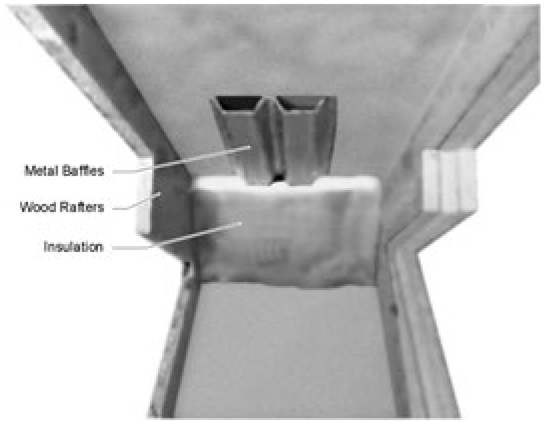
Attic Ventilation (Options B and C)

Proper attic ventilation occurs at two points at the roof: the soffit (or eave) vents and the ridge vents.

When installing insulation below the roof deck, vent baffles and insulation barriers should be used to maintain proper ventilation space. Proper airflow through the space helps remove moisture and prevents any associated issues.

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 3-14: Baffles at the Eave in Attics.) 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 several acceptable methods for maintaining ventilation air, including preformed baffles made of cardboard or plastic. In some cases, plywood or rigid foam baffles are used.

Figure 3-14: Baffles at the Eave in Attics



Source: California Energy Commission

The CBC requires a minimum vent area to be provided in roofs with attics, including enclosed rafter roofs that create 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 must not be less than 1/300 of the area of the space ventilated.
2. CBC, Title 24, Part 2.5, Section R806.2 requires that the net-free ventilating area must 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 Climate Zones 14 and 16.

If meeting number 1 above, a minimum of 40 percent and not more than 50 percent of the vents must be located at least 3 feet (ft.) above the eave or cornice vents in the upper portion of the space being ventilated.

Insulation must not block the free flow of air, and a minimum 1-inch air space must be provided between the insulation and the roof sheathing and at the location of the vent.

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 to determine if ventilation requirements are met.

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

Ducts and Air Handlers Located in Conditioned Space

Ducts may be located and verified to be in conditioned space instead of installing insulation at the roof deck. If complying with this option, ceiling and duct insulation must be installed at the values specified in Table 170.2-B for Option C, and a radiant barrier is required in most climate zones.

Energy Code Compliance (ECC) Verification (Option C)

Locating ducts in conditioned space does not alone qualify for this requirement; an ECC-Rater must test and verify for low-leakage ducts within conditioned space and verify that the ducts are insulated to a level required in Table 170.2-K of the Energy Code.

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 ducts and equipment must be within the air barrier of the building. Locating ducts within an unvented attic does not meet Option C requirements.

Ceiling Insulation (Options B and C)

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 deck. This condensation can cause structural damage and reduce the effectiveness of the insulation.

Based on area-weighted averaging, 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, or raised heel truss, is not required but may be desirable in some applications. **«»**

C. Radiant barrier. A radiant barrier required in Table 170.2-A shall meet the requirements specified in Section 110.8(j) and shall meet the installation criteria specified in Reference Residential Appendix RA4**.**

«» Commentary for Section 170.2(a)1C:

The prescriptive requirements call for Option C vented attics to have a radiant barrier in Climate Zones 2 through 15, while Option B vented attics require a radiant barrier in Climate Zones 2, 3, and 5 through 7.

Installation

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.

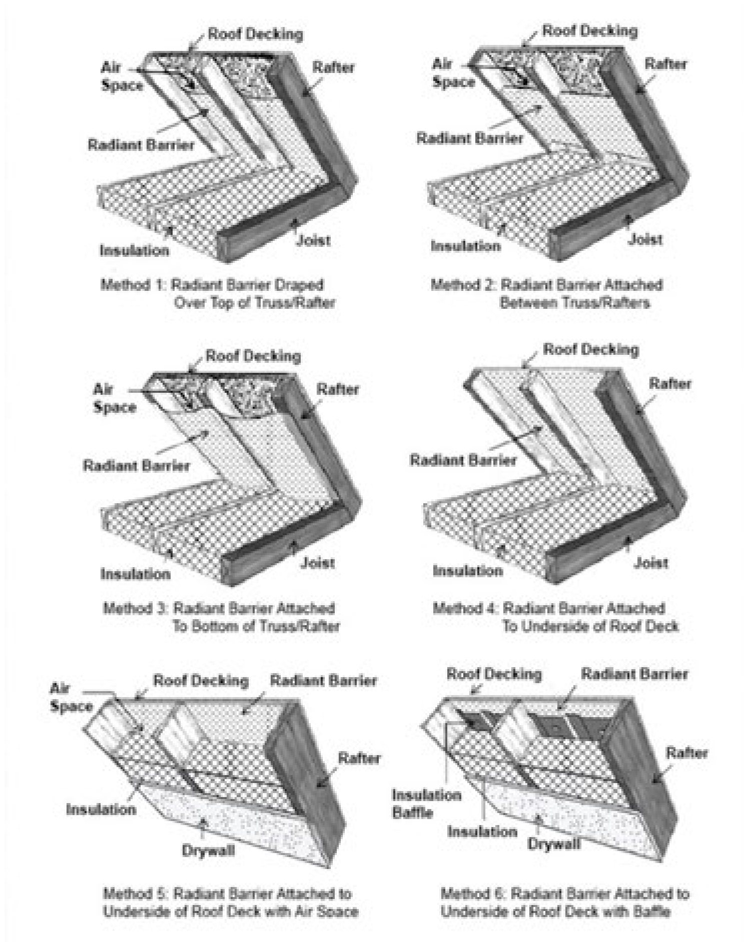
Alternatively, a radiant barrier material that meets the same ASTM test and moisture perforation requirements that apply to factory-laminated foil can be field-laminated. Field lamination must use a secure mechanical means of holding the foil-type material to the bottom of the roof decking such as staples 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 the gable ends 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 Reference Appendices, Residential Appendix 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 to the roof sheathing between framing members. This construction type is described in the Residential Reference Appendices RA4.2.1.1. Figure 3-15: Methods of Installation for Radiant Barriers for drawings of radiant barrier installation methods.

If a radiant barrier is installed in closed rafter spaces, such as a cathedral ceiling, the required air space for radiant barriers must be provided and must meet the ventilation requirements of the CBC, Title 24, Part 2.5, Section R806.1.

Figure 3-15: Methods of Installation for Radiant Barriers



Source: California Energy Commission

«»

2. **Wall insulation.**

   A. Exterior walls shall have an overall assembly U-factor no greater than the applicable value in Table 170.2-A.

   B. Demising walls shall meet the requirements of Section 160.1(b)7. Vertical windows in demising walls between conditioned and unconditioned spaces shall have an area-weighted average U-factor no greater than the applicable value in Table 170.2.

«» Commentary for Section 170.2(a)2B:

Requirements for wall U-factor and insulation are grouped by a combination of factors: wall assembly fire rating and construction type. In prescriptive requirements, all framed walls regardless of the framing material (wood, metal, or others) are subdivided into those with one-hour or lower fire rating and those with higher than one-hour fire rating. This differentiation in the Energy Code allows high-fire rating (one-hour or higher) wall types, which have constructability limitations and are more costly to insulate, to adhere to less stringent U-factor requirements than walls with lower fire ratings (lower than one hour).

The fire-resistance rating of a wall's is determined by the fire code and is measured in hours. Chapter 6 of the CBC describes fire-resistance rating in detail, and the specific rating of a building's is ultimately decided upon by the local building official. The fire rating for the exterior walls of a building depends on the construction type, based on the number of stories, building height, occupancy type, and fire-suppression system type. A wall's fire-resistance rating can also vary due to fire-separation distance, though for residential occupancy types, fire-separation distance never changes a wall's rating from 1-hour to 2-hour (or more). Code officials use CBC Tables 601, 602, 504.3 and 504.4 in combination to make the wall fire-rating determinations. The determination method is generally well understood, and fire-resistance rating info is readily available from the building architect. Generally, buildings with six or more stories and heavy-timber buildings have high fire-ratings, while buildings of five or fewer stories have a low-fire rating. In most cases, all walls of a specific building will fall under one of the two categories used in Table 170.2-A.

There are five common classes of wall constructions: wood-framed, metal-framed, metal building walls, light mass, and heavy mass (Figure 3-16: Classes of Wall Construction). The following provides information about these wall systems, as well as furred walls, spandrel panels and opaque curtain walls.

Wood-framed walls

As defined by the 2022 California Building Code, Type V buildings typically have wood-framed walls. Framing members typically consist of 2x4 or 2x6 framing members spaced at 24-inch or 16-inch OC. Composite framing members and engineered wood products also qualify as wood framed walls if the framing members are nonmetallic. Reference Joint Appendix JA4, Table 4.3.1 has data for conventional wood-framed walls.

Metal-framed walls

Many nonresidential buildings require noncombustible construction, and this is often achieved with metal-framed walls. Often metal-framed walls are not structural and are used as infill panels in rigid framed steel or concrete buildings. Batt insulation is less effective for metal-framed walls (compared to wood-framed walls) because the metal framing members are more conductive. In most cases, continuous insulation is required to meet prescriptive U-factor requirements. Reference Appendices, Joint Appendix JA4, Table 4.3.3, has data for metal-framed walls.

Metal building walls

Metal building walls consist of a metal building skin that is directly attached to metal framing members. The framing members are typically positioned in a horizontal direction and spaced at about 4 feet. A typical method of insulating metal building walls is to drape the insulation over the horizontal framing members and to compress the insulation when the metal exterior panel is installed.

Light-mass walls

Light-mass walls have a heat capacity (HC) greater or equal to 7.0 but less than 15.0 Btu/°F-ft². See the definition below for heat capacity. From Reference Appendices, Joint Appendix

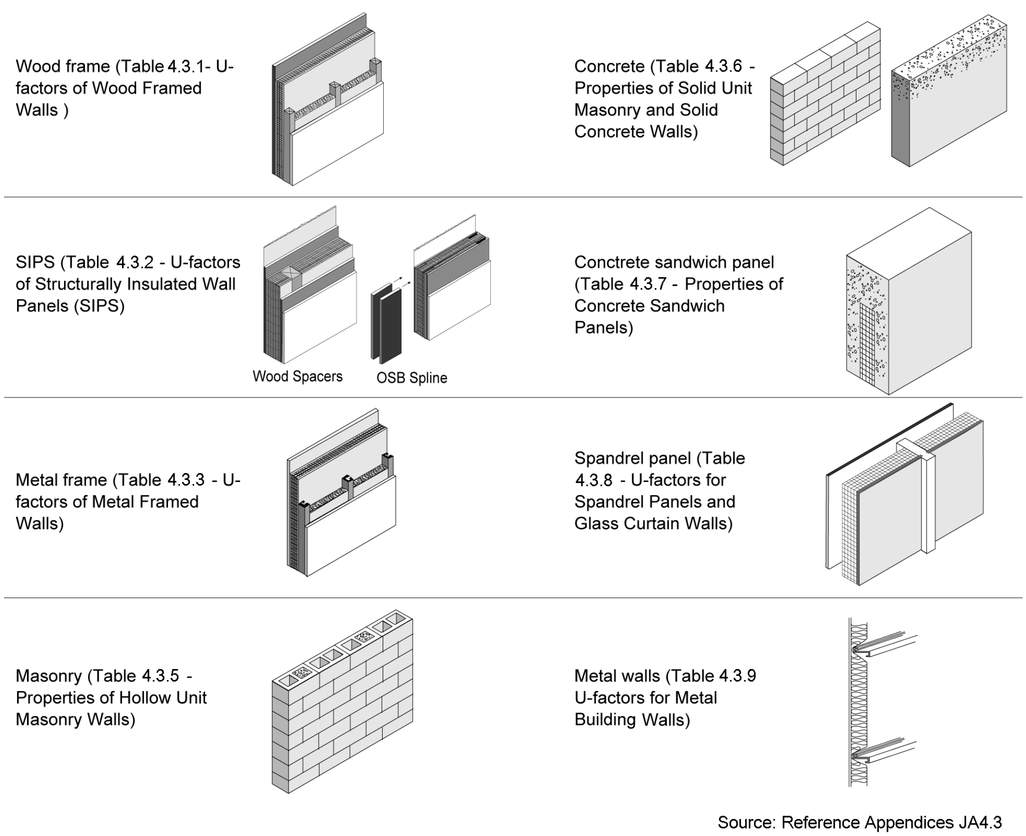
JA4, Tables 4.3.5 and 4.3.6 have U-factor, C-factor, and heat capacity data for hollow unit masonry walls, solid unit masonry and concrete walls, and concrete sandwich panels.

Heavy-mass walls

Have a HC equal to or greater than 15.0 Btu/°F-ft². See Reference Joint Appendix JA4 for HC data on mass walls.

For light- and heavy-mass walls, heat capacity (HC) is the amount of heat required to raise the temperature of the material by 1 degree F. In the Energy Code, it is defined as the product of the density (lb/ft^3), specific heat (Btu/lb-F), and wall thickness (ft). For instance, a 6" medium weight concrete hollow unit masonry wall has a heat capacity of 8.4 and is considered a light mass wall. The same masonry wall with solid grout that is 10 inches thick has a heat capacity of 19.7 and is considered a heavy mass wall.

Figure 3-16: Classes of Wall Construction



Source: California Energy Commission

«»

3. **Fenestration.**

   A. Vertical fenestration and glazed doors in exterior walls shall comply with Subsections i, ii and iii:

      i. Percent fenestration area shall be limited in accordance with the applicable requirements of a and b below:

         a. A total fenestration area no greater than 20 percent of the conditioned floor area; and

         b. A total fenestration area no greater than 40 percent of the gross exterior wall area.

         Note: Demising walls are not exterior walls, and therefore demising wall area is not part of the gross exterior wall area, and fenestration in demising walls is not part of the fenestration area limitation.

«» Commentary for Section 170.2(a)3A:

Multifamily buildings have three prescriptive fenestration area limitations. All three must be met for prescriptive compliance.

1. Total combined vertical fenestration and skylight area may not exceed 20 percent of the conditioned floor area (CFA).
2. Total vertical fenestration may not exceed 40 percent of the gross exterior wall area.
3. Total skylight area may not exceed 5 percent of the gross exterior roof area.

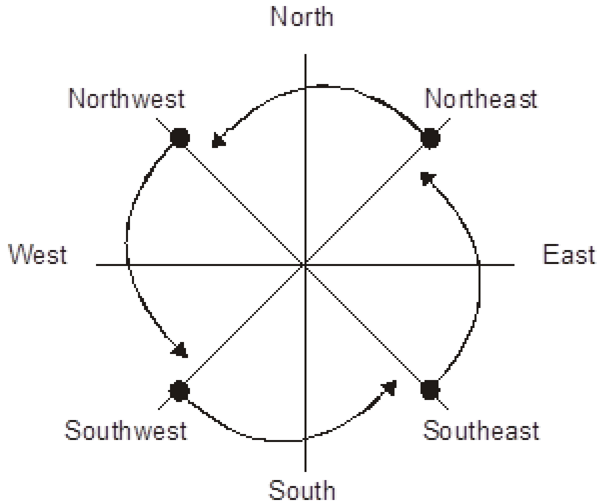
Glazing in a demising wall does not count toward the total building allowance. There is no limit to the amount of glazing allowed in demising walls, but it must meet the prescriptive U-factor requirements for the climate zone.

Window area is generally taken from the rough opening dimensions. To the extent this opening is slightly larger than the frame, the rough opening area will be slightly larger than the formally defined window area.

Glazed doors use the rough opening area, except where the door glass area is less than 25 percent of the door, in which case the glazing area may be either the entire door area or the glass area plus 2 inches added to all four sides of the glass (to represent the "window frame") for a window in a door. Calculate the window area from the rough opening dimensions and divide by the gross exterior wall area, which does not include demising walls.

The orientation can be determined from an accurate site plan. Any orientation within 45 degrees of true north, east, south, or west will be assigned to that orientation. Figure 3-17: Four Surface Orientations demonstrates how surface orientations are determined and what to do if the surface is oriented exactly at 45 degrees of a cardinal orientation. For example, an east-facing surface cannot face exactly northeast, but it can face exactly southeast. If the surface were facing exactly northeast, it would be considered north-facing.

Figure 3-17: Four Surface Orientations



Source: California Energy Commission

«»

ii. Fenestration properties. Installed fenestration products, including glazed doors, shall have an area-weighted average U-factor, Relative Solar Heat Gain Coefficient (RSHGC), and Visible Transmittance (VT) meeting the applicable fenestration values in Table 170.2-A and shall be determined in accordance with Sections 110.6(a)2 and 110.6(a)3.

Vertical fenestration in demising walls between conditioned and unconditioned spaces is only required to comply with the area-weighted average U-factor requirement in Table 170.2-A.

Exception 1 to Section 170.2(a)3Aii: For each dwelling unit, up to 3 square feet of new glazing area installed in doors shall not be required to meet the U-factor and RSHGC requirements of Table 170.2-A.

Exception 2 to Section 170.2(a)3Aii: For fenestration containing chromogenic type glazing:

a. The lower-rated labeled U-factor and SHGC shall be used with automatic controls to modulate the amount of solar gain and light transmitted into the space in multiple steps in response to daylight levels or solar intensity;

b. Chromogenic glazing shall be considered separately from other fenestration; and

c. Area-weighted averaging with other fenestration that is not chromatic shall not be permitted and shall be determined in accordance with Section 110.6(a).

Exception 3 to Section 170.2(a)3Aii: For dwelling units containing unrated site-built fenestration that meets the maximum area restriction, the U-factor and SHGC can be determined in accordance with Nonresidential Reference Appendix NA6 or using default values in Table 110.6-A and Table 110.6-B.

Exception 4 to Section 170.2(a)3Aii: Fenestration in dwelling units of buildings in Climate Zones 1, 3, 5 and 16 is not required to comply with the RSHGC requirements.

Exception 5 to Section 170.2(a)3Aii: Fenestration in dwelling units is not required to comply with the VT requirements.

«» Commentary for Section 170.2(a)3Aii:

There are several fenestration types and fenestration categories as described below.

Windows

A window is a vertical fenestration product that is an assembled unit consisting of a frame and sash component holding one or more pieces of glazing. Window performance is measured with the U-factor, solar heat gain coefficient (SHGC), and visible transmittance (VT).

Windows are considered part of an exterior wall when the slope is 60° or more. When the slope of fenestration is less than 60°, the glazing is considered a skylight and part of the roof.

Skylights and 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. 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 building 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 energy efficient.

Glazed doors

Glazed door is an exterior door having a glazed area of 25 percent or more of the area of the door. When the door has less than 25 percent glazing material, it is no longer considered a glazed door. (See exterior doors in previous section). All glazed areas will be counted toward the overall glazed area of the conditioned space in any calculations.

Manufactured fenestration

Manufactured fenestration is a fenestration product constructed of materials that 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.

Site-built fenestration

Site-built fenestration is designed to be field-glazed or field-assembled units, using specific factory-cut or other factory-formed framing, and glazing units that are manufactured with the intention of being assembled at the construction site. These include storefront systems, curtain walls or large-track sliding glass walls, and atrium roof systems.

Field-fabricated fenestration

Field-fabricated fenestration is when the windows are fabricated at the building site from elements that are not sold together as a fenestration product (that is, 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).

Prescriptive multifamily fenestration requirements depend on which of the following window types are installed.

Curtainwall, window wall, or storefront

Curtain wall, window wall, or storefront windows consist of metalized or glass panels often hung outside structural framing to create exterior wall elements around fenestration and between floors.

NAFS Performance Class AW (architectural windows)

NAFS Performance Class AW adhere to industry standard – AAMA/ WDMA/ CSA 101/ I.S.2/ A440 NAFS-2017 North American Fenestration Standard/ Specification, which includes testing requirements for fenestration products based on air leakage resistance, water penetration resistance, uniform load resistance and forced-entry resistance. The Performance Classes are designated R, LC, CW, and AW in order of performance. Higher rated products typically rely on metal window framing materials which lead to high thermal bridging in the window frame and thus higher U-factors. Windows must be certified as NAFS rated to qualify for the category.

The architect calculates the building's wind loads to determine if Class AW windows are needed.

All other fenestration

All other fenestration includes operable windows, punched fixed windows, glass doors, and skylights that do not qualify as NAFS Performance Class AW.

Prescriptive Fenestration Requirements

For vertical and skylight fenestration, for multifamily buildings refer to Table 170.2-A. The maximum fenestration U-factor and maximum relative solar heat gain coefficient (RSHGC), and minimum visible transmittance (VT) depend on window type and climate zone. In heating dominant climate zones 1,3,5, and 16 there is no maximum RSHGC requirement to allow building designers the flexibility to achieve ideal RSHGC levels for annual energy efficiency based on building fenestration orientation and local heating and cooling demand. There is no longer a distinction between buildings with four or more habitable stories and those with three or less habitable stories. VT requirements apply to multifamily building common use areas.

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 RSHGC of windows, glazed doors, and skylights can be area weight-averaged together to meet the prescriptive requirement. **«»**

iii. Shading. Where Table 170.2-A requires a maximum RSHGC, the requirements shall be met with an area-weighted average RSHGC excluding the effects of interior shading, no greater than the applicable value in Table 170.2-A.

For the purposes of this paragraph, the RSHGC of a vertical window is:

a. The solar heat gain coefficient of the window; or

b. Relative solar heat gain coefficient is calculated using Equation 170.2-A, if the window has an overhang that extends beyond each side of the window jamb by a distance equal to the overhang's horizontal projection.

Exception 1 to Section 170.2(a)3Aiiib: An area-weighted average relative solar heat gain coefficient of 0.56 or less shall be used for windows:

I. That are in the first story of exterior walls that form a display perimeter; and

II. For which codes restrict the use of overhangs to shade the windows.

Exception 2 to Section 170.2(a)3Aiiib: For vertical glazing containing chromogenic type glazing:

I. the lower-rated labeled RSHGC shall be used with automatic controls to modulate the amount of heat flow into the space in multiple steps in response to daylight levels or solar intensity; and

II. chromogenic glazing shall be considered separately from other glazing; and

III. area-weighted averaging with other glazing that is not chromogenic shall not be permitted.

Note: Demising walls are not exterior walls, and therefore fenestration in demising walls is not subject to SHGC requirements.

$RSHGC = SHGC \times [1 + a \times (2.72^{-PF} - 1) \times (\sin(b \times Az) + c)]$ (Equation 170.2-A)

WHERE:

Component	**a**	**b**	**c**

Overhang	0.150	0.008727	5.67
Exterior Horizontal Slat	0.144	0.008727	5.13

RSHGC = Relative Solar Heat Gain Coefficient.

SHGC = Solar Heat Gain Coefficient of the vertical fenestration.

Az = Azimuth of the vertical fenestration I degrees.

PF = Projection factor as calculated by Equation 140.3-C.

EQUATION 140.3-C PROJECTION AND DISTANCE FACTOR CALCULATION

Projection Factor = Projection / Spacing

Distance Factor – D / (H_{AS} x Projection Factor)

Where:

Projection = The horizontal distance between the base edge and the projected edge of the overhang, slat, or light shelf..

Spacing = For overhangs, the vertical distance between the projected edge of the overhang and sill of the vertical fenestration below it.
For horizontal slats, the vertical distance between the projected edge of a slat to the base edge of the slat below it.
For interior light shelves, the vertical distance between the projected edge of the light shelf and head of the clerestory fenestration above it.
For exterior light shelves, the vertical distance between the projected edge of the light shelf and sill of the vertical fenestration below it.

D = Distance between the existing structure or nature object and the fenestration

H_{AS} = Height difference between the top of the existing structure or nature object and the bottom of the fenestration

NOTE: The base edge is the edge of an overhang, slat, or light shelf that is adjacent to the vertical fenestration. The projected edge is the opposite edge from the base edge.

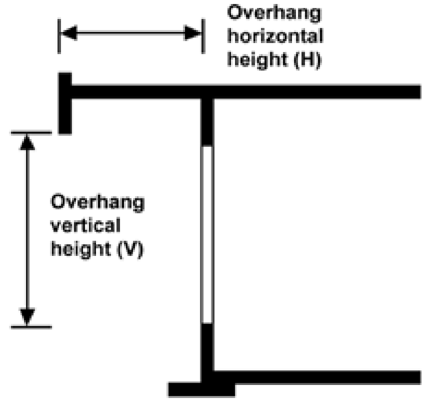
«» Commentary for Section 170.2(a)3Aiii:

Relative solar heat gain coefficient (RSHGC) allows for an external shading correction from exterior shading devices and overhangs. A fenestration product with an SHGC greater than prescriptively required may qualify if an opaque exterior shading device or overhang is used and the combined area-weighted average complies with the prescriptive requirements. Balconies that extend above glazing are common overhangs in multifamily buildings.

For credit, exterior shading devices must be permanently attached as opposed to being attached using clips, hooks, latches, snaps, or ties.

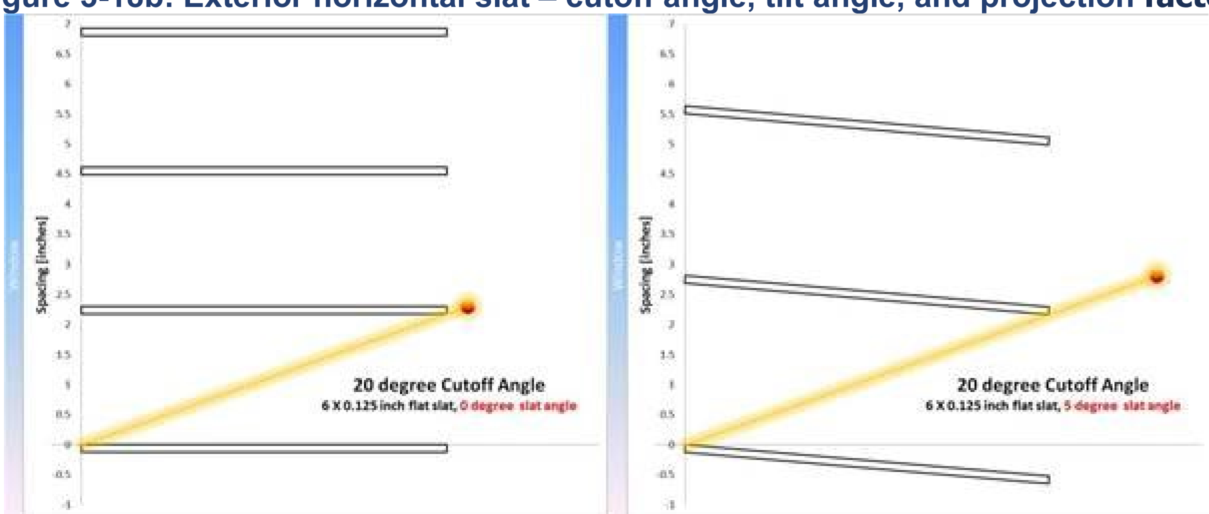
Shading factors depend upon the projection factor (PF) from Equation 140.3-C which is the ratio of the projection (P) and the spacing (s). These dimensions are measured from the vertical and horizontal planes passing through the bottom edge of the window glazing for overhangs or the slat below for horizontal slats, as shown in Figure 3-18a: Overhang Dimensions and Figure 3-18b: Exterior horizontal slat – cutoff angle, tilt angle, and projection factor. A shading factor may be used if the shading extends beyond both sides of the window jamb a distance equal to the overhang projection (Section 140.3(a)5), or if the entire horizontal slat assembly is completely contained within a window setback. If the shading is continuous along the side of a building, this restriction will usually be met. If there are shades for individual windows, each must be shown to comply.

Figure 3-18a: Overhang Dimensions



Source: California Energy Commission

Figure 3-18b: Exterior horizontal slat – cutoff angle, tilt angle, and projection factor



$RSHGC = SHGC \times [1 + a \times (2.72^{-PF} - 1) \times (\sin(b \times Az) + c)]$

Where:

RSHGC = Relative solar heat gain

SHGC = NFRC SHGC of the window

Az = Azimuth (orientation) of the window in degrees clockwise from north

PF = Project factor of the exterior shade

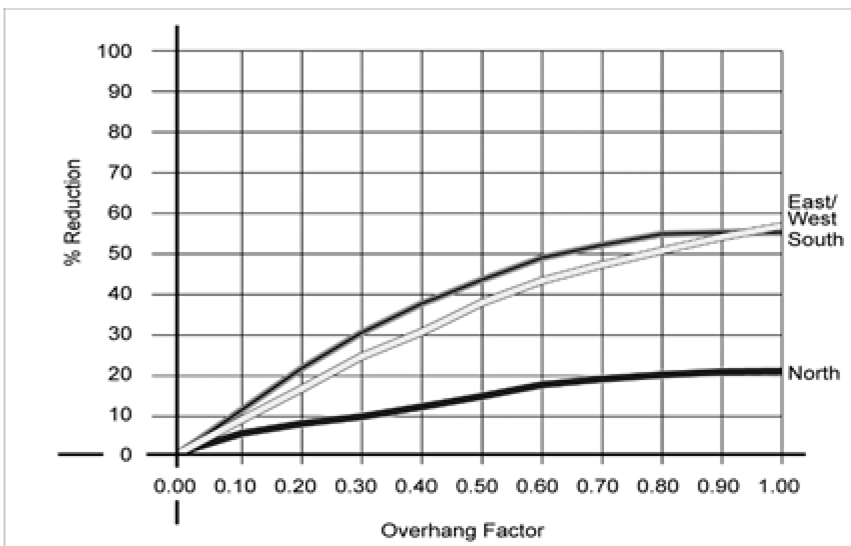
a = 0.170 for overhang or 0.144 for horizontal slat

b = 0.008727 for overhang and horizontal slat

c = 5.67 for overhang or 5.13 horizontal slat

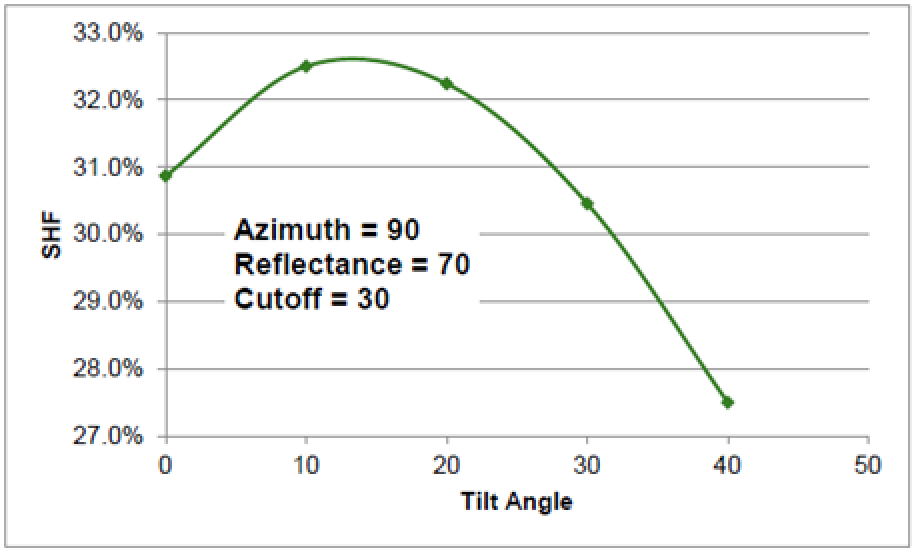
Figure 3-19a: Graph of Shading Factors for Overhangs and Figure 3-19b: Graph of Shading Factors for Horizontal Slats illustrate the benefits of shading factors of the various projection factors as a function of azimuth (orientation) for overhangs and as a function of tilt angle for horizontal slats. The chosen projection factors correspond to cutoff angles every 15 degrees. The graph shows that savings can be significant and that benefits increase as windows face more towards a southerly direction and also increase as overhangs or slats project more (i.e., have a higher projection factor).

Figure 3-19a: Graph of Shading Factors for Overhangs



Source: California Energy Commission

Figure 3-19b: Graph of Shading Factors for Horizontal Slats



Source: California Energy Commission

Chromogenic Glazing

If a multifamily building includes chromogenic type glazing that is automatically controlled, the lowest U-factor and lowest SHGC must meet the prescriptive requirements. This type of product cannot be weight averaged with nonchromogenic products as per Exception to Section 170.2(a)3Bii and Section 170.2(a)3Biii, Exception 2 to Section 170.2(a)3Aiiib and Exception 3 to Section 170.2(a)3Aiv. **«»**

iv. Vertical fenestration shall have an area-weighted average Visible Transmittance (VT) no less than the applicable value in Table 170.2-A, or Equation 170.2-B, as applicable.

Exception 1 to Section 170.2(a)3Aiv: When the window's primary and secondary sidelit daylit zones are completely overlapped by one or more skylit daylit zones, then the window need not comply with Section 170.2(a)3Aivw.

Exception 2 to Section 170.2(a)3Aiv: If the window's VT is not within the scope of NFRC 200 or ASTM E972, then the VT shall be calculated according to Reference Nonresidential Appendix NA6.

Exception 3 to Section 170.2(a)3Aiv: For vertical windows containing chromogenic type glazing:

a. The higher rated labeled VT shall be used with automatic controls to modulate the amount of light transmitted into the space in multiple steps in response to daylight levels or solar intensity;

b. Chromogenic glazing shall be considered separately from other glazing; and

c. Area-weighted averaging with other glazing that is not chromogenic shall not be permitted.

Exception 4 to Section 170.2(a)3Aiv: Fenestration in dwelling units is not required to comply with the VT requirements.

NOTE: Demising walls are not exterior walls, and therefore windows in demising walls are not subject to VT requirements.

$$VT \geq 0.11/WWR \qquad \text{(Equation 170.2-B)}$$

where:

WWR = Window Wall Ratio, the ratio of (i) the total window area of the entire building to (ii) the total gross exterior wall area of the entire building. If the WWR is greater than 0.40, then 0.40 shall be used as the value for WWR in Equation 170.2-B.

VT = Visible Transmittance of framed window.

«» Commentary for Section 170.2(a)3Aiv:

Fenestration in multifamily common areas must meet the climate zone-specific prescriptive requirement of having an area-weighted average VT of 0.42 or greater for fixed windows, 0.32 or greater for operable windows, 0.46 or greater for curtain walls and 0.17 or greater for glazed doors. Products with spectrally selective "low-e" coatings (also known as single, double or triple silver low-e) are available to meet this requirement.

A combination of high VT glazing in the upper part of a window (clerestory) and lower VT glazing at the lower part of the window (view window) can be used, as long as the area-weighted average meets the prescriptive requirement. This allows daylight to enter the space through the high VT glazing making a better daylighting design.

Fenestration in multifamily dwelling units does not have to comply with the prescriptive VT requirements. «»

B. **Skylights shall**:

i. Have an area no greater than 5 percent of the gross exterior roof area Skylight Roof Ratio (SRR); and

Exception 1 to Section 170.2(a)3Bi: Buildings with an atrium over 55 feet high shall have a skylight area no greater than 10 percent of the gross exterior roof area.

ii. Have an area-weighted performance rating U-factor no greater than the applicable value in Table 170.2-A.

Exception 2 to Section 170.2(a)3Bii: For each dwelling unit up to 16 square feet of new skylight area with a maximum U-factor of 0.55 and a maximum SHGC of 0.30.

iii. Solar heat gain coefficient. Have an area-weighted performance rating solar heat gain coefficient no greater than the applicable value in Table 170.2-A.

Exception to Sections 170.2(a)3Bii and 170.2(a)3Biii: For skylights containing chromogenic type glazing:

a. the lower-rated labeled SHGC shall be used with automatic controls to modulate the amount of heat flow into the space in multiple steps in response to daylight levels or solar intensity; and

b. chromogenic glazing shall be considered separately from other glazing; and

c. area-weighted averaging with other glazing that is not chromogenic shall not be permitted.

iv. Haze value. Have a glazing material or diffuser that has a measured haze value greater than 90 percent, determined according to ASTM D1003 or other test method approved by the Energy Commission.

Exception to Section 170.2(a)3Biv: Skylights designed and installed to exclude direct sunlight entering the occupied space by the use of fixed or automated baffles or the geometry of the skylight and light well.

«» Commentary for Section 170.2(a)3Biv:

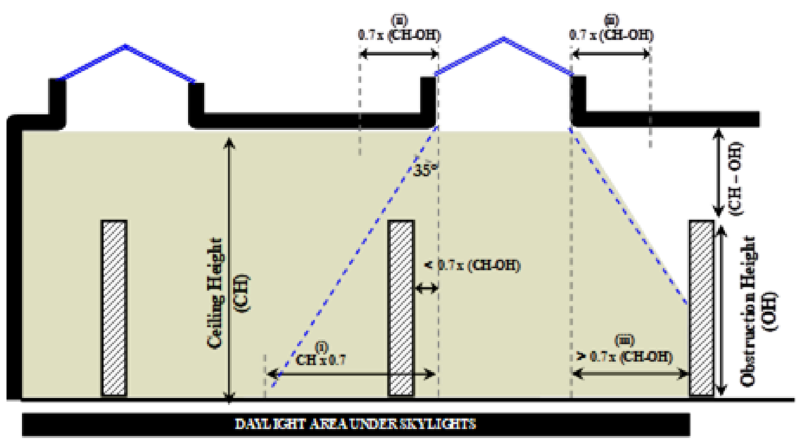
Skylight area is defined in Reference Appendices, Joint Appendix JA1 as the area of the rough opening of a skylight. The area limit for skylights is 5 percent of the gross exterior roof area, called the skylight roof ratio (SRR). The limit increases to 10 percent for buildings with an atrium more than 55 feet high. The 55-foot height is the threshold at which the California Building Code requires a mechanical smoke-control system for atriums (CBC Sec. 909). This means that the 10 percent SRR is not allowed for atriums unless they also meet the smoke control requirement.

Skylights shall have a glazing material or diffuser that has a measured haze value greater than 90 percent, tested according to ASTM D1003 (notwithstanding its scope) or other test method approved by the Energy Commission.

When the skylights are above unconditioned spaces (as per Section 170.2(b)), there is no limitation placed on the maximum skylight area or the U-factor or SHGC. Regardless of whether the space is conditioned, the Energy Code requires that the skylights diffuse and bring in enough sunlight so that, when the electric lights are turned off, the occupants have relatively uniform daylight in the space. If the space is unconditioned, single-glazed skylights will comply with the code requirements as long as the glazing or diffuser material has a haze rating greater than 90 percent. Products that have such a rating include prismatic diffusers, laminated glass with diffusing interlayers, pigmented plastics, and so forth. This requirement assures that light is diffused over all sun angles. Any unconditioned space that later becomes conditioned must meet the newly constructed building envelope requirements. Therefore, if the space may become conditioned in the future, it is recommended that the envelope meet the conditioned envelope thermal requirements.

Other methods that result in sufficient diffusion of light over the entire year would also be acceptable in lieu of using diffusing glazing. Acceptable alternatives are baffles or reflecting surfaces that ensure direct beam light is reflected off a diffuse surface before entering the space over all sun angles encountered during a year. This alternative method of diffusion would need to be documented by the designer and approved by the code authority in your jurisdiction.

Figure 3-20: Daylit Area Under Skylights



Source: California Energy Commission

«»

4. All exterior doors, excluding glazed doors, that separate conditioned space from unconditioned space or from ambient air shall have a U-factor not greater than the applicable value in Table 170.2-A. Glazed doors must comply with the requirements of Section 170.2(a)3A.

   Exception to Section 170.2(a)4: Swinging doors that are required to have fire protection are not required to meet the applicable door value in Table 170.2-A.

«» Commentary for Section 170.2(a)4:

An opaque door is an installed swinging door separating conditioned space from outside or adjacent unconditioned space with less than 25 percent glazed area. A door that has 25 percent or more glazed area is a glazed door and is treated like a fenestration product. The requirement is applicable to doors for individual dwelling units and in common use area.

Opaque dwelling unit entry doors between conditioned and unconditioned space are prescriptively required to have an area-weighted average U-factor no greater than U-0.20, per Table 170.2-A. Swinging common use entry doors on separating conditioned and unconditioned space prescriptively require a 0.70 U-factor. Swinging doors between unconditioned and conditioned space that are required to have fire protection are exempt from the prescriptive requirement. As an example, this may include a fire protection door that separates a conditioned dwelling unit and unconditioned corridor space. Non-swinging entry doors for common use areas must have a 1.45 U-factor requirement to meet prescriptive requirements, except in climate zones 1 and 16 where the U-factor requirement is 0.50. The U-factor must be rated in accordance with NFRC 100, or the applicable default U-factor defined in Reference Appendices, Joint Appendix JA4, Table 4.5.1 must be used.

At the field inspection, the field inspector verifies that the door U-factor meets the energy compliance values by checking the NFRC label sticker on the product. When 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. Default U-factors values for various door types are shown in Table 3-7: Default U-Factors for Doors per JA Table 4.5.1.

Table 3-7: Default U-Factors for Doors per JA Table 4.5.1

Description	U-factor (Btu/ °F-ft2)
Uninsulated single-layer metal swinging doors or non-swinging doors, including single-layer uninsulated access hatches and uninsulated smoke vents:	1.45
Uninsulated double-layer metal swinging doors or non-swinging doors, including double-layer uninsulated access hatches and uninsulated smoke vents:	0.70
Insulated metal swinging doors, including fire-rated doors, insulated access hatches, and insulated smoke vents:	0.50

Wood doors, minimum nominal thickness of 1-3/4 in. (44 mm), including panel doors with minimum panel thickness of 1-1/8 in. (28 mm), and solid core flush doors, and hollow core flush doors:	0.50
Any other wood door:	0.60
Uninsulated single layer metal roll up doors including fire rated door	1.45
Insulated single layer metal sectional doors, minimum insulation nominal thickness of 1-3/8 inch; expanded polystyrene (R-4 per inch).	0.179

Source: California Energy Commission

«»

5. Floors shall meet the following requirements:
   A. Raised floors shall be insulated such that the floor assembly has an assembly U-factor equal to or less than shown in Table 170.2-A, or shall be insulated between wood framing with insulation having an R-value equal to or greater than shown in Table 170.2-A.
   B. Slab floors shall have perimeter insulation installed with an F-factor equal to or less than or R-value equal to or greater than shown in Table 170.2-A. The minimum depth of concrete slab floor perimeter insulation shall be 16 inches or the depth of the footing of the building, whichever is less.

   Exception to Section 170.2(a)5: Raised-floor insulation may be omitted if the foundation walls are insulated to meet the wall insulation minimums shown in Table 170.2-A.

«» Commentary for Section 170.2(a)5B:

Raised-Floor Prescriptive Requirements

The prescriptive requirements differ for concrete raised floors and wood-framed floors. While the requirements for framed floors are the same in all climate zones, the requirements for (concrete) raised mass floors differ.

Wood Framed Raised Floors

The prescriptive U-factor requirement is the same as the mandatory level, at a maximum area-weighted U-factor of 0.037. Alternatively, the prescriptive requirement can be met by having a minimum of R-19 insulation installed between wood framing for framed raised floors in all climate zones.

Concrete Raised Floors

Concrete floors separating multifamily habitable space from a parking garage or other unconditioned spaces are considered exterior raised floors. Insulation requirements for concrete raised floors differ by climate zone, summarized in Table 3-8: Insulation Requirements for Concrete Raised Floors per Table 170.2-A.

Table 3-8: Insulation Requirements for Concrete Raised Floors per Table 170.2-A

Climate Zone	1,2,11,13,14,16	12,15	3-10
U-Factor	< 0.092	< 0.138	< 0.269
R-Value of Continuous Insulation	> R-8	> R-4	No Req.

Source: California Energy Commission

Other Raised Floors

Other raised floors including metal framed floors. The prescriptive U-factor is 0.048 in climate zone 1, and 0.39 in climate zones 2 and 14 – 16. In climate zones 3 – 13, the prescriptive requirement matches the mandatory requirement at 0.071 U-factor.

Installation

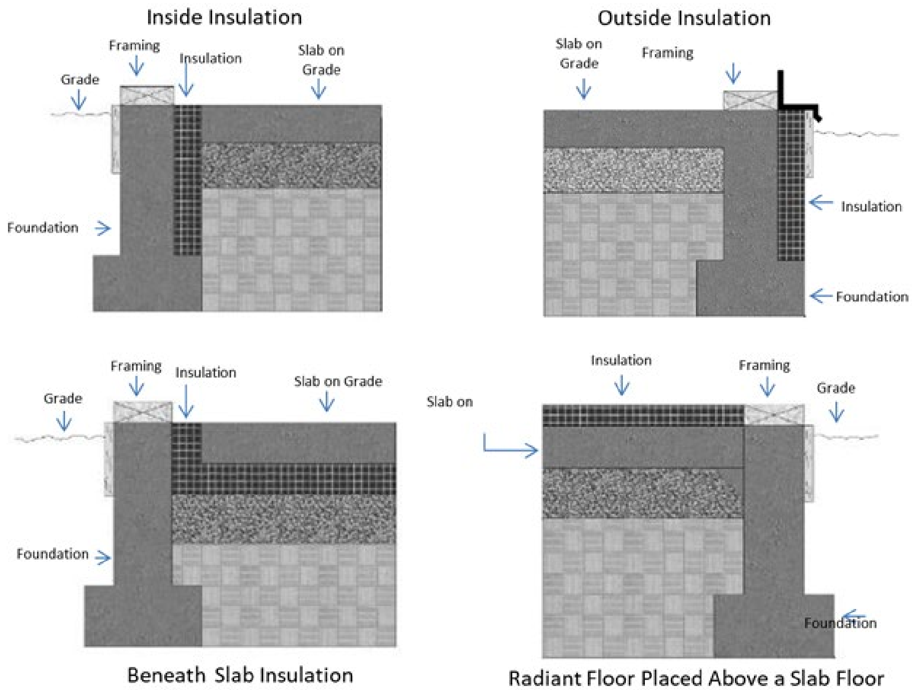
Floor insulation should be installed in direct contact with the subfloor so that there is no air space between the insulation and the floor. Support is needed to prevent the insulation from falling, sagging, or deteriorating. Options for support include netting stapled to the underside of floor joists, insulation hangers running perpendicular to the joists, or other suitable means. Insulation hangers should be spaced at 18 inches or less before rolling out the insulation. Insulation hangers are heavy wires up to 48 inches 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.

Slab on Grade Floors.

The 2025 Energy Code has updated Table 170.2-A to require slab insulation for unheated slabs in multifamily buildings in climate zone 16. All heated slabs must meet mandatory insulation requirements in Section 110.8(g).

For unheated slabs in climate zone 16, a minimum of R-7 slab-edge insulation or a maximum F-factor of 0.58 must be achieved. The insulation must be installed to a minimum depth of 16 inches 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.

Figure 3-21: Allowed Slab Edge Insulation Placement



Source: California Energy Commission

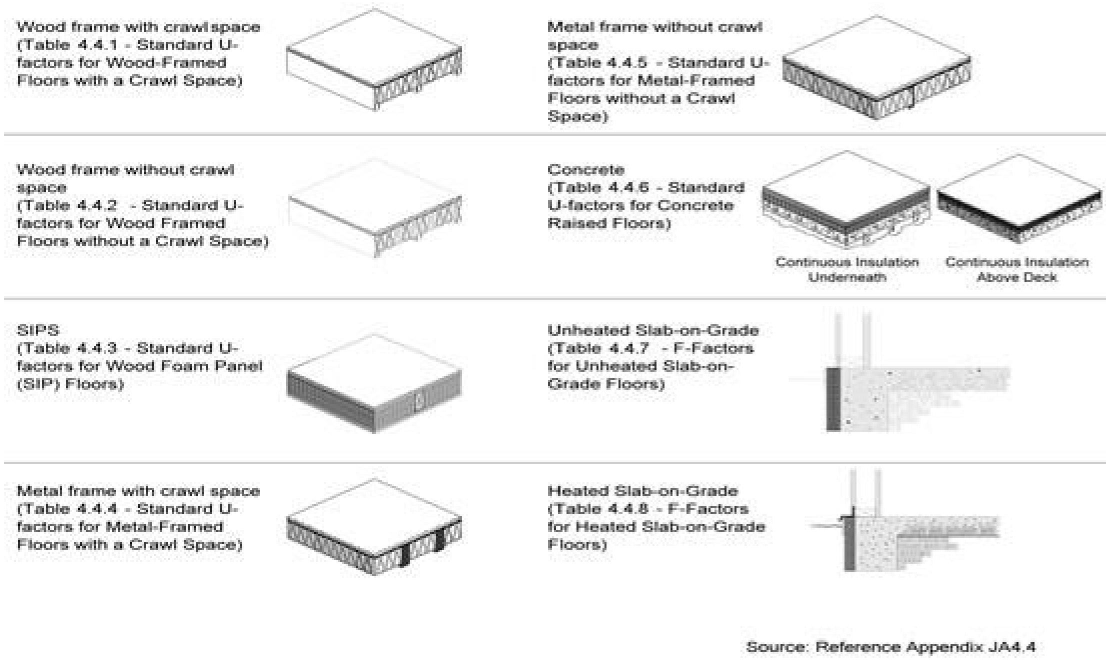
Perimeter insulation is not required along the slab edge between conditioned space and the concrete slab of an attached unconditioned enclosed space such as a garage or covered patio.

The U-factor criteria for concrete raised floors depend on whether the floor is a mass floor or not. A mass floor is one constructed of concrete with a heat capacity (HC) greater than or equal to 7.0 Btu/°F-ft².

Insulation levels for multifamily concrete raised floors with HC ≥ 7.0 using U-factor for compliance, from Reference Appendices, Joint Appendix JA4, Table 4.4.6, are equivalent to no insulation in climate zones 3-10 and associated U-factors to continuous insulation of R-8 in climate zones 1, 2, 11 through 15; and R-15 in climate zone 16.

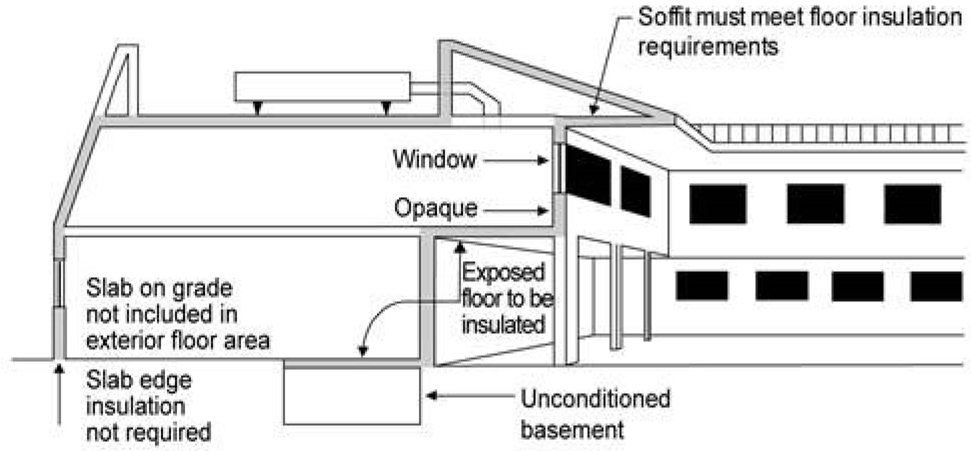
Table 4.4.6 from Reference Appendices, Joint Appendix JA4 is used with mass floors while Tables 4.4.1 through 4.4.5 are used for non-mass floors. (See Figure 3-22: Classes of Floor Constructions.)

Figure 3-22: Classes of Floor Constructions



Source: California Energy Commission

Figure 3-23: Requirements for Floor/Soffit Surfaces



Source: California Energy Commission

«»

6. All buildings up to three habitable stories shall comply with the quality insulation installation (QII) requirements shown in Table 170.2-A. When QII is required, insulation installation shall meet the criteria specified in Reference Appendix RA3.5.

«» Commentary for Section 170.2(a)6:

All insulation must be installed according to manufacturer specifications, throughout the building. In multifamily buildings up to three habitable stories in climate zones 1 – 6 and 8 – 16, a third-party ECC-Rater is required to verify the integrity of the installed insulation. The installer must provide evidence to the ECC-Rater using compliance documentation that all insulation specified is installed to meet specified R-values and assembly U-factors.

To meet QII, two primary installation criteria must be adhered to, and they both must be field-verified by an ECC-Rater. They include air sealing of the building enclosure (including walls, ceiling/roof, and floors), as well as proper installation of insulation. Refer to Reference Appendices, Residential Appendix RA3.5 for more details.

Many multifamily 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 that allow air leakage.
2. Insulation is not in contact with the air barrier, creating air spaces that short-circuit the thermal break of the insulation.
3. The insulation has voids or gaps, resulting in portions of the construction assembly that are not properly insulated and, therefore, have 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.

QII requires third-party ECC inspection to verify that an air barrier and insulation are installed correctly. Guidance for QII is provided in the Reference Appendices, Residential Appendix RA3.5. QII applies to framed and non-framed assemblies, including the following:

Table 3-9: Framed Assemblies vs. Non-Framed Assemblies

Framed Assemblies	Framed assemblies include wood and steel construction insulated with batts of mineral fiber, mineral and natural wool, or cellulose; loose-fill insulation of mineral fiber, mineral and natural wool, cellulose, or spray polyurethane foam (SPF). Rigid board insulation may be used on the exterior or interior of framed or non-framed assemblies.
Non-framed Assemblies	Non-framed assemblies include structural insulated panels (SIP), insulated concrete forms (ICF), and mass walls of masonry, concrete and concrete sandwich panels, log walls, and straw bale.

Source: California Energy Commission

Table 3-10: Installer Tips for Implementing QII provides information on applicability and installation tips and examples for QII practices.

Table 3-10: Installer Tips for Implementing QII

QII Scheduling	In a multifamily building, it is typically necessary to coordinate and schedule multiple site visits to capture the totality of both the air-sealing, and installed insulation portions of the QII inspection requirements. The ECC-Rater must see the entirety of the envelope twice. Once to inspect air-sealed cavities before insulation is installed and again to inspect insulation before it is covered with drywall or other internal finishes. QII coordination and scheduling should account for the following: Staged construction timing between floors or building-zones for hanging insulation and covering it with internal finishes.

	Special interior finishes or structures that may close wall cavities off. For example – bathtubs, tiling, cabinets, and stairwells. Interior finishes being installed soon after insulation is installed. At some sites, contractors will hang drywall on the same day the insulation is installed. The ECC-Rater must inspect the insulation in that small time window.
Applies to all Insulation	QII applies to the whole building (roof/ceilings, walls, and floors). Combinations of insulation types (hybrid systems) are allowed.
Air Barriers	An air barrier must be installed for the entire envelope.
Insulated Headers	Headers must meet one of the following criteria for QII: Two-member header with insulation in between. The header and insulation must fill the wall cavity. There are prefabricated 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. Two-member header, less than the wall width, with insulation on the interior face. The header and insulation must fill the wall cavity. Example: a 2x6 wall with two 2x nominal headers. Insulation is required to fill the wall cavity and must be installed to the interior face of the wall. 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, provided that the entire wall has at least R-2 insulation.
Panel Box Headers	Wood structural panel box headers may also be used as load-bearing headers in exterior wall construction, when built in accordance with 2019 California Residential Code (CRC) Figure R602.7.3 and Table R602.7.3.
Structural Bracing, Tie-Downs, Steel Structural Framing	Metal bracing, tie-downs, or steel structural framing can be used to connect to wood framing for structural or seismic purposes, and comply with QII if:

	Metal bracing, tie-downs, or steel structural framing is identified on the structural plans. Insulation is installed in a manner that minimizes the thermal bridging through the structural framing assembly. Insulation fills the entire cavity and/or adheres to all six sides and ends of structural assemblies that separate conditioned from unconditioned space. The structural portions of assemblies are airtight.

Source: California Energy Commission

Air Barrier

When an air barrier is required, the air barrier must be installed in a continuous manner across all components of framed and non-framed envelope assemblies. The installer must provide evidence with compliance documentation that the air barrier system meets one or more of the air barrier requirements. 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.

As part of QII for multifamily buildings up to three habitable stories in climate zones 1 – 6 and 8 – 16, a third-party ECC-Rater is required to verify that the air barrier has been installed properly and is integral with the insulation being used throughout the building.**«»**

> **Exception to Section 170.2(a):** The insulation requirements of Table 170.2-A and Table 170.2-B may be met by ceiling, roof deck, wall or floor assemblies that meet the required maximum U-factors using a U-factor calculation method that considers the thermal effects of all elements of the assembly and is approved by the Executive Director.

TABLE 170.2-A ENVELOPE COMPONENT PACKAGE – Multifamily Standard Building Design

Building Component - Roofs and Ceilings	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Option B[9] Below Roof Deck Insulation [1,2] (with air space)	NR	NR	NR	R19	NR	NR	NR	R19	R19	R13	R19	R19	R19	R19	R19	R13
Option B[9] Ceiling Insulation	R 38	R 38	R 30	R 38	R 30	R 30	R 30	R 38	R 38	R 38	R 38	R 38	R 38	R 38	R 38	R 38
Option B[9] Radiant Barrier	NR	REQ	REQ	NR	REQ	REQ	REQ	NR	NR	NR	NR	NR	NR	NR	NR	NR
Option B[9] Low-Slope-Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.63	NR	0.63	NR
Option B[9] Low-Sloped-Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.75	NR	0.75	NR
Option B[9] Low-Sloped-Solar Reflectance Index	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	75	NR	75	NR
Option B[9] Steep-Sloped-Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.25	0.25	0.20	0.25	0.20	0.25	NR
Option B[9] Steep-Sloped-Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0. 75	0.75	0.75	0.75	0.75	0.75	NR
Option B[9] Steep-Sloped-Solar Reflectance Index	NR	NR	NR	NR	NR	NR	NR	NR	NR	23	23	16	23	16	23	NR
Option C[10]-Ceiling Insulation	R 38	R 30	R 30	R 30	R 30	R 30	R 30	R 30	R 30	R 30	R 38	R 38	R 38	R 38	R 38	R 38
Option C[10]-Radiant Barrier	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR
Option C[10] Low-Sloped-Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.63	NR	0.63	NR
Option C[10] Low-Sloped-Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.75	NR	0.75	NR
Option C[10] Low-Sloped-Solar Reflectance Index	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	75	NR	75	NR

Building Component - Roofs and Ceilings	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Option C[10] Steep-Sloped-Aged Solar Reflectance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0.20	0.20	0.20	0.20	0.20	0.20	NR
Option C[10] Steep-Sloped-Thermal Emittance	NR	NR	NR	NR	NR	NR	NR	NR	NR	0. 75	0.75	0.75	0.75	0.75	0.75	NR
Option C[10] Steep-Sloped-Solar Reflectance Index	NR	NR	NR	NR	NR	NR	NR	NR	NR	16	16	16	16	16	16	NR
Option D[11]-Metal Building U-factor	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
Option D[11]-Wood Framed and Other U-factor	0.028	0.028	0.034	0.028	0.034	0.034	0.039	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
Option D[11] Low-Sloped-Aged Solar Reflectance	NR	0.63	NR	0.63	NR	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	NR
Option D[11] Low-Sloped-Thermal Emittance	NR	0.75	NR	0.75	NR	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	NR
Option D[11] Low-Sloped-Solar Reflectance Index	NR	75	NR	75	NR	75	75	75	75	75	75	75	75	75	75	NR
Option D[11] Steep-Sloped-Aged Solar Reflectance	NR	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	NR
Option D[11] Steep-Sloped-Thermal Emittance	NR	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	NR
Option D Steep-Sloped-Solar Reflectance Index	NR	16	16	16	16	16	16	16	16	16	16	16	16	16	16	NR

TABLE 170.2-A ENVELOPE COMPONENT PACKAGE – Multifamily Standard Building Design (continued)

Building Component - Walls, Floors, Doors, and QII	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Walls - Metal Building - Any Fire Rating	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.057	0.057	0.057	0.057	0.057	0.057
Walls - Framed (wood, metal) and other - >1hr fire rating	0.059	0.059	0.059	0.059	0.059	0.065	0.065	0.059	0.059	0.059	0.051	0.059	0.059	0.051	0.051	0.051
Walls - Framed (wood, metal) and other - ≤1hr fire rating[3]	0.051	0.051	0.051	0.051	0.051	0.065	0.065	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
Walls - Mass Light[4]	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.077 R 13	U 0.059 R 17
Walls - Mass Heavy	0.253	0.650	0.650	0.650	0.650	0.690	0.690	0.690	0.690	0.650	0.184	0.253	0.211	0.184	0.184	0.160
Floors/Soffits - Slab Perimeter[8]	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	F 0.58 R 7.0
Floors/Soffits – Wood Framed	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19	U 0.037 R 19
Floors/Soffits - Raised Mass	U 0.092 R 8.0	U 0.092 R 8.0	U 0.269 R 0	U 0.269 R 0	U- 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.269 R 0	U 0.092 R 8.0	U 0.138 R 4.0	U 0.092 R 8.0	U 0.092 R 8.0	U 0.138 R 4.0	U 0.092 R 8.0
Floors/Soffits - Other	0.048	0.039	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.039	0.071	0.071	0.039	0.039	0.039
Exterior Doors[6] - Max U-Factor Dwelling Unit Entry	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Building Component - Walls, Floors, Doors, and QII	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Exterior Doors[6] - Max U-Factor Common Use Area Entry Non-Swinging	0.50	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	0.50
Exterior Doors[6] - Max U-Factor Common Use Area Entry Swinging	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Quality Insulation Installation up to 3 habitable stories	Yes	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

TABLE 170.2-A ENVELOPE COMPONENT PACKAGE – Multifamily Standard Building Design (continued)

Building Component - Fenestration	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Curtain Wall/ Storefront[7] - Maximum U-factor	0.38	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.38
Curtain Wall/ Storefront[7] - Maximum RSHGC	NR	0.26	NR	0.26	NR	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.26	NR
Curtain Wall/ Storefront[7] - Minimum VT, common use area	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
NAFS 2017 Performance Class AW[5] - Maximum U-factor	0.38	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.38
NAFS 2017 Performance Class AW[5] - Maximum RSHGC	NR	0.24	NR	0.24	NR	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	NR
NAFS 2017 Performance Class AW[5] - Minimum VT, common use areas	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
All Other Fenestration - Maximum U-factor	0.28	0.30	0.28	0.28	0.28	0.34	0.34	0.30	0.30	0.30	0.28	0.30	0.28	0.28	0.28	0.28
All Other Fenestration - Maximum RSHGC	NR	0.23	NR	0.23	NR	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	NR
Maximum Window to Floor Ratio	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Maximum Window to Wall Ratio	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
Maximum Skylight Roof Ratio	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%

Footnote requirements to TABLE 170.2-A:

1. Install the specified R-value with an air space present between the roofing and the roof deck. Such as standard installation of concrete or clay tile.
2. R-values shown for below roof deck insulation are for wood-frame construction with insulation installed between the framing members. Alternatives including insulation above rafters or above roof deck shall comply with the performance standards.
3. Assembly U-factors for exterior framed walls can be met with cavity insulation alone or with continuous insulation alone, or with both cavity and continuous insulation that results in an assembly U-factor equal to or less than the U-factor shown. Use Reference Joint Appendices JA4 Table 4.3.1, 4.3.1(a), or Table 4.3.4 to determine alternative insulation products to be less than or equal to the required maximum U-factor.
4. Mass wall has a heat capacity greater than or equal to 7.0 Btu/h-ft^2.
5. Product must be certified to meet the North American Fenestration Standard/Specification for an Architectural Window (AW).
6. Glazed doors must meet the fenestration requirements.
7. Requirements apply to doors included in the Curtainwall/Storefront construction assembly.
8. If using F-factor to comply, use Reference Joint Appendices JA4, Table 4.4.7 to determine alternate depth and R-value to be less than or equal to the required maximum F-factor.
9. Option B meets §170.2(a)1Bii
10. Option C meets §170.2(a)1BIiii
11. Option D meets §170.2(a)1Biv

(b) **Minimum daylighting requirement for large enclosed spaces.** In Climate Zones 2 through 15, conditioned enclosed spaces and unconditioned enclosed spaces that are greater than 5,000 ft² and that are directly under a roof with ceiling heights greater than 15 feet shall meet the following requirements:

1. A combined total of at least 75 percent of the floor area, as determined in building floor plan (drawings) view, shall be within one or more of the following:

   A. Primary sidelight daylight zone in accordance with Section 160.5(b)4Dib, or

   B. The total floor area in the space within a horizontal distance of 0.7 times the average ceiling height from the edge of rough opening of skylights.

2. All skylit daylit zones and primary sidelit daylit zones shall be shown on building plans.

3. General lighting in daylit zones shall be controlled in accordance with Section 160.5(b)4D.

4. The total skylight area is at least 3 percent of the total floor area in the space within a horizontal distance of 0.7 times the average ceiling height from the edge of rough opening of skylights; or the product of the total skylight area and the average skylight visible transmittance is no less than 1.5 percent of the total floor area in the space within a horizontal distance of 0.7 times the average ceiling height from the edge of rough opening of skylights.

5. All skylights shall have a glazing material or diffuser that has a measured haze value greater than 90 percent, tested according to ASTM D1003 (notwithstanding its scope) or another test method approved by the Commission.

Exception 1 to Section 170.2(b): In buildings with unfinished interiors, future enclosed spaces for which there are plans to have:

A. A floor area of less than or equal to 5,000 square feet; or

B. Ceiling heights of less than or equal to 15 feet. This exception shall not be used for S-1 or S-2 (storage), or for F-1 or F-2 (factory) occupancies.

Exception 2 to Section 170.2(b): Enclosed spaces having a designed general lighting system with a lighting power density less than 0.5 watts per square foot.

Exception 3 to Section 170.2(b): Enclosed spaces where it is documented that permanent architectural features of the building, existing structures or natural objects block direct beam sunlight on at least half of the roof over the enclosed space for more than 1500 daytime hours per year between 8 a.m. and 4 p.m.

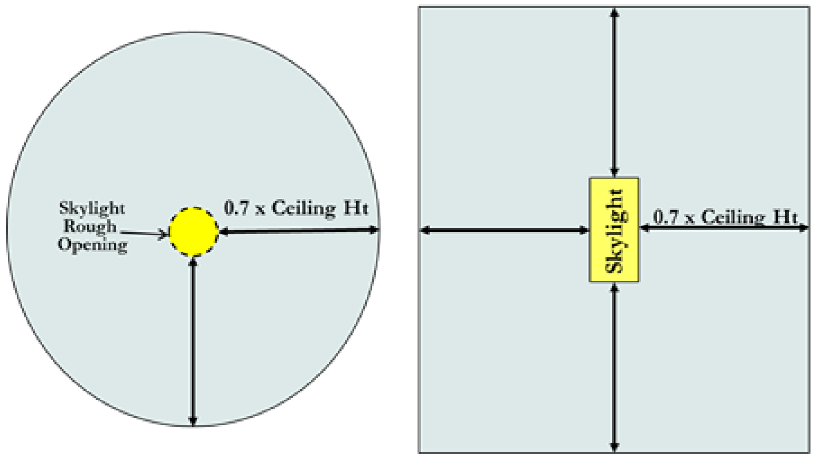
«» Commentary for Section 170.2(b):

Appropriately sized skylight systems can dramatically reduce the lighting energy consumption of a building when combined with appropriate daylighting controls.

Sizing is important; since too little skylight area has insufficient light available to turn off electric lighting; where too much skylight area, solar gains and heat losses through skylights negate the lighting savings by adding heating and cooling loads.

Skylights and automatic daylighting controls are most cost-effective in large open spaces and are prescriptively required in enclosed spaces (rooms).

Figure 3-24: Area Within 0.7 Times Ceiling Height of Rough Opening of Circular Skylight and Rectangular Skylight



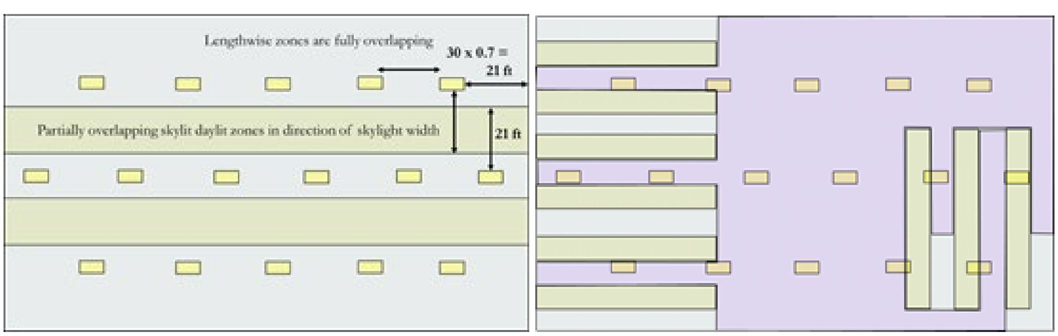
Source: California Energy Commission

The shape of the skylit daylit zone will be similar in shape to the rough opening of the skylight (Figure 3-24: Area Within 0.7 Times Ceiling Height of Rough Opening of Circular Skylight and Rectangular Skylight).

For example, if the skylight is circular, the area that is within a horizontal distance 0.7 times the average ceiling height from the edge of the rough opening, is also a circle, with the radius of the circle being the radius of the skylight + 0.7 x the ceiling height.

If the skylight is rectangular, the zone is rectangular, with the edges increased in each direction by 0.7 times the ceiling height.

Figure 3-25: Comparison of Skylit Area for Calculating Minimum Skylit Area (left) and the Skylit Daylit Zone for Controlling Luminaires in Section 160.5(b)4D (right)



Source: California Energy Commission

The specifications for daylighting controls in Section 160.5(b)4D describe which luminaires must be controlled, and consider the daylight obstructing effects of tall racks, shelves, and partitions taller than one-half the distance from the floor to the bottom of the skylight when determining if daylight will reach a given space. As shown in Figure 3-25: Comparison of Skylit Area for Calculating Minimum Skylit Area (left) and the Skylit Daylit Zone for Controlling Luminaires in Section 160.5(b)4D (right), it is considerably easier to calculate.

1. The total floor area in the space within a horizontal distance of 0.7 times the average ceiling height from the edge of rough opening of skylights. This is represented by the left example in Figure 3-25: Comparison of Skylit Area for Calculating Minimum Skylit Area (left) and the Skylit Daylit Zone for Controlling Luminaires in Section 160.5(b)4D (right).
2. The total floor area in the space within a horizontal distance of 0.7 times the average ceiling height from the edge of rough opening of skylights, minus any area on a plan beyond a permanent obstruction that is taller than the following: A permanent obstruction that is taller than one-half the distance from the floor to the bottom of the skylight. This is represented by the right example in Figure 3-25: Comparison of Skylit Area for Calculating Minimum Skylit Area (left) and the Skylit Daylit Zone for Controlling Luminaires in Section 160.5(b)4D (right).

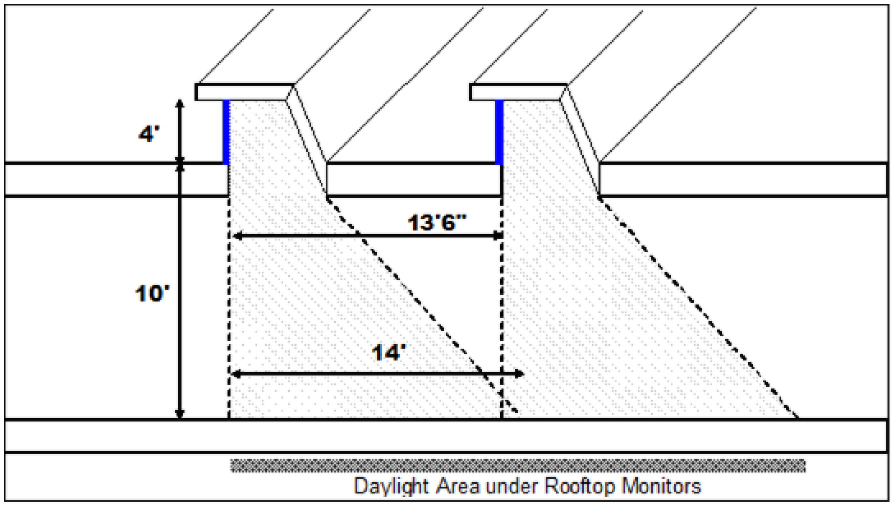
The left example in Figure 3-25: Comparison of Skylit Area for Calculating Minimum Skylit Area (left) and the Skylit Daylit Zone for Controlling Luminaires in Section 160.5(b)4D (right) is required to be calculated to comply with minimum skylight area requirements of Section 170.2, and (b) is required to comply with the automatic daylighting control requirements of Section 160.5(b) (essentially, to ensure that daylighting controls are not installed where they would not be effective).

In Section 160.5(b)4D, the skylit daylit areas are required to be drawn on the plans, and any general lighting luminaires that are in the daylit zones must be separately controlled by automatic daylighting controls.

Rooftop Monitors

Rooftop monitors are considered vertical fenestration, and the daylight area next to them is the same as the daylit area next to other vertical fenestration. The daylit area is from the inward facing plane of the fenestration one window head height and in the direction parallel to the fenestration 0.5 window head heights on either side.

Figure 3-26: Daylight Area Under Rooftop Monitors (Primary Sidelit Daylit Zone)



Source: California Energy Commission

Exceptions for Shading

Minimum daylighting requirements are exempted for spaces where permanent architectural features of the building, existing structures, or natural objects, block direct beam sunlight on at least half of the roof over the enclosed space for more than 1,500 daytime hours per year between 8 a.m. and 4 p.m. This can be documented to the local building official using a variety of tools including equipment that superimposes the sun path diagram on a photograph of the sky taken at the site, hand calculation tools such as the sun path calculator, and computer-aided design software tools that automate this calculation. «»

SECTION 180.0 – GENERAL

Additions, alterations and repairs to existing attached dwelling units and common use areas in multifamily buildings, existing outdoor lighting for these occupancies, and internally and externally illuminated signs shall meet the requirements specified in Sections 100.0 through 110.10, 160.1, and 160.3 through 170.2 that are applicable to the building project, and either the performance compliance approach (energy budgets) in Section 180.1(b) (for additions) or 180.2(c) (for alterations), or the prescriptive compliance approach in Section 180.1(a) (for additions) or 180.2(b) (for alterations), for the climate zone in which the building is located. Climate zones are shown in Figure 100.1-A.

Covered process requirements for additions, alterations and repairs to existing multifamily buildings are specified in Section 141.1.

Nonresidential occupancies in mixed occupancy buildings shall comply with nonresidential requirements in Sections 120.0 through 141.1.

NOTE: For alterations that change the occupancy classification of the building, the requirements specified in Section 180.2 apply to the occupancy after the alterations.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8 and 25943, Public Resources Code.

«» Commentary for Section 180.0:

The Energy Code offers prescriptive approaches and a performance approach to additions and alterations, but they do not apply to repairs. See Section 100.1(b) for detailed definitions.

Addition

Addition is a change to an existing building that increases conditioned floor area and volume. When an unconditioned building or unconditioned part of a building adds heating or cooling so that it becomes newly conditioned for the first time, this area is treated as an addition. Following are examples of an addition.

1. Obtaining a permit to legalize an existing, habitable, conditioned space that was previously added to a residential building without a permit.
2. Adding a bay window that extends from floor to ceiling, thereby increasing both floor area and volume.

Alteration

Alteration is a change to an existing building that is not an addition. An alteration could include a new HVAC system, lighting system, or change to the building envelope, such as a new window. Roof replacements (reroofing) and reconstructions and renewal of the roof are considered alterations and are subject to all applicable Energy Code requirements. For alterations, the compliance procedure includes:

1. The prescriptive envelope component approach.
2. The existing-plus-alteration performance approach.
3. The existing-plus-addition-plus alteration performance approach.

Following are examples of alterations.

1. Adding insulation to an existing ceiling, exterior roof, exterior wall, or raised floor that is over a crawl space, garage, or unheated basement.
2. Replacing or installing a new finish surface to an existing roof (reroofing) and replacing either portions of or the entire roof assembly.
3. Replacing existing fenestration or adding fenestration area (for example, windows, glazed doors, dynamic glazing, or skylights) to an existing building.
4. Replacing an existing skylight or increasing the skylight area of an existing roof.
5. Constructing an entirely new roof over an existing conditioned space.
6. Adding a loft within the conditioned volume of an existing home.
7. Adding window film.

Repair

Repair is the reconstruction or renewal of any part of an existing building for maintenance. Repairs must not increase the preexisting energy consumption of the repaired component, system, or equipment; otherwise, it is an alteration.

For example, a repair could include the replacement of a pane of glass in an existing multi-lite window without replacing the entire window.

Note: Repairs to residential buildings are not within the scope of the Energy Code.

For example, when a component, system, or equipment in 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, the component, system, or equipment is replaced with a new or different one, the scope of work is considered an alteration and not a repair and requirements of the Energy Code must be met. **«»**

SECTION 180.1 – ADDITIONS

Additions to existing multifamily buildings shall meet the applicable requirements of Sections 110.0 through 110.9; Sections 160.0, 160.1, and 160.2(c) and (d); Sections 160.3 through 160.7; and either Section 180.1(a) or 180.1(b).

Exception 2 to Section 180.1: Additions of 300 square feet or less are not required to comply with the roofing product requirements of Section 170.2(a)1A.

(a) Prescriptive approach. The envelope and lighting of the addition; any newly installed space-conditioning or ventilation system, electrical power distribution system, or water-heating system; any addition to an outdoor lighting system; and any new sign installed in conjunction with an indoor or outdoor addition shall meet the applicable requirements of Sections 110.0 through 110.12**;** 160.0, 160.1, and 160.2(c) and (d); and 160.3 through 170.2.

1. **Envelope.**
   - A. Additions that are greater than 700 square feet shall meet the requirements of Section 170.2(a), with the following modifications:
     - i. Framed walls extension. Extensions of existing wood-framed walls may retain the dimensions of the existing walls and shall install cavity insulation of R-15 in a 2x4 framing and R-21 in a 2x6 framing.
     - ii. The maximum allowed fenestration area shall be the greater of 175 square feet or 20 percent of the addition floor area.
     - iii. When existing siding of a wood-framed wall is not being removed or replaced, cavity insulation of R-15 in a 2x4 framing and R-21 in a 2x6 framing shall be installed and continuous insulation is not required.
     - iv. Additions that consist of the conversion of existing spaces from unconditioned to conditioned space shall not be required to perform the air sealing part of QII when the existing air barrier is not being removed or replaced.
   - B. Additions that are 700 square feet or less shall meet the requirements of Section 170.2(a), with the following modifications.
     - i. Roof and ceiling insulation in a ventilated attic shall meet one of the following requirements:
       - a. In Climate Zones 1, 2, 4, and 8 through 16, achieve an overall assembly U-factor not exceeding 0.025. In wood framed assemblies, compliance with U-factors may be demonstrated by installing insulation with an R-value of R-38 or greater.

b. In Climate Zones 3 and 5 through 7, achieve an overall assembly U-factor not exceeding 0.031. In wood framed assemblies, compliance with U-factors may be demonstrated by installing insulation with an R-value of R-30 or greater.

ii. Radiant barrier. For buildings three habitable stories or less, radiant barriers shall be installed in attics with exposed attic deck undersides in Climate Zones 2–15.

iii. Extensions of existing wood-framed walls may retain the dimensions of the existing walls and shall install cavity insulation of R-15 in a 2x4 framing and R-21 in a 2x6 framing; and

iv. Fenestration products must meet the U-factor, RSGHC and VT requirements of Table 180.2-B.

v. Quality Insulation Installation (QII) requirements of Section 170.2(a)6 do not apply.

Exception to Section 180.1(a)1B: Insulation in an enclosed rafter ceiling shall meet the requirements of Section 160.1(a).

Exception to Section 180.1(a)1: Additions that increase the area of the roof by 2,000 square feet or less are not required to comply with the solar ready requirements of Section 160.8.

«» Commentary for Section 180.1:

Wood-framed Wall Extensions in Multifamily Additions

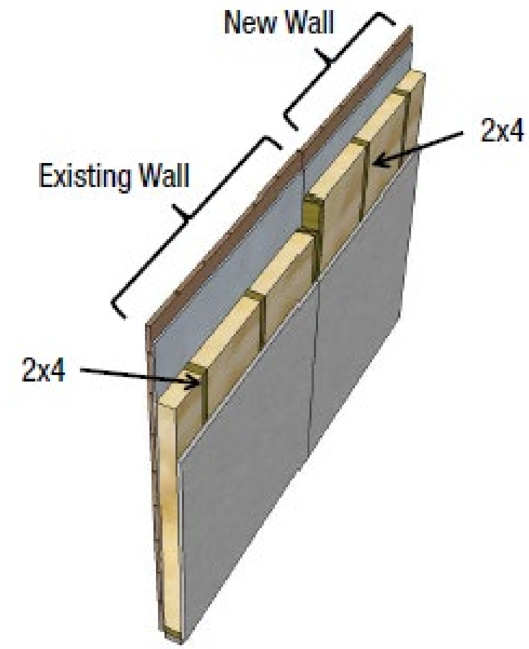
Figure 3-27: The new wall extends out straight from the existing wall through Figure 3-29: The new wall extends out perpendicularly from the existing wall are examples of common ways new walls are connected to existing walls.

In Figure 3-27: The new wall extends out straight from the existing wall and Figure 3-28: The new wall extends out straight from one of the existing walls, the new wall extends out straight from an existing wall. These are considered wall extensions. The new walls in Figure 3-27: The new wall extends out straight from the existing wall and Figure 3-28: The new wall extends out straight from one of the existing walls are 2x4 wood-framing, and are required to have R-15 cavity insulation.

Examples are not shown for 2x6 wood-framing. If the existing wall has 2x6 wood-framing, the new wall will also have 2x6 wood-framing and will require R-21 cavity insulation.

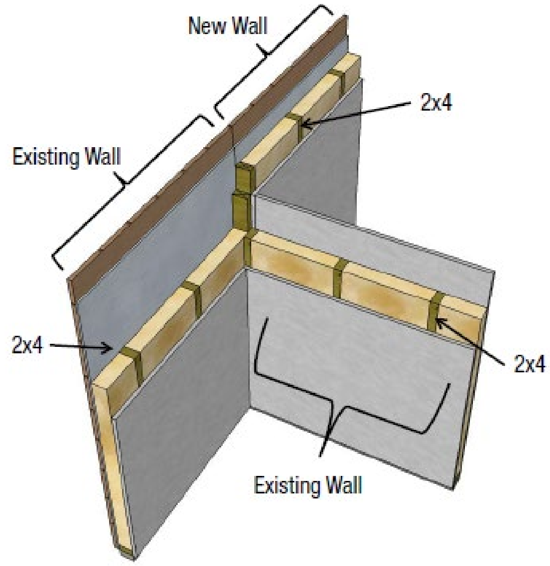
In Figure 3-29: The new wall extends out perpendicularly from the existing wall, the new wall is perpendicular to the existing wall. This is not a wall extension, and is subject to the prescriptive insulation requirements of Section 170.2(a)2A. In most cases, this will require 2x6 framing with both cavity and continuous insulation.

Figure 3-27: The new wall extends out straight from the existing wall



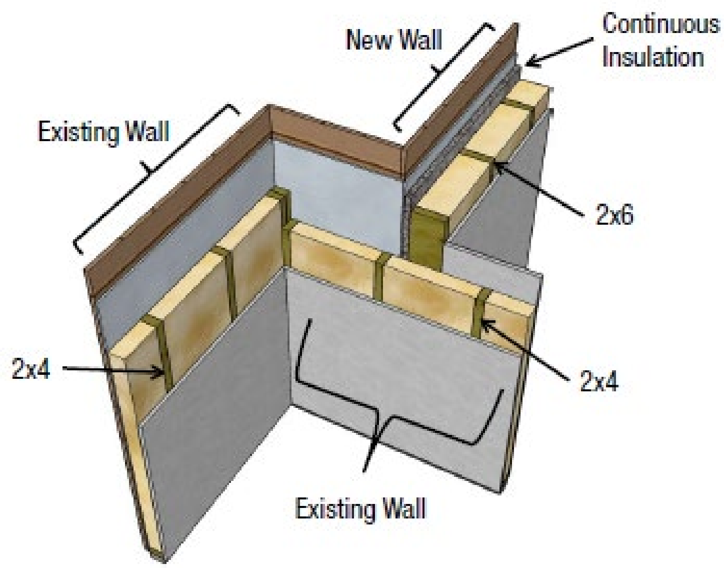
Source: California Energy Commission

Figure 3-28: The new wall extends out straight from one of the existing walls



Source: California Energy Commission

Figure 3-29: The new wall extends out perpendicularly from the existing wall



Source: California Energy Commission

NOTE: The figures show horizontal wall extensions. These requirements are also applicable to vertical wall extensions such as a second floor addition. **«»**

(b) Performance approach. Performance calculations shall meet the requirements of Sections 170.0 through 170.2(a), pursuant to the applicable requirements in Items 1, 2 and 3 below.

1. **For additions alone.** The addition complies if the addition alone meets the energy budgets expressed in terms of Long-Term System Cost (LSC) energy.
2. **Existing plus alteration plus addition.** The standard design for existing plus alteration plus addition energy use is the combination of the existing building's unaltered components to remain; existing building altered components that are the more efficient, in LSC energy, of either the existing conditions or the requirements of Section 180.2(c); plus the proposed addition's energy use meeting the requirements of Section 180.1(a). The proposed design energy use is the combination of the existing building's unaltered components to remain and the altered components' energy features, plus the proposed energy features of the addition.

   Exception to Section 180.1(b)2: Existing structures with a minimum R-11 insulation in framed walls showing compliance with Section 180.1(b) are not required to show compliance with Section 160.1(b).

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 180.2 – ALTERATIONS

Alterations to components of existing multifamily buildings, including alterations made in conjunction with a change in building occupancy to a multifamily occupancy, shall meet Item (a), and either Item (b) or (c) below:

(a) Mandatory requirements. Altered components in a multifamily building shall meet the minimum requirements in this section.

1. **Roof/ceiling insulation.** The opaque portions of the roof/ceiling that separate conditioned spaces from unconditioned spaces or ambient air shall meet the requirements of Section 180.2(b)1B.
2. **Wall insulation. For the altered** opaque portion of walls separating conditioned spaces from unconditioned spaces or ambient air shall meet the applicable requirements of Items A through D below:
   - A. **Metal building.** A minimum of R-13 insulation between framing members, or the area-weighted average U-factor of the wall assembly shall not exceed U-0.113.
   - B. **Metal framed.** A minimum of R-13 insulation between framing members, or the area-weighted average U-factor of the wall assembly shall not exceed U-0.217.
   - C. **Wood framed and others.** A minimum of R-11 insulation between framing members, or the area-weighted average U-factor of the wall assembly shall not exceed U-0.110.
   - D. **Spandrel panels and curtain walls.** A minimum of R-4, or the area-weighted average U-factor of the wall assembly shall not exceed U-0.280.

   Exception to Section 180.2(a)2: Light and heavy mass walls.
3. **Floor insulation.** For the altered portion of raised floors that separate conditioned spaces from unconditioned spaces or ambient air shall meet the applicable requirements of Items A through B below:
   - A. **Raised framed floors.** A minimum of R-11 insulation between framing members, or the area-weighted average U-factor of the floor assembly shall not exceed U-0.071.
   - B. **Raised mass floors.** A minimum of R-6 insulation, or the area-weighted average U-factor of the floor assembly shall not exceed U-0.111.

(b) Prescriptive approach. The altered component and any newly installed equipment serving the alteration shall meet the applicable requirements of Sections 110.0 through 110.9 and all applicable requirements of Sections 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c) and 160.5; and

1. **Envelope.**
   A. **Roof alterations**. Existing roofs being replaced, recovered or recoated of a multifamily building shall meet the requirements of Section 110.8(i). For roofs with more than 50 percent of the roof area or more than 2,000 square feet of roof, whichever is less, being altered, the requirements of i through iii below apply:
      i. Low-sloped roofs in Climate Zones 2, 4, and 6 through 15 shall have a minimum aged solar reflectance of 0.63 and a minimum thermal emittance of 0.75, or a minimum SRI of 75.

      Exception to Section 180.2(b)1Ai: The aged solar reflectance requirement can be met by using insulation at the roof deck specified in Table 180.2-A.

Table 180.2-A Roof/Ceiling Insulation Tradeoff for Low-Sloped Aged Solar Reflectance

Minimum Aged Solar Reflectance	Roof Deck Continuous Insulation R-value (Climate Zones 6-7)	Roof Deck Continuous Insulation R-value (Climate Zones 2, 4, 8-15)
0.60	2	16
0.55	4	18
0.50	6	20
0.45	8	22
No requirement	10	24

      ii. Steep-sloped roofs in Climate Zones 4 and 8 through 15 shall have a minimum aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum SRI of 16.

      Exception to Section 180.2(b)1Aii: The following shall be considered equivalent to Subsection ii:

      a. Buildings with ceiling assemblies with a U-factor lower than or equal to 0.025 or that are insulated with at least R-38 ceiling insulation in an attic; or

b. Buildings with a radiant barrier in the attic, where the radiant barrier is not installed directly above spaced sheathing, meeting the requirements of Section 170.2(a)1C; or

c. Buildings that have no ducts in the attic in Climate Zones 2, 4, 9, 10, 12 and 14; or

d. Buildings with R-2 or greater continuous insulation above or below the roof deck.

Exception 1 to Sections 180.2(b)1Ai and ii: Roof area covered by building integrated photovoltaic panels and building integrated solar thermal panels is not required to meet the minimum requirements for solar reflectance, thermal emittance or SRI.

Exception 2 to Sections 180.2(b)1Ai and ii: Roof constructions with a weight of at least 25 lb/ft² are not required to meet the minimum requirements for solar reflectance, thermal emittance or SRI.

«» Commentary for Section 180.2(b)1Aii:

Existing roofs being replaced, recovered, or recoated on multifamily buildings shall meet the requirements of Section 110.8(i). When the alteration is being made to 50 percent or more of the existing roof area or when more than 2,000 ft^2 of the roof is being altered, (whichever is less) the requirements apply. When a small repair is made, these requirements do not apply. For example, the requirements for roof insulation would not be triggered if the existing roof surface were overlaid instead of replaced.

These requirements apply to roofs over conditioned, non-process spaces even if the building has a portion that is a process space. These roof areas can be delineated by the fire separation walls between process areas and conditioned, non-process areas.

The CBC and local amendments place limitations on the number of new roof covering layers that are allowed to overlay an existing roof covering in accordance with CBC 1510. When this limit is reached, the existing roof covering must be removed down to the roof deck or insulation recover boards. **«»**

iii. For low-sloped roofs, the area of the roof recover or roof replacement shall be insulated to R-14 continuous insulation or a U-factor of 0.039 in Climate Zones 1, 2, 4, and 8 through 16.

Exception 1 to Section 180.2(b)1Aiii: Roof recovers with new R-10 insulation added above deck do not need to be insulated to meet R-14.

Exception 2 to Section 180.2(b)1Aiii: When existing mechanical equipment located on the roof will not be disconnected and lifted, insulation added may be limited to the greater of R-10 or the maximum installed thickness that will allow the distance between the height of the roof membrane surface to the top of the base flashing to remain in accordance with the manufacturer's instructions.

Exception 3 to Section 180.2(b)1Aiii: At the drains and other low points, tapered insulation with a thermal resistance less than R-14 may be used, provided that insulation thickness is increased at the high points of the roof so that the average thermal resistance equals or exceeds R-14.

Exception 4 to Section 180.2(b)1Aiii: The area of the roof recoat is not required to be insulated.

«» Commentary for Section 180.2(b)1Aiii:

When a roof is replaced or recovered, and the alteration complies with the prescriptive requirements for roofing products, the altered roof area shall be insulated to the levels specified in Section 180.2(b)1Aiii of the Energy Code.

Roof replacement and roof recover are defined in Title 24, Part 2, Chapter 2 – Definitions. A roof replacement is the process of removing the existing roof covering, repairing any damaged substrate and installing a new roof covering. A roof recover is the process of installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering. Roof recovers are typically a less expensive option but can only be performed if the existing roof is in good condition. Usually, one roof recover is allowed before the roof needs to be replaced. Title 24, Part 2, Chapter 15 does not permit roof recovers where the existing roof or roof covering is water soaked or has deteriorated to the point where it is not an adequate base for additional roofing; where the existing roof covering is slate, clay, cement, or asbestos-cement title; or where the existing roof has two or more applications of any type of roof covering.

If a roof has an existing coating, the application of a coating for the purposes of renewal or maintenance (i.e., a roof recoat) is exempt from the low-sloped roof insulation requirements of 180.2(b)1Aiii. Roof recoats that are part of a roof recover are considered a roof recover as defined in Section 100.1 and are required to meet the insulation requirements for roof recovers in Section 180.2(b)1Aiii.

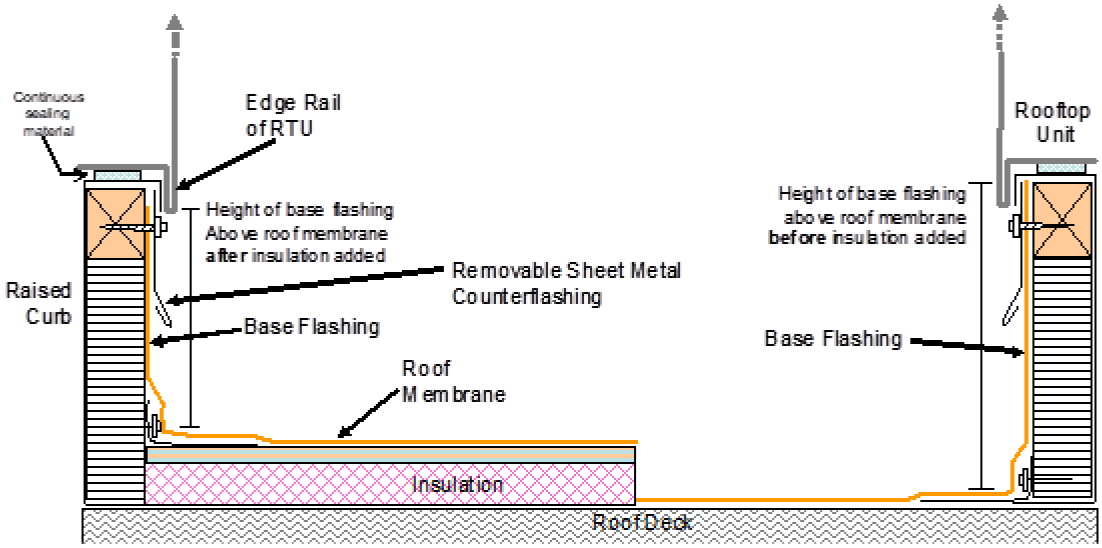
When mechanical equipment located on the roof will not be disconnected and lifted as part of the roof replacement, insulation added may be the greater of R-10 or the maximum installed thickness that will allow the distance between the height of the roof membrane surface to the top of the base flashing to remain in accordance with the manufacturer’s instructions.

Increasing the elevation of the roof membrane by adding insulation may also affect roof drainage. The Energy Code allows tapered insulation to be used that has a thermal resistance less than that prescribed in Section 180.2(b)1Aiii at the drains and other low points, provided that the thickness of insulation is increased at the high points of the roof so that the average thermal resistance equals or exceeds the value that is specified in Section 180.2(b)1Aiii.

When insulation is added on top of a roof, the elevation of the roof membrane is increased. When insulation is added to a roof and the curb height (counterflashing for walls) is unchanged (Figure 3-30: Base Flashing on Rooftop Unit Curb Detail), the height of the base flashing above the roof membrane will be reduced. In some cases, when the overhanging edge of the space-conditioning equipment is very close to the side of the curb, this may also limit how far up the curb the base flashing may be inserted. Many manufacturers and the National Roofing Contractors Association (NRCA) recommend maintaining a minimum base flashing height of 8 inches above the roofing membrane.

When adding insulation on top of a formerly uninsulated or under-insulated roof, consider the effects on base flashing height. It may be desirable to increase curb heights or counterflashing heights to maintain the same or higher base flashing heights above the roof membrane. In other cases, where leak risk is low, ask the roofing manufacturer for a variance on installation requirements for a roofing warranty; this may require additional waterproofing measures to obtain the manufacturer’s warranty. Installing insulation under the roof deck when access is feasible doesn’t change the base flashing height and, in some cases, may be the least expensive way to insulate the roof.

Figure 3-30: Base Flashing on Rooftop Unit Curb Detail



Source: California Energy Commission

«»

B. **Roof/ceiling insulation**.

i. **Attic roof**. Vented attics shall meet the following:

a. In Climate Zones 1 through 4 and 8 through 16, insulation shall be installed to achieve a weighted U-factor of 0.020 or insulation installed at the ceiling level shall result in an installed thermal resistance of R-49 or greater for the insulation alone; and

Exception to Section 180.2(b)1Bia: In Climate Zones 1, 3, 4 and 9, dwelling units with at least R-19 existing insulation installed at the ceiling level**.**

b. In Climate Zones 2 and 11 through 16, air seal all accessible areas of the ceiling plane between the attic and the conditioned space in accordance with Section 110.7; and

Exception 1 to Section 180.2(b)1Bib: Dwelling units with at least R-19 existing insulation installed at the ceiling level.

Exception 2 to Section 180.2(b)1Bib: Dwelling units with atmospherically vented space heating or water-heating combustion appliances located inside the pressure boundary of the dwelling unit.

c. In Climate Zones 1 through 4 and 8 through 16, recessed downlight luminaires in the ceiling shall be covered with insulation to the same depth as the rest of the ceiling. Luminaires not rated for insulation contact must be replaced or fitted with a fireproof cover that allows for insulation to be installed directly over the cover; and

Exception to Section 180.2(b)1Bic: In Climate Zones 1 through 4 and 8 through 10, dwelling units with at least R-19 existing insulation installed at the ceiling level.

d. Attic ventilation shall comply with the California Building Code requirements.

Exception 1 to Section 180.2(b)1Bi: Dwelling units with at least R-38 existing insulation installed at the ceiling level.

Exception 2 to Section 180.2(b)1Bi: Dwelling units where the alteration would directly cause the disturbance of asbestos unless the alteration is made in conjunction with asbestos abatement.

Exception 3 to Section 180.2(b)1Bi: Dwelling units with knob and tube wiring located in the vented attic.

Exception 4 to Section 180.2(b)1Bi: Where the accessible space in the attic is not large enough to accommodate the required R-value, the entire accessible space shall be filled with insulation, provided such installation does not violate Section 806.3 of Title 24, Part 2.5.

Exception 5 to Section 180.2(b)1Bi: Where the attic space above the altered dwelling unit is shared with other dwelling units and the requirements of Section 180.2(b)1Bi are not triggered for the other dwelling units.

«» Commentary for Section 180.2(b)1Bi:

Vented Attics

Attic insulation and air sealing prescriptive requirements in vented attics apply when the ceiling above a conditioned space is altered or when an entirely new duct system is installed in the vented attic. A ceiling may be considered altered under various conditions including when the existing attic insulation is replaced, new attic insulation is added, or the ceiling plane is replaced.

On hot days, a typical vented attic is hotter than outside and if poorly ventilated the temperature difference between the attic and outdoors can be substantial. In homes with little or no attic insulation, this temperature difference can result in significant total heat gain or loss through the ceiling. High levels of attic insulation and an air barrier at the ceiling is an important approach to minimize those gains and losses and result in considerable energy savings.

A common circumstance that results in the disruption of existing attic insulation occurs when a new duct system is installed in a vented attic. At minimum, existing insulation is moved to access certain areas and then replaced. Sometimes, insulation is disturbed and left unfixed. In cases where penetrations are added to the ceiling layer for new registers, air sealing is critical to limit gains or losses to and from the home. By requiring insulation improvements and proper air sealing at duct replacement, vented attics are addressed as a system saving energy and improving comfort for the occupant.

When an attic is altered or a new duct system is installed, there are four primary sets of requirements as listed below.

1. Air seal the ceiling between conditioned spaces and the unconditioned attic.
2. Insulate the attic floor over any conditioned spaces to R-49.
3. Insulate over all recessed can lighting fixtures. Any recessed can lighting fixtures not rated for insulation contact (IC-rated) must be replaced with IC-rated fixtures or have a fire rated cover installed over the attic side of the fixture to allow for insulation to be installed over the fixtures.
4. Ensure attic ventilation meets California Building Code requirements.

An ECC-Rater is not required to verify any of these prescriptive requirements. All requirements will be verified by an official from the building department.

These components combine to form a package that addresses many issues in existing attics. They provide a much greater benefit than any of these measures do on their own. If an attic is insulated without first air sealing the ceiling assembly, the opportunity to seal any penetrations between the attic and conditioned space below is lost, and sealing can only be performed in the future if the insulation is removed. Once installed, R-49 insulation is 16-20” deep and it becomes a challenge to maneuver around the attic space. Air infiltration through the ceiling plane between the attic and conditioned space also reduces the effectiveness of attic insulation.

Items #1 through #3 above may or may not be required depending on climate zone and the existing attic insulation level. For projects that are subject to all or a portion of these requirements, the first step is to identify which requirements apply. Air sealing, recessed cans, and attic ventilation must be addressed prior to adding attic insulation. Table 3-11: Altered Attic Requirements by Climate Zone summarizes when these prescriptive requirements apply.

Table 3-11: Altered Attic Requirements by Climate Zone

Climate Zones	Building with < R-19 existing attic insulation	Building with ≥ R-19 existing attic insulation
5, 7	Attic ventilation only1	Attic ventilation only
6	R-49, attic ventilation	Attic ventilation only
1, 3	R-49, recessed cans, attic ventilation	Attic ventilation only
2, 4, 8-10	R-49, recessed cans & air sealing, attic ventilation	R-49, attic ventilation
11-16	R-49, recessed cans & air sealing, attic ventilation	R-49 & recessed cans, attic ventilation

[1]Mandatory minimum R-19 insulation requirements still apply if the ceiling is being altered.

Source: California Energy Commission

If any of the following four conditions are met, the project is exempt from all of the four requirements:

1. Existing attic insulation of R-38 or better.
2. Alteration directly causes the disturbance of asbestos located in the ceiling, attic, or ductwork and remediation of asbestos is not being done as part of the scope of work.
3. Knob and tube wiring located in the attic, which is not being removed as part of the scope of work.
4. Altered attic space is shared with other dwelling units whose attic space is not considered altered.

Below is additional detail on each of the four prescriptive requirements.

Air Sealing

In climate zones 2 and 11 – 16, where existing attic insulation is less than R-19, all accessible areas of the attic floor between the attic and the conditioned space must be air sealed (Table 3-12: Attic Air Sealing Requirements by Climate Zone). Homes with atmospherically vented space heating or water heating combustion appliances located inside the building pressure boundary are exempt from this requirement. This exception does not cover combustion appliances located in a vented attic, garage, or crawlspace.

Table 3-12: Attic Air Sealing Requirements by Climate Zone

Climate Zones	< R-19 existing attic insulation	≥ R-19 existing attic insulation
1, 3, 5-7	No requirement	No requirement
2, 4, 8-10	Yes	No requirement
11-16	Yes	No requirement

Source: California Energy Commission

Addressing air leakage requires removing or temporarily moving any existing insulation around the attic to access the attic floor. Most air sealing can be completed with caulking or foam. Areas where large holes might exist, such as at soffits and dropped ceilings, will require an air barrier to be installed if not already in place and the perimeter will need to be secured and fully sealed. Areas that present sources of air leakage that should be inspected when sealing the attic include:

1. Soffits, dropped ceilings, and chases connected to conditioned space
2. Gaps around chimneys and combustion venting
3. Along the top plate
4. Electric and plumbing penetrations
5. Ceiling mounted duct boots
6. Ceiling mounted exhaust fans and exhaust ducts
7. Attic hatches
8. Kneewalls
9. Recessed lighting fixtures

Recessed Can Lighting

In climate zones 1 – 4 and 8 – 16 any recessed can fixtures in the ceiling shall be covered with insulation to the same depth as the rest of the attic floor. Fixtures not rated for insulation contact must be replaced or retrofitted with a fire-proof cover that allows for insulation to be installed directly over the cover. Homes in climate zones 1 – 4 and 8 – 10 with existing attic insulation of R-19 or greater are exempt from this requirement. Table 3-13: Recessed Can Lighting Requirements by Climate Zone summarizes the recessed can lighting requirements by climate zone and existing insulation value.

Table 3-13: Recessed Can Lighting Requirements by Climate Zone

Climate Zones	< R-19 existing attic insulation	≥ R-19 existing attic insulation
5-7	No requirement	No requirement
1-4, 8-10	Yes	No requirement
11-16	Yes	Yes

Source: California Energy Commission

For recessed can fixtures to be directly covered with insulation the fixtures must be rated for Insulation Contact (IC). Fixtures that are IC rated usually have an Underwriters Laboratory (UL) sticker or stamp on the inside of the housing that says “IC” in some form. The lamp will likely need to be removed to properly view the housing. If the housing has slits or holes in it, it is not IC rated. If it cannot be determined whether a fixture is IC rated or not, it should be assumed that it is not. Recessed cans that are not IC rated present a serious fire hazard if they are surrounded by any flammable material because of the heat generated by the fixture. In these cases, the fixtures must be dammed to maintain separation between them and the attic insulation. This results in areas of the attic floor with minimal or no insulation where heat gains and losses are high, contributing to degraded insulation performance across the entire attic.

When present, older recessed can lighting can be a significant contributor to air leakage through a ceiling plane. Existing recessed cans typically are not airtight, and their perimeter can present a path for conditioned air to flow into the attic or unconditioned attic air to enter the conditioned space below. In addition to an IC rating, recessed can fixtures can also be rated to be “Airtight”. This prescriptive standard does not require that existing fixtures be airtight. However, if existing recessed fixtures are being entirely replaced with new luminaires, the requirements of Section 160.5(a)1C must be met which requires the fixtures be certified as airtight with air leakage tested in accordance with ASTM E283 to be less than 2 cfm at 75 Pascals. Existing fixtures that are IC rated but not airtight can be retrofit with a retrofit trim kit which provides an airtight enclosure. Recessed cans that are not IC or AT rated may be replaced with IC rated housing units designed for retrofit applications.

In some cases, a fire-rated attic recessed light cover, shaped as domes or boxes, can be installed over the fixture allowing for insulation to be installed directly up to and over the cover. The recessed can fixture must have a thermal switch, which disconnect the electricity to the light if the temperature exceeds unsafe levels. The covers are to be installed over existing fixtures and sealed around the perimeter to the ceiling floor. Example covers are shown in Figure 3-31: Example fire rated cover products.). Products that act as dams for the can lighting but do not allow insulation to cover the area over the fixture are not acceptable for meeting these prescriptive requirements. If it cannot be determined whether the fixture has a thermal switch, assume that it does not, and a fire-rated recessed light cover cannot be used.

Figure 3-31: Example fire rated cover products.

(1) https://www.recessedlightcover.com/product-selection/tenmat-ff130e-recessed-light-draft-stop-cover/

(2) https://insulation4us.com/products/recessed-light-cover-solid-insullite-all-sizes?variant=32508051849265&gclid=CjwKCAjwqcKFBhAhEiwAfEr7zfAPOJY7SqKTCmwahDo05n7klkNhzihRNF6K_VJccWpRpaDuLdEyXhoCVgUQAvD_BwE

Attic Insulation

In all climate zones, except 5, 6 and 7, attic insulation shall be installed at the attic floor to a level of R-49 or to achieve a weighted U-factor of 0.020. Table 3-14: Attic Insulation Requirements by Climate Zone summarizes the insulation requirements by climate zone, based on whether the existing attic insulation meets a minimum R-19 or not.

Table 3-14: Attic Insulation Requirements by Climate Zone

Climate Zones	< R-19 existing attic insulation	≥ R-19 existing attic insulation
5 - 7	No requirement	No requirement
1, 3, 4, 9	R-49	No requirement
2, 8, 10-16	R-49	R-49

In cases where there is limited vertical height in an attic (preventing the installation of the required insulation R-value), an exception allows for the installation of a lower R-value. Insulation must still be installed to maximize the depth of insulation while still meeting code requirements for roof ventilation as specified in Section 806.3 of the California Residential Code (Title 24, Part 2.5). A minimum of 1 inch air gap must be provided between the insulation and roof deck as well as at all vent locations. The use of blocking, bridging and insulation must not block the free flow of air.

Attic insulation is either batt, loose fill (blown-in), rigid, or spray foam and can be made of various materials. Most new and retrofit attics use blown-in fiberglass or cellulose insulation. Blown-in insulation is a loose fill product installed using a blowing machine with a large, attached hose. While both blown-in and batt insulation have similar properties, it is much easier to achieve a consistent installation with loose fill since the particles more easily fill in small gaps and hard to reach areas. R-value ratings per inch vary somewhat by product type and across manufacturers. Manufacturers provide coverage charts which specify how many bags of insulation are needed to cover a certain square footage based on the ceiling framing spacing and depth. The charts account for settling of the insulation due to compression under its own weight.

Insulation must be installed evenly throughout the attic space and insulation levels must be documented on the certificate of installation (LMCI or NRCI, as applicable). 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 also must meet the manufacturer’s specified minimum weight per ft^2 for the corresponding R-value. When using loose fill insulation at the ceiling, baffles should be installed at eaves or soffit vents to keep the insulation from blocking ventilation and prevent air movement under the insulation. Attic access doors shall have permanently attached insulation using adhesive or mechanical fasteners.

Attic ventilation

When any work is conducted in an existing attic, ventilation is required to be reviewed and altered as necessary to ensure compliance with current code requirements per the California Building Code. Ventilation allows the natural flow of air that removes accumulated warm air and moisture from the attic. The relevant requirements that usually need to be addressed from Title 24, Part 2.5 Section R806 are listed below.

1. A minimum net free ventilating area of 1/150 of the area of the attic space.
2. Ventilation openings shall be no smaller than 1/16” and no greater than 1/4".

Ridge baffles should be installed when ceiling insulation is next to eave or soffit vents. The baffles should be placed at the top plate to direct ventilation air up and over the ceiling insulation. It is important to ensure the baffle extends sufficiently beyond the height of the ceiling insulation so as not to disturb the insulation. **«»**

C. Fenestration alterations other than repair shall meet the requirements of Items i and ii below:

   Note: Glass replaced in an existing sash and frame or sashes replaced in an existing frame are considered repairs. In these cases, Section 180.2(b) requires that the replacement be at least equivalent to the original in performance.

   i. Fenestration installed to replace existing fenestration of the same total area shall meet either a or b:

      a. The maximum U-factor, RSHGC and VT requirements of Table 180.2-B, or

      b. The area-weighted U-factor and RSHGC of Table 170.2-A.

      Exception 1 to Section 180.2(b)1Ci: In an alteration, where 150 square feet or less of the entire building's vertical fenestration is replaced, RSHGC and VT requirements of Table 180.2-B shall not apply.

   ii. Alterations that add vertical fenestration and skylight area shall meet the total fenestration area requirements of Section 170.2(a)3 and the U-factor, RSHGC and VT requirements of Table 180.2-B.

      Exception 1 to Section 180.2(b)1Cii: Alterations that add vertical fenestration area of up to 50 square feet shall not be required to meet the total fenestration area requirements of Sections 170.2(a)3, nor the RSHGC and VT requirements of Table 180.2-B.

      Exception 2 to Section 180.2(b)1Cii: Alterations that add up to 16 square feet of new skylight area per dwelling unit with a maximum U-factor of 0.55 and a maximum RSHGC of 0.30 shall not be required to meet the total fenestration area requirements of Section 170.2(a)3.

D. **Exterior doors.** Alterations that add exterior door area shall meet the U-factor requirement of Section 170.2(a)4.

Table 180.2-B Altered Fenestration Maximum U-Factor and Maximum SHGC and RSHGC, Minimum VT

Building Type	**Feature**	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Curtainwall / Storefront / Window Wall[1]	U-factor	0.38	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.38
Curtainwall / Storefront / Window Wall[1]	RSHGC	NR	0.26	NR	0.26	NR	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	NR
Curtainwall / Storefront / Window Wall[1]	VT[2]	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
NAFS 2017 Performance Class AW Window – Fixed	U-factor	0.38	0.38	0.38	0.38	0.38	0.47	0.47	0.41	0.41	0.38	0.38	0.38	0.38	0.38	0.38	0.38
NAFS 2017 Performance Class AW Window – Fixed	RSHGC	NR	0.25	NR	0.25	NR	0.31	0.31	0.26	0.26	0.25	0.25	0.25	0.25	0.25	0.25	NR
NAFS 2017 Performance Class AW Window – Fixed	VT[2]	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
NAFS 2017 Performance Class AW Window – Operable	U-factor	0.43	0.43	0.43	0.43	0.43	0.47	0.47	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
NAFS 2017 Performance Class AW Window – Operable	RSHGC	NR	0.24	NR	0.24	NR	0.31	0.31	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	NR
NAFS 2017 Performance Class AW Window – Operable	VT[2]	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37

Building Type	Feature	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
All Other Windows and Glazed Doors	U-factor	0.28	0.30	0.28	0.28	0.28	0.30	0.34	0.30	0.30	0.30	0.28	0.30	0.28	0.28	0.30	0.28
All Other Windows and Glazed Doors	RSHGC	NR	0.23	NR	0.23	NR	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	NR

Table 180.2-B Altered Fenestration Maximum U-Factor and Maximum SHGC and RSHGC, Minimum VT (Continued)

Building Type	Feature	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Skylights	U-factor	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Skylights	SHGC	NA	0.25	NA	0.25	NA	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	NA
Skylights, Serving Common Areas	VT[2]	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49

Footnotes to TABLE 180.2-B:

1. Requirements apply to glazed doors included in the Curtainwall/Storefront construction assembly.
2. Minimum VT requirements for fenestration other than Skylights do not apply to multifamily buildings 3 habitable stories or less.

«» Commentary for Section 180.2(b)1Bi:

Fenestration Alterations

The area-weighted U-factor of all fenestration, including skylights, may not exceed the mandatory maximum of 0.58.

Alterations that replace existing fenestration of the same total area can meet prescriptive requirements by meeting the U-factor, RSHGC, and VT requirements of Table 180.2-B for each window replaced or an area weighted U-factor and RSHGC across all replaced windows from Table 170.2-A. Note that U-factor and RSHGC values in the table are maximum values, and VT values are minimums. Where 150 square feet or less of the building's vertical fenestration is replaced, the building is exempt from the RSHGC and VT requirements.

Replacement Fenestration

Any fenestration (i.e., windows, skylights, clerestories, and glazed doors) that is being removed and replaced in an exterior wall or roof is considered "replacement fenestration."

Replacement fenestration is an area of new fenestration that replaces an equal or lesser 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 openings as the glazing being removed as long as it is being installed in the same existing wall or roof surface that remains a part of the existing building. Any added fenestration area that is larger than the total altered glazing area is labeled as "new." **«»**

(c) Performance approach. The altered component(s) and any newly installed equipment serving the alteration shall meet the applicable requirements of Subsections 1, 2 and 3 below. The energy budget for alterations is expressed in terms of Long-Term System Cost (LSC) energy.

1. The altered components shall meet the applicable requirements of Sections 110.0 through 110.9, 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c), and 160.5. Entirely new or complete replacement mechanical ventilation systems as these terms are used in Section 180.2(b)5A shall comply with the requirements in Section 180.2(b)5A. Altered mechanical ventilation systems shall comply with the requirements of Sections 180.2(b)5B. Entirely new or complete replacement space-conditioning systems, and entirely new or complete replacement duct systems, as these terms are used in Sections 180.2(b)2Ai and 180.2(b)2Aiia, shall comply with the requirements of Sections 160.2(a)1 and 160.3(b)5L.
2. The standard design for an altered component shall be the higher efficiency of existing conditions or the requirements of Section 180.2(b). For components not being altered, the standard design shall be based on the unaltered existing conditions such that the standard and proposed designs for these components

are identical. When the third-party verification option is specified, all components proposed for alteration for which the additional credit is taken, must be verified by a certified ECC-rater.

3. The proposed design shall be based on the actual values of the altered components.

NOTES TO SECTION 180.2(c):

1. If an existing component must be replaced with a new component, that component is considered an altered component for the purpose of determining the standard design altered component energy budget and must meet the requirements of Section 180.2(c)2.
2. The standard design shall assume the same geometry and orientation as the proposed design.
3. The “existing efficiency level” modeling rules, including situations where nameplate data is not available, are described in Section 10-109(c) and Section 10-116.

EXCEPTION 1 to Section 180.2(c): Any dual-glazed greenhouse or garden window installed as part of an alteration complies with the U-factor requirements in Section 170.2.

EXCEPTION 2 to Section 180.2(c): Where the space in the attic or rafter area is not large enough to accommodate the required R-value, the entire space shall be filled with insulation provided such installation does not violate Section 1203.2 of Title 24, Part 2.

Note: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

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INTRODUCTION

Chapter 4 Introduction

This chapter covers heating, ventilation, and air conditioning (HVAC) system requirements for all dwelling units and common use areas in multifamily buildings for newly constructed buildings and additions or alterations to existing buildings.

Guidance on general requirements is included in the Multifamily Compliance Manual Chapter 1: General Requirements. Guidance on administrative requirements is included in the Multifamily Compliance Manual Chapter 2: Compliance and Enforcement. This chapter includes guidance on mechanical system requirements.

Table 4-1: Excerpt from Table 100.0-A Application of Standards provides an overview of the location of the HVAC system requirements that apply to multifamily occupancies in the Energy Code.

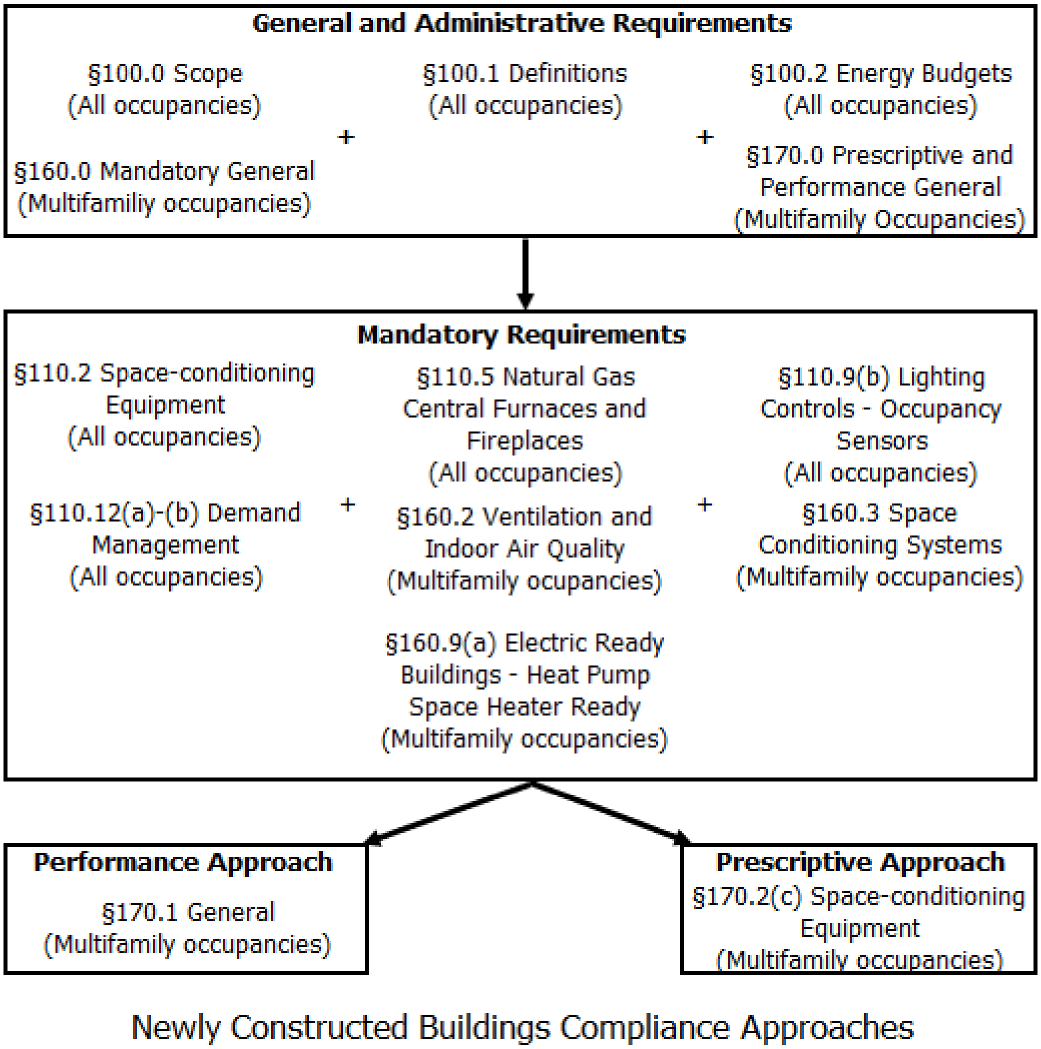
Table 4-1: Excerpt from Table 100.0-A Application of Standards

Application	Mandatory	Prescriptive	Performance	Additions/ Alterations
General[1]	160.0	170.0	170.0	180.0
HVAC	110.2, 110.5, 110.9, 110.12, 160.2, 160.3, 160.9	170.2	170.1	180.1, 180.2

Source: California Energy Commission

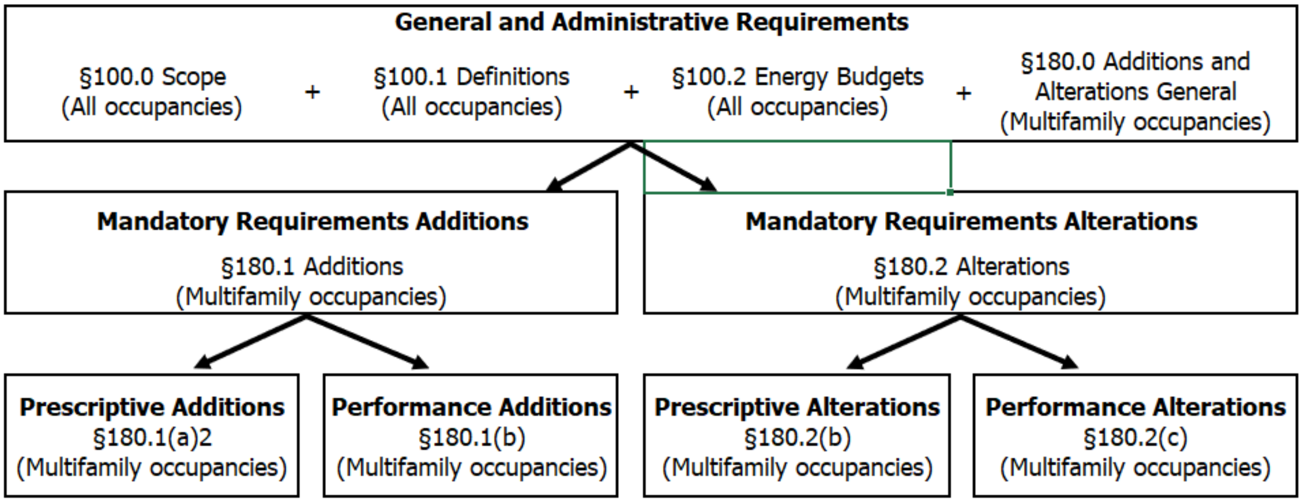
Figure 4-1: Flowchart Guidance for Application of New Construction Multifamily HVAC Requirements and Figure 4-2: Flowchart Guidance for Application of New Construction Multifamily HVAC Requirements below illustrate the applicable sections for newly constructed buildings and additions or alterations to existing buildings.

Figure 4-1: Flowchart Guidance for Application of New Construction Multifamily HVAC Requirements



Source: California Energy Commission

Figure 4-2: Flowchart Guidance for Application of New Construction Multifamily HVAC Requirements



Addition, Alteration Compliance Approaches

Source: California Energy Commission

SECTION 110.2 – MANDATORY REQUIREMENTS FOR SPACE-CONDITIONING EQUIPMENT

Certification by manufacturers. Any space-conditioning equipment listed in this section may be installed only if the manufacturer has certified to the Commission that the equipment complies with all the applicable requirements of this section.

(a) Efficiency. Equipment shall meet the applicable efficiency requirements in Tables 110.2-A through 110.2-L, subject to the following:

1. If more than one efficiency standard is listed for any equipment in Tables 110.2-A through 110.2-L, the equipment shall meet all the applicable standards that are listed; and
2. If more than one test method is listed in Tables 110.2-A through 110.2-L, the equipment shall comply with the applicable efficiency standard when tested with each listed test method; and
3. Where equipment serves more than one function, it shall comply with the efficiency standards applicable to each function; and
4. Where a requirement is for equipment rated at its “maximum rated capacity” or “minimum rated capacity,” the capacity shall be as provided for and allowed by the controls, during steady-state operation.

«» Commentary for Section 110.2(a):

California Appliance Standards and Equipment Certification: Most heating and cooling equipment installed in California multifamily buildings is regulated by the National Appliance Efficiency Conservation Act (NAECA) and/or the California Appliance Efficiency Regulations (Title 20). Both the federal and state appliance standards apply to the manufacturing and sale of new equipment, whether for installation or replacement in newly constructed buildings, additions, or alterations. The Appliance Efficiency Regulations are enforced at the point of sale (except central split-system air conditioners and central single package air conditioners, see Title 20, Section 1605.1(c), Table C-3), while the Energy Code explained in this compliance manual is enforced by local enforcement agencies.

The equipment listed below is covered by the Appliance Efficiency Regulations. The manufacturer must certify that the equipment complies with the current Appliance Efficiency Regulations at the time of manufacture. The energy efficiency of other equipment, usually larger equipment, is regulated by the Energy Code Section 110.2(a).

Appliances covered by the Appliance Efficiency Regulations include:

1. Room air-conditioners
2. Room air-conditioning heat pumps
3. Central air conditioners with a cooling capacity of less than 135,000 British thermal units per hour (Btu/hr.)
4. Central air conditioning heat pumps
5. Gas-fired central furnaces
6. Gas-fired boilers
7. Gas-fired furnaces
8. Gas-fired floor furnaces
9. Gas-fired room heaters
10. Gas-fired duct furnaces
11. Gas-fired unit heaters

The Appliance Efficiency Regulations do not require certification for:

1. Electric resistance space heaters.
2. Oil-fired wall furnaces, floor furnaces, and room heaters. (Some are voluntarily listed with certified gas-fired furnaces.)

Equipment that does not meet the federal appliance efficiency standards may not be sold in California. Any equipment covered by the Appliance Efficiency Regulations and sold in California must have the date of manufacture permanently displayed in an accessible place on that equipment. This date is frequently included as part of the serial number.

Generally, equipment manufactured before the effective date of a new standard may be sold and installed in California indefinitely as long as the performance approach demonstrates energy compliance of the building using the lower efficiency of the relevant appliances. An exception is central split-system air conditioners and central single package air conditioners installed in California. The U.S. Department of Energy (DOE) requires compliance with the minimum efficiencies specified in Title 20, Section 1605.1(c), Table C-3 at the time of installation.

The compliance and enforcement processes should ensure that all installed HVAC equipment regulated by the Appliance Efficiency Regulations is certified by the California Energy Commission.

Equipment Efficiency

The efficiency of most dwelling unit heating and cooling equipment is regulated by the National Appliance Energy Conservation Act of 1987 (NAECA, the federal appliance standard) and California’s Appliance Efficiency Regulations. These regulations are not contained in the Energy Code but are published separately. These regulations are referenced in Section 110.1. The energy efficiency of larger equipment is regulated by Section 110.2(a). The Appliance Efficiency Regulations include definitions for all types of equipment and are regularly updated.

Note: The Appliance Efficiency Regulations that are in effect when the building permit is applied for will determine the minimum efficiency of the appliances identified in the compliance documentation. Because the Title 20 Appliance Efficiency Regulations are updated on a regular basis, it is important to confirm which version of Title 20 is in effect before permit submittal.

Central, Single-Phase Air Conditioners and Air Source Heat Pumps

Central, single-phase air conditioners and air source heat pumps commonly installed in multifamily dwelling units have a capacity less than 65,000 Btu/hr.

Air conditioner efficiencies are determined according to federal test procedures. The efficiencies are reported in terms of SEER and EER. The Appliance Efficiency Regulations for this equipment require minimum SEER. The SEER of all new central, single-phase air conditioners and air source heat pumps with an output less than 65,000 Btu/h must be certified to the Energy Commission to have values no less than the values listed in Title 20, Section 1605.1(c), Table C-3.

Heat Pumps and Electric Heating

Efficiency requirements for package terminal air conditioners, package terminal heat pumps, single-package vertical air conditioners, and single-package vertical heat pumps must meet federal minimum efficiency requirements.

Heat pumps must be certified to have a HSPF or coefficient of performance (COP) equal to or better than those listed in Title 20, Section 1605.1(c), Tables C-3 through C-6.

There are no minimum appliance efficiency standards for electric-resistance or electric-radiant heating systems.

Other Air Conditioners and Heat Pumps

The Appliance Efficiency Regulations contain minimum efficiency requirements for three-phase models, larger-capacity central air conditioners and heat pumps, and all room air conditioners and room air conditioner heat pumps. The efficiency for these types of equipment must be certified to the Energy Commission by the manufacturer. Title 20, Section 1605.1(b) and (c), Tables B-3, C-4, and C-5 include efficiency requirements for equipment with a cooling capacity less than 65,000 Btu/hour. Efficiency requirements for larger equipment are covered later in this chapter.

Gas and Oil-Fired Furnaces

The Appliance Efficiency Regulations require gas- and oil-fired central furnaces with outputs less than 225,000 Btu/hr to be rated according to the associated annual fuel utilization efficiency (AFUE). Gas- and oil-fired central furnaces with outputs greater than or equal to 225,000 Btu/hr are rated according to the respective thermal (or steady-state) efficiency.

Equipment with all output capacities are listed in Table E-6 of the Appliance Efficiency Regulations (Title 20, Section 1605.1(e)).

Noncentral gas furnaces and space heaters must be certified to have AFUE values greater than or equal to those listed in Title 20, Section 1605.1(e), Table E-2.

Gas- and Oil-Fired Central Boilers and Electric Boilers

Gas- and oil-fired central boilers must be certified to have an AFUE or combustion efficiency equal to or better than those listed in the Energy Code Table 110.2-J. **«»**

Exception 1 to Section 110.2(a): Water-cooled centrifugal water-chilling packages that are not designed for operation at ANSI/AHRI Standard 550/590 test conditions of 44°F leaving chilled water temperature and 85°F entering condenser water temperature with 3 gallons per minute per ton condenser water flow shall have a maximum full load kW/ton and NPLV ratings adjusted using the following equation:

Adjusted maximum full-load kW/ton rating = (full- load kW/ton from Table 110.2-D)/Kadj

Adjusted maximum NPLV rating = (IPLV from Table 110.2-D)/Kadj

Where:

Kadj = (A) × (B)

$A = 0.00000014592 \times (LIFT)^4 - 0.0000346496 \times (LIFT)^3 + 0.00314196 \times (LIFT)^2 - 0.147199 \times (LIFT) + 3.9302$

LIFT = LvgCond – LvgEvap (°F)

LvgCond = Full-load leaving condenser fluid temperature (°F)

LvgEvap = Full-load leaving evaporator fluid temperature (°F)

B = (0.0015 × LvgEvap) + 0.934

The adjusted full-load and NPLV values are only applicable for centrifugal chillers meeting all of the following full-load design ranges:

- Minimum Leaving Evaporator Fluid Temperature: 36°F
- Maximum Leaving Condenser Fluid Temperature: 115°F
- LIFT ≥ 20°F and ≤ 80°F

Centrifugal chillers designed to operate outside of these ranges are not covered by this exception.

Exception 2 to Section 110.2(a): Positive displacement (air-cooled and water-cooled) chillers with a leaving evaporator fluid temperature higher than 32°F shall show compliance with Table 110.2-D when tested or certified with water at standard rating conditions, per the referenced test procedure.

Exception 3 to Section 110.2(a): Equipment primarily serving refrigerated warehouses or commercial refrigeration.

(b) Controls for heat pumps with supplementary heaters.

Control requirements for heat pumps with supplementary heaters in single-family residential buildings are specified in Section 150.0(h)7 and Section 150.0(i)2. Heat pumps with supplementary heaters in nonresidential and multifamily buildings shall have controls:

1. That prevent supplementary heater operation when the heating load can be met by the heat pump alone; and

2. In which the cut-on temperature for heat pump heating is higher than the cut-on temperature for supplementary heating, and the cut-off temperature for heat pump heating is higher than the cut-off temperature for supplementary heating.

Exception 1 to Section 110.2(b): The controls may allow supplementary heater operation during:

A. Defrost; and

B. Transient periods such as start-ups and following room thermostat setpoint advance, if the controls provide preferential rate control, intelligent recovery, staging, ramping or another control mechanism designed to preclude the unnecessary operation of supplementary heating.

Exception 2 to Section 110.2(b): Room air-conditioner heat pumps.

«» Commentary for Section 110.2(b):

Heat Pump System Controls

Heat pump systems must be controlled by a central energy management control system (EMCS) or by a setback thermostat as described under Dwelling Units Controls.

Heat pumps with supplemental heaters must have controls that limit the operation of the supplemental heater to defrost and as a second stage of heating when the heat pump alone cannot satisfy the load. The most effective solution is to specify an electronic thermostat designed specifically for use with heat pumps. This "anticipatory" thermostat can detect if the heat pump is raising the space temperature during warm-up fast enough to warrant locking out the supplemental heater.

This requirement can also be met using conventional electronic controls with a two-stage thermostat and an outdoor lockout thermostat wired in series with the supplemental heater. The outdoor thermostat must be set to a temperature where the heat pump capacity is sufficient to warm up the space in a reasonable time (e.g., above 40 °F). This conventional control system is depicted schematically below in Figure 4-3: Heat Pump Auxiliary Heat Control, Two-Stage and Outdoor Air Thermostats.

The first required capability is to set the cut-on and cut-off temperatures for the heat pump and supplementary heating at different levels.

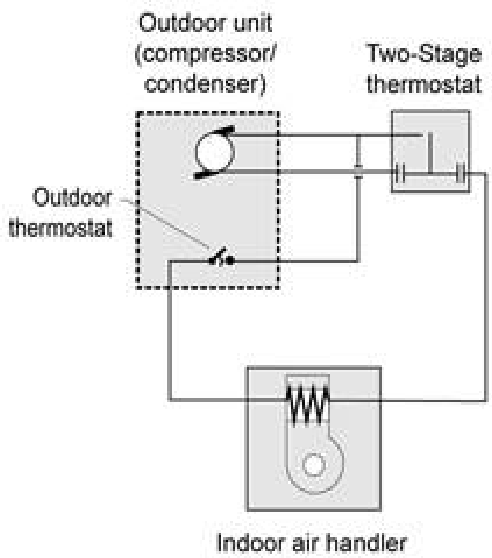
For example, if the heat pump begins heating when the inside temperature reaches 68°F, the supplementary heating may be set to come on if the temperature goes below 65°F if the heat pump alone could not maintain the set point of 68°F. Also, there must be an OFF mode that automatically shuts off the supplementary heating when the inside temperature reaches 68°F.

The second control capability must prevent the supplementary heater from operating if the heat pump alone can meet the heating load, except during defrost. There is a limited exception to this second function for "smart thermostats" that provide intelligent recovery, staging, ramping, or another control mechanism that prevents the unnecessary operation of supplementary heating when the heat pump alone can meet the heating load.

To meet the thermostat requirements, a thermostat for a heat pump with supplementary heating must be a thermostat that minimizes the use of supplementary heating during startup and recovery from setbacks.

Room air conditioner heat pumps are not required to comply with the thermostat requirements.

Figure 4-3: Heat Pump Auxiliary Heat Control, Two-Stage and Outdoor Air Thermostats



Source: California Energy Commission

«»

(c) Thermostats. All heating or cooling systems not controlled by a central energy management control system (EMCS) shall have a setback thermostat.

1. **Setback capabilities.** All thermostats shall have a clock mechanism that allows the building occupant to program the temperature setpoints for at least four periods within 24 hours. Thermostats for heat pumps shall meet the requirements of Section 110.2(b).

Exception to Section 110.2(c): Gravity gas wall heaters, gravity floor heaters, gravity room heaters, noncentral electric heaters, fireplaces or decorative gas appliances, wood stoves, room air conditioners and room air-conditioner heat pumps.

«» Commentary for Section 110.2(c):

Dwelling Unit Controls

The Energy Code includes a mandatory requirement for thermostat controls. Unless controlled by a central energy management control system the thermostat must have setback capabilities.

When it is required, the setback thermostat must have a clock or other mechanism that allows the resident to schedule the heating and/or cooling set points for at least four periods over 24 hours.

If more than one piece of heating or cooling equipment is installed in a dwelling unit, the setback requirement may be met by controlling all heating or cooling units by one thermostat or by controlling each unit with a separate thermostat. Separate heating or cooling units may be provided with a separate on/off control capable of overriding the thermostat.

Thermostats for heat pumps equipped with supplementary heating must be thermostats that minimize the use of supplementary heating during startup and recovery from setback. **«»**

(d) Gas-fired and oil-fired furnace standby loss controls. Gas-fired and oil-fired forced-air furnaces with input ratings ≥ 225,000 Btu/hr shall also have an intermittent ignition or interrupted device (IID), and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for furnaces where combustion air is drawn from the conditioned space. All furnaces with input ratings ≥ 225,000 Btu/hr, including electric furnaces, that are not located within the conditioned space shall have jacket losses not exceeding 0.75 percent of the input rating.

«» Commentary for Section 110.2(d):

Standby Losses and Pilot Lights

Per Section 110.5, fan-type central furnaces may not have a continuously burning pilot light. This requirement does not apply to wall furnaces, floor furnaces, or any gravity-type furnace. Household cooking appliances also must not have a continuously burning pilot light, except for those without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/h.

Per Section 110.2(d), larger gas-fired and oil-fired forced air furnaces with input ratings equal to or greater than 225,000 Btu/h must also have an intermittent ignition device and either power venting or a flue damper.

A vent damper is an acceptable alternative to a flue damper for furnaces where combustion air is drawn from the conditioned space. All furnaces with input ratings equal to or greater than 225,000 Btu/h, including electric furnaces, that are not within the conditioned space must have jacket losses not exceeding 0.75 percent of the input rating. **«»**

(e) Open and closed-circuit cooling towers. All open and closed-circuit cooling tower installations shall comply with the following:

1. Be equipped with conductivity controls that maximize cycles of concentration based on local water quality conditions. Controls shall automate system bleed and chemical feed based on conductivity. Conductivity controllers shall be installed in accordance with manufacturer's specifications in order to maximize accuracy.
2. Documentation of maximum achievable cycles of concentration. Building owners shall document the cycles of concentration achievable based on local water supply conditions as reported annually by the local water supplier, and using the calculations below. The calculations are intended to determine maximum achievable cycles of concentration based on the parameters identified in Table 110.2-A-1. Building owner shall document maximum achievable cycles of concentration on the mechanical compliance form which shall be reviewed and signed by the Professional Engineer (P.E.) of Record.

The maximum achievable cycles of concentrations are based on the local water supply quality as reported by the local water supplier, and shall be the minimum of:

A. 2970 divided by the conductivity of the entering make-up water

B. 1845 divided by the total dissolved solids of the entering make-up water

C. 540 divided by the M-alkalinity excluding galvanized steel of the entering make-up water

D. 450 divided by the M-alkalinity including galvanized steel of the entering make-up water

E. 540 divided by the calcium hardness of the entering make-up water

F. 270 divided by the chlorides of the entering make-up water

G. 225 divided by the sulfates of the entering make-up water

H. 135 divided by the silica of the entering make-up water

I.

Langelier Saturation Index =

$$10^{(-12.038895*[\mathrm{Log}(M*0.9*1.219)-0.061105*\mathrm{Log}(C*0.8)+0.55*\mathrm{Log}(H*M)+0.0050325*T-5.95])}$$

Langelier Saturation Index = 10−12.038895∗LogM∗0.9∗1.219−0.061105∗LogC∗0.8+0.55∗LogH∗M+0.0050325∗T−5.95

Where:

C = Conductivity of the entering make-up water.

H = Calcium hardness of the entering make-up water.

M = M-alkalinity excluding galvanized steel of the entering make-up water.

T = Max skin temperature

3. Cooling towers shall not allow blowdown until one or more of the parameters in Table 110.2-A-1 reaches the maximum value specified:

Table 110.2-A-1 RECIRCULATING WATER PROPERTIES

Recirculating Water Parameters	ximum Values
Conductivity (micro-siemens/cm)	2970 micro-siemens/cm
Total dissolved solids (ppm)	1845 ppm
Total alkalinity as CaCO3 (ppm) excluding galvanized steel	540 ppm
Total alkalinity as CaCO3 (ppm) galvanized steel (passivated)	450 ppm
Calcium hardness as CACO3 (ppm)	540 ppm
Chlorides as Cl (ppm)	270 ppm
Sulfates (ppm)	225 ppm
Silica (ppm)	135 ppm
Langelier saturation index (LSI)	2.5 (LSI)

4. Be equipped with a flow meter with an analog output for flow either hardwired or available through a gateway on the makeup water line.
5. Be equipped with an overflow alarm to prevent overflow of the sump in case of makeup water valve failure. Overflow alarm shall send an audible signal or provide an alert via the energy management control system to the tower operator in case of sump overflow.
6. Be equipped with efficient drift eliminators that achieve drift reduction to 0.002 percent of the circulated water volume for counter-flow towers and 0.005 percent for cross-flow towers.
7. Conductivity controls and overflow alarm shall be verified according to NA 7.5.18.

«» Commentary for Section 110.2(e):

Water-Conservation Measures for Cooling Towers

There are mandatory requirements for the efficient use of water in the operation of open (direct) and closed (indirect) cooling towers.

As water is evaporated off the tower, the concentration of dissolved solids, like calcium carbonate and silica, will increase. The pH of the water will also change. With high levels of silica, or dissolved solids, deposits will form on the tower fill or clog the tower nozzles, which will reduce the tower's heat rejection capacity. High pH is a concern for metal tower basins and structural members. As the thresholds of these contaminants of concern are approached the automated controls should bleed some of the concentrated water out and dilute it with make-up water. The bleed can be controlled by measurement of make-up water flow (an indirect measurement of water drift and evaporation) or through conductivity (a measurement of the dissolved solids). The term "cycles of concentration" is the metric of how concentrated the contaminants are at the controlled level. The right value depends on the characteristics of the supply water, the rate of tower drift, the weather characteristics, and the load on the tower.

Open- and Closed-Circuit Cooling Towers

All open and closed-circuit cooling towers with rated capacity of 150 tons or greater must have a control system that maximizes the cycles of concentration based on the water quality conditions. If the controls system is conductivity based, then the system must automate bleed and chemical feed based on conductivity. The installation criteria for the conductivity controllers must be in accordance with the manufacturer's specifications to maximize accuracy. If the control system is flow based, then the system must be automated in proportion to metered makeup volume, metered bleed volume, and recirculating pump run time (or bleed time).

The makeup water line must be equipped with an analog flow meter and an alarm to prevent overflow of the sump in the event of water valve failure. The alarm system may send an audible signal or an alert through an EMCS.

Drift eliminators are louvered or comb-like devices that are installed at the top of the cooling tower to capture air stream water particles. These drift eliminators are now required to achieve drift reduction to 0.002 percent of the circulated water volume for counter-flow towers and 0.005 percent for crossflow towers.

Additionally, maximum achievable cycles of concentration must be calculated with an Energy Commission approved calculator based on local water quality conditions (which is reported annually by the local utility) and a Langelier Saturation Index (LSI) of 2.5 or less.

The Langelier Saturation Index predicts scaling. It indicates whether water will precipitate, dissolve, or be in equilibrium with calcium carbonate. The index is a function of hardness, alkalinity, conductivity, pH, and temperature expressed as the difference between the actual system pH and the saturation pH.

The maximum cycles of concentration must be cataloged in the mechanical compliance documentation and reviewed and approved by the Professional Engineer (P.E.) of record. «»

(f) Low leakage air-handling units. To qualify as a low leakage air-handling unit for use for meeting the requirements for applicable low leakage air-handling unit compliance credit(s) available in the performance standards set forth in Sections 150.1(b) and 140.1, the manufacturer shall certify to the Energy Commission that the air-handling unit meets the specifications in Reference Joint Appendix JA9.

«» Commentary for Section 110.2(f):

Joint Appendix JA9 provides the qualification requirements for air-handling units to meet the requirements for low leakage air-handling unit compliance credit(s) available in the performance standards set forth in the Energy Code, Sections 170.1(d)2C, 150.1(b) and 140.1. Joint Appendix JA9 is applicable to air-handling units intended for installation in ducted forced-air space conditioning systems. Joint Appendix JA9 is applicable to air-handling units that are rated by the manufacturer to move less than 3,000 cfm (1400 L/s) of air.

Air-handling unit equipment types include furnaces, heat pumps, and air conditioners.

Joint Appendix JA9 does not apply to coil boxes, filter boxes, or other duct system components that are not an integral part of the air-handling unit cabinet or enclosure certified by the manufacturer.

Joint Appendix JA9 does not apply to ducts, plenums, or other field-constructed components. «»

TABLE 110.2-A AIR CONDITIONERS AND CONDENSING UNITS – MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Efficiency	Test Procedure[b]
Air conditioners, air cooled both split system and single package	≥ 65,000 Btu/h and < 135,000 Btu/h	11.2 EER[a] Federal Minimum IEER[a]	AHRI 340/360
Air conditioners, air cooled both split system and single package	≥ 135,000 Btu/h and < 240,000 Btu/h	11.0 EER[a] Federal Minimum IEER[a]	AHRI 340/360
Air conditioners, air cooled both split system and single package	≥ 240,000 Btu/h and < 760,000 Btu/h	10.0 EER[a] Federal Minimum IEER[a]	AHRI 340/360
Air conditioners, air cooled both split system and single package	≥ 760,000 Btu/h	9.7 EER[a] 12.5 IEER[a]	AHRI 340/360

Air conditioners, water cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Federal Minimum EER[a] 13.9 IEER[a]	AHRI 340/360
Air conditioners, water cooled	≥135,000 Btu/h and < 240,000 Btu/h	Federal Minimum EER[a] 13.9 IEER[a]	AHRI 340/360
Air conditioners, water cooled	≥240,000 Btu/h and < 760,000 Btu/h	Federal Minimum EER[a] 13.6 IEER[a]	AHRI 340/360

CONTINUED: TABLE 110.2-A AIR CONDITIONERS AND CONDENSING UNITS – MINIMUM EFFICIENCY REQUIREMENTS (continued)

Equipment Type	Size Category	Efficiency	Test Procedure[b]
Air conditioners, water cooled	≥ 760,000 Btu/h	12.2EER[a] 13.5 IEER[a]	AHRI 340/360
Air conditioners, evaporatively cooled	≥65,000 Btu/h and < 135,000 Btu/h	Federal Minimum EER[a] 12.3 IEER[a]	AHRI 340/360
Air conditioners, evaporatively cooled	≥ 135,000 Btu/h and < 240,000 Btu/h	Federal Minimum EER[a] 12.2 IEER[a]	AHRI 340/360
Air conditioners, evaporatively cooled	≥240,000 Btu/h and < 760,000 Btu/h	Federal Minimum EER[a] 12.1 IEER[a]	AHRI 340/360
Air conditioners, evaporatively cooled	≥ 760,000 Btu/h	11.7 EER[a] 11.9 IEER[a]	AHRI 340/360
Condensing units, air cooled	≥ 135,000 Btu/h	10.5 EER Federal Minimum IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h	13.5 EER Federal Minimum IEER	AHRI 365
Condensing units, evaporatively cooled	≥ 135,000 Btu/h	13.5 EER Federal Minimum IEER	AHRI 365

a Deduct 0.2 from the required EERs and IEERs for units with a heating section other than electric resistance heat.

b Applicable test procedure and reference year are provided under the definitions.

TABLE 110.2-B HEAT PUMPS, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Rating Condition	Efficiency [a]	Test Procedure[b]
Air Cooled (Cooling Mode), both split system and single package	≥ 65,000 Btu/h and < 135,000 Btu/h		11.0 EER Federal Minimum IEER	AHRI 340/360
Air Cooled (Cooling Mode), both split system and single package	≥ 135,000 Btu/h and < 240,000 Btu/h		10.6 EER Federal Minimum IEER	AHRI 340/360
Air Cooled (Cooling Mode), both split system and single package	≥ 240,000 Btu/h		9.5 EER Federal Minimum IEER	AHRI 340/360
Water source (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	86ºF entering water	Federal Minimum EER	ISO-13256-1
Groundwater source (cooling mode)	< 135,000 Btu/h	59ºF entering water	18.0 EER	ISO-13256-1
Ground source (cooling mode)	< 135,000 Btu/h	77ºF entering water	14.1 EER	ISO-13256-1
Water source water-to-water (cooling mode)	< 135,000 Btu/h	86ºF entering water	10.6 EER	ISO-13256-2
Groundwater source water-to-water (cooling mode)	< 135,000 Btu/h	59ºF entering water	16.3 EER	ISO-13256-2

Ground source brine-to-water (cooling mode)	< 135,000 Btu/h	77ºF entering water	12.1 EER	ISO-13256-2
Air Cooled (Heating Mode) Split system and single package	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	47° F db/43° F wb outdoor air	Federal Minimum COP	AHRI 340/360
Air Cooled (Heating Mode) Split system and single package	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	17° F db/15° F wb outdoor air	2.25 COP	AHRI 340/360

CONTINUED: TABLE 110.2-B HEAT PUMPS, MINIMUM EFFICIENCY REQUIREMENTS (continued)

Equipment Type	**Size Category**	**Rating Condition**	**Efficiency** [a]	**Test Procedure**[b]
Air Cooled (Heating Mode) Split system and single package	≥ 135,000 Btu/h and < 240,000 Btu/h (cooling capacity)	47° F db/43° F wb outdoor air	Federal Minimum COP	AHRI 340/360
Air Cooled (Heating Mode) Split system and single package	≥ 240,000 Btu/h and < 760,000 Btu/h	47° F db/43° F wb outdoor air	Federal Minimum COP	AHRI 340/360
Air Cooled (Heating Mode) Split system and single package	≥ 135,000 Btu/h (cooling capacity)	17° F db/15° F wb outdoor air	2.05 COP	AHRI 340/360
Water source (heating mode)	< 135,000 Btu/h (cooling capacity)	68ºF entering water	Federal Minimum COP	ISO-13256-1
Water source (heating mode)	≥ 135,000 Btu/h and < 240,000 Btu/h	68ºF entering water	Federal Minimum COP	ISO-13256-1

Groundwater source (heating mode)	< 135,000 Btu/h (cooling capacity)	50ºF entering water	3.7 COP	ISO-13256-1
Ground source (heating mode)	< 135,000 Btu/h (cooling capacity)	32ºF entering water	3.2 COP	ISO-13256-1
Water source water-to-water (heating mode)	< 135,000 Btu/h (cooling capacity)	68ºF entering water	3.7 COP	ISO-13256-2
Groundwater source water-to-water (heating mode)	< 135,000 Btu/h (cooling capacity)	50ºF entering water	3.1 COP	ISO-13256-2
Ground source brine-to-water (heating mode)	< 135,000 Btu/h (cooling capacity)	32ºF entering water	2.5 COP	ISO-13256-2

a Deduct 0.2 from the required EERs and IEERs for units with a heating section other than electric resistance heat.

b Applicable test procedure and reference year are provided under the definitions.

TABLE 110.2-C AIR-COOLED GAS-ENGINE HEAT PUMPS

Equipment Type	**Size Category**	**Subcategory or Rating Condition**	**Efficiency**	**Test Procedure[a]**
Air-Cooled Gas-Engine Heat Pump (Cooling Mode)	All Capacities	95° F db Outdoor Air	0.60 COP	ANSI Z21.40.4A
Air-Cooled Gas-Engine Heat Pump (Heating Mode)	All Capacities	47° F db/43° F wb Outdoor Air	0.72 COP	ANSI Z21.40.4A

a Applicable test procedure and reference year are provided under the definitions.

TABLE 110.2-D WATER CHILLING PACKAGES – MINIMUM EFFICIENCY REQUIREMENTS [a,b]

Equipment Type	**Size Category**	**Path A Efficiency [a,b]**	**Path B Efficiency [a,b]**	**Test Procedure [c]**

Air Cooled, With Condenser Electrically Operated	< 150 Tons	≥ 10.100 EER ≥ 13.700 IPLV	≥ 9.700 EER ≥15.800 IPLV	AHRI 550/590
Air Cooled, With Condenser Electrically Operated	≥ 150 Tons	≥ 10.100 EER ≥ 14.000 IPLV	≥ 9.700 EER ≥16.100 IPLV	AHRI 550/590
Air Cooled, Without Condenser Electrically Operated	All Capacities	Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements.	Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements.	AHRI 550/590
Water Cooled, Electrically Operated, Reciprocating	All Capacities	Reciprocating units must comply with the water-cooled positive displacement efficiency requirements.	Reciprocating units must comply with the water-cooled positive displacement efficiency requirements.	AHRI 550/590
Water Cooled, Electrically Operated Positive Displacement	< 75 Tons	≤0.750kW/ton ≤ 0.600 IPLV	≤ 0.780 kW/ton ≤ 0.500 IPLV	AHRI 550/590
Water Cooled, Electrically Operated Positive Displacement	≥ 75 tons and < 150 tons	≤ 0.720 kW/ton ≤ 0.560 IPLV	≤ 0.750 kW/ton ≤ 0.490 IPLV	AHRI 550/590
Water Cooled, Electrically Operated Positive Displacement	≥ 150 tons and < 300 tons	≤ 0.660 kW/ton ≤ 0.540 IPLV	≤ 0.680 kW/ton ≤ 0.440 IPLV	AHRI 550/590
Water Cooled, Electrically Operated Positive Displacement,	≥ 300 Tons and < 600 tons	≤ 0.610kW/ton ≤ 0.520 IPLV	≤ 0.625 kW/ton ≤ 0.410 IPLV	AHRI 550/590
Water Cooled, Electrically Operated Positive Displacement	≥ 600 tons	≤ 0.560 kW/ton ≤ 0.500 IPLV	≤ 0.585 kW/ton ≤ 0.380 IPLV	AHRI 550/590

CONTINUED: TABLE 110.2-D WATER CHILLING PACKAGES – MINIMUM EFFICIENCY REQUIREMENTS [a,b]

Equipment Type	Size Category	Path A Efficiency [a,b]	Path B Efficiency [a,b]	Test Procedure [c]
Water Cooled, Electrically Operated, Centrifugal	< 150 Tons	≤ 0.610 kW/ton ≤ 0.550IPLV	≤ 0.695 kW/ton ≤ 0.440 IPLV	AHRI 550/590
Water Cooled, Electrically Operated, Centrifugal	≥ 150 tons and < 300 tons	≤ 0.610 kW/ton ≤ 0.550 IPLV	≤ 0.635 kW/ton ≤ 0.400 IPLV	AHRI 550/590
Water Cooled, Electrically Operated, Centrifugal	≥ 300 tons and < 400 tons	≤ 0.560 kW/ton ≤ 0.520 IPLV	≤ 0.595 kW/ton ≤ 0.390 IPLV	AHRI 550/590
Water Cooled, Electrically Operated, Centrifugal	≥ 400 tons and < 600 tons	≤ 0.560 kW/ton ≤ 0.500 IPLV	≤ 0.585 kW/ton ≤ 0.380 IPLV	AHRI 550/590
Water Cooled, Electrically Operated, Centrifugal	≥ 600 tons	≤ 0.560 kW/ton ≤ 0.500 IPLV	≤ 0.585 kW/ton ≤ 0.380 IPLV	AHRI 550/590
Air Cooled Absorption, Single Effect	All Capacities	≥0.600 COP	N.A. [d]	AHRI 560
Water Cooled Absorption, Single Effect	All Capacities	≥ 0.700 COP	N.A. [d]	AHRI 560
Absorption Double Effect, Indirect-Fired	All Capacities	≥ 1.000 COP ≥ 1.050 IPLV	N.A. [d]	AHRI 560
Absorption Double Effect, Direct-Fired	All Capacities	≥ 1.000 COP ≥1.000 IPLV	N.A. [d]	AHRI 560

Water Cooled Gas Engine Driven Chiller	All Capacities	≥ 1.2 COP ≥ 2.0 IPLV	N.A. [d]	ANSI Z21.40.4A

a. No requirements for:
   1. Centrifugal chillers with design leaving evaporator temperature < 36°F; or
   2. Positive displacement chillers with design leaving fluid temperature ≤ 32°F; or
   3. Absorption chillers with design leaving fluid temperature < 40°F.

b. Must meet the minimum requirements of Path A or Path B. However, both the full load (COP) and IPLV must be met to fulfill the requirements of the applicable Path.

c. See Section 100.1 for definitions.

d. N.A. means not applicable.

TABLE 110.2-E PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT

Equipment Type	**Total System Heat Rejection Capacity at Rated Conditions**	**Subcategory or Rating Condition**	**Performance Required ,[a ,b, c, d]**	**Test Procedure [e]**
Propeller or axial fan Open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering air wb	≥ 42.1 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Centrifugal fan Open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering air wb	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Propeller or axial fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering air wb	≥ 16.1 gpm/hp	CTI ATC-105S and CTI STD-201 RS
Centrifugal fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering air wb	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201 RS

Propeller or axial fan evaporative condensers	All	R-448A test fluid 165ºF entering gas temp 105ºF condensing temp 75ºF entering air wb	≥ 157,000 Btu/h • hp	CTI ATC-106
Propeller or axial fan evaporative condensers	All	Ammonia test fluid 140ºF entering gas temp 96.3ºF condensing temp 75ºF entering air wb	≥ 134,000 Btu/h • hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	R-448A test fluid 165ºF entering gas temp 105ºF condensing temp 75ºF entering air wb	≥ 135,000 Btu/h • hp	CTI ATC-106

CONTINUED: TABLE 110.2-E PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT

Equipment Type	**Total System Heat Rejection Capacity at Rated Conditions**	**Subcategory or Rating Condition**	**Performance Required ,[a ,b, c, d]**	**Test Procedure [e]**
Centrifugal fan evaporative condensers	All	Ammonia test fluid 140ºF entering gas temp 96.3ºF condensing temp 75ºF entering air wb	≥ 110,000 Btu/h • hp	CTI ATC-106
Air cooled condensers	All	125°F condensing temperature 190°F entering gas temperature 15°F subcooling 95°F entering drybulb	≥ 176,000 Btu/h ▪ hp	AHRI 460

Propeller or axial fan dry coolers (air-cooled fluid coolers)	All	115°F entering water 105°F leaving water 95°F entering air db	> 4.5 gpm/hp	CTI ATC-105DS

a For purposes of this table, open-circuit cooling tower performance is defined as the water flow rating of the tower at the given rated conditions divided by the fan motor nameplate power.

b For purposes of this table, closed-circuit cooling tower performance is defined as the process water flow rating of the tower at the given rated conditions divided by the sum of the fan motor nameplate rated power and the integral spray pump motor nameplate power.

c For purposes of this table dry cooler performance is defined as the process water flow rating of the unit at the given thermal rating condition divided by the total fan motor nameplate power of the unit and air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan motor nameplate power of the unit.

d Open cooling towers shall be tested using the test procedures in CTI ATC-105. Performance of factory assembled open cooling towers shall be either certified as base models as specified in CTI STD-201 or verified by testing in the field by a CTI approved testing agency. Open factory assembled cooling towers with custom options added to a CTI certified base model for the purpose of safe maintenance or to reduce environmental or noise impact shall be rated at 90 percent of the CTI certified performance of the associated base model or at the manufacturer's stated performance, whichever is less. Base models of open factory assembled cooling towers are open cooling towers configured in exact accordance with the Data of Record submitted to CTI as specified by CTI STD-201. There are no certification requirements for field erected cooling towers.

e Applicable test procedure and reference year are provided under the definitions. For refrigerated warehouses or commercial refrigeration applications, condensers shall comply with requirements specified by Section 120.6(a) or Section 120.6(b).

TABLE 110.2-F Electrically Operated Variable Refrigerant Flow (VRF) Air Conditioners Minimum Efficiency Requirements

Equipment Type	**Size Category**	**Heating Section Type**	**Sub-Category or Rating Condition**	**Minimum Efficiency**	**Test Procedure[a]**
VRF Air Conditioners, Air Cooled	<65,000 Btu/h	All	VRF Multi-split System	13.0 SEER Before 1/1/2023 Federal Minimum SEER2 On or After 1/1/2023	AHRI 1230 Before 1/1/2023 AHRI 210/240 On or After 1/1/2023

VRF Air Conditioners, Air Cooled	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System	10.5 EER Federal Minimum IEER [b]	AHRI 1230
VRF Air Conditioners, Air Cooled	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System	10.3 EER Federal Minimum IEER [b]	AHRI 1230
VRF Air Conditioners, Air Cooled	≥240,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System	9.5 EER Federal Minimum IEER [b]	AHRI 1230

a Applicable test procedure and reference year are provided under the definitions.

b IEERs are only applicable to equipment with capacity control as specified by AHRI 1230 test procedures.

TABLE 110.2-G Electrically Operated Variable Refrigerant Flow Air-to-Air and Applied Heat Pumps - Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency	Test Procedure [b]
VRF Air Cooled, (cooling mode)	<65,000 Btu/h	All	VRF Multi-split System	13.0 SEER Before 1/1/2023 Federal Minimum =SEER2 On or after 1/1/2023	AHRI 1230 Before 1/1/2023 AHRI 210/240 On or After 1/1/2023
VRF Air Cooled, (cooling mode)	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System [a]	10.3 EER Federal Minimum IEER [c]	AHRI 1230

VRF Air Cooled, (cooling mode)	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System [a]	9.9 EER Federal Minimum IEER [c]	AHRI 1230
VRF Air Cooled, (cooling mode)	≥240,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System [a]	9.1 EER Federal Minimum IEER [c]	AHRI 1230
VRF Water source (cooling mode)	<65,000 Btu/h	All	VRF Multi-split systems [a] 86ºF entering water	12.0 EER Federal Minimum IEER [c]	AHRI 1230
VRF Water source (cooling mode)	≥65,000 Btu/h and <135,000 Btu/h	All	VRF Multi-split System [a] 86ºF entering water	12.0 EER Federal Minimum IEER [c]	AHRI 1230
VRF Water source (cooling mode)	≥135,000 Btu/h and < 240,000	All	VRF Multi-split System [a] 86ºF entering water	10.0 EER Federal Minimum IEER [c]	AHRI 1230
VRF Water source (cooling mode)	≥ 240,000 Btu/h	All	VRF Multi-split System[a] 86ºF entering water	10.0 EER Federal Minimum IEER	AHRI 1230

CONTINUED: TABLE 110.2-G Electrically Operated Variable Refrigerant Flow Air-to-Air and Applied Heat Pumps - Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency	Test Procedure [b]

VRF Groundwater source (cooling mode)	<135,000 Btu/h	All	VRF Multi-split System [a] 59ºF entering water	16.2 EER	AHRI 1230
VRF Groundwater source (cooling mode)	≥135,000 Btu/h	All	VRF Multi-split System [a] 59ºF entering water	13.8 EER	AHRI 1230
VRF Ground source (cooling mode)	<135,000 Btu/h	All	VRF Multi-split System [a] 77ºF entering water	13.4 EER	AHRI 1230
VRF Ground source (cooling mode)	≥135,000 Btu/h	All	VRF Multi-split System [a] 77ºF entering water	11.0 EER	AHRI 1230
VRF Air Cooled (heating mode)	<65,000 Btu/h (cooling capacity)	---	VRF Multi-split System	7.7 HSPF Before 1/1/2025 7.5 HSPF2 On or after 1/1/2025	AHRI 1230 Before 1/1/2025 AHRI 210/240 On or After 1/1/2025
VRF Air Cooled (heating mode)	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)	---	VRF Multi-split system 47ºF db/ 43ºF wb outdoor air	Federal Minimum COP	AHRI 1230
VRF Air Cooled (heating mode)	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)	---	VRF Multi-split system 17ºF db/15ºF wb outdoor air	2.25 COP	AHRI 1230

VRF Air Cooled (heating mode)	≥135,000 Btu/h (cooling capacity)	---	VRF Multi-split system 47ºF db/ 43ºF wb outdoor air	Federal Minimum COP	AHRI 1230

CONTINUED: TABLE 110.2-G Electrically Operated Variable Refrigerant Flow Air-to-Air and Applied Heat Pumps - Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency	Test Procedure [b]
VRF Air Cooled (heating mode)	≥135,000 Btu/h (cooling capacity)	---	VRF Multi-split system 17ºF db/15ºF wb outdoor air	2.05 COP	AHRI 1230
VRF Water source (heating mode)	< 65,000 Btu/h (cooling capacity)	---	VRF Multi-split System 68ºF entering water	Federal Minimum COP	AHRI 1230
VRF Water source (heating mode)	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)	---	VRF Multi-split System 68ºF entering water	Federal Minimum COP	AHRI 1230
VRF Water source (heating mode)	≥135,000 Btu/h and < 240,000 Btu/h (cooling capacity)	---	VRF Multi-split System 68ºF entering water	Federal Minimum COP	AHRI 1230
VRF Water source (heating mode)	≥ 240,000 Btu/h (cooling capacity)	---	VRF Multi-split System 68ºF entering water	Federal Minimum COP	AHRI 1230
VRF Groundwater source (heating mode)	<135,000 Btu/h (cooling capacity)	---	VRF Multi-split System 50ºF entering water	3.6 COP	AHRI 1230

VRF Groundwater source (heating mode)	≥135,000 Btu/h (cooling capacity)	---	VRF Multi-split System 50ºF entering water	3.3 COP	AHRI 1230
VRF Ground source (heating mode)	<135,000 Btu/h (cooling capacity)	---	VRF Multi-split System 32ºF entering water	3.1 COP	AHRI 1230
VRF Ground source (heating mode)	≥135,000 Btu/h (cooling capacity)	---	VRF Multi-split System 32ºF entering water	2.8 COP	AHRI 1230

a. Deduct 0.2 from the required EERs and IEERs for Variable Refrigerant Flow (VRF) Multi-split system units with a heating recovery section.
b. Applicable test procedure and reference year are provided under the definitions.
c. IEERs are only applicable to equipment with capacity control as specified by AHRI 1230 test procedures.

TABLE 110.2-H DX-DOAS Units, Single-Package and Remote Condenser – Minimum Efficiency Requirements

Equipment Type	Energy Recovery	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure[a]
Air cooled (dehumidification mode)	Without energy recovery	NA	3.8 ISMRE2	AHRI 920
Air source heat pumps (dehumidification mode)	Without energy recovery	NA	3.8 ISMRE2	AHRI 920
Water cooled (dehumidification mode)	Without energy recovery	Cooling Tower Condenser Water	4.7 ISMRE2	AHRI 920
Water source heat pump (dehumidification mode)	Without energy recovery	Ground source, closed and open loop	4.6 ISMRE2	AHRI 920

Water source heat pump (dehumidification mode)	Without energy recovery	Water source	3.8 ISMRE2	AHRI 920
Air source heat pumps (heating mode)	Without energy recovery	NA	2.05 ISCOP2	AHRI 920
Water source heat pump (heating mode)	Without energy recovery	Ground source, closed and open loop	2.13 ISCOP2	AHRI 920
Water source heat pump (heating mode)	Without energy recovery	Water source	2.13 ISCOP2	AHRI 920
Air cooled (dehumidification mode)	With energy recovery	NA	5.0 ISMRE2	AHRI 920
Air source heat pumps (dehumidification mode)	With energy recovery	NA	5.0 ISMRE2	AHRI 920

CONTINUED: *TABLE 110.2-H DX-DOAS Units, Single-Package and Remote Condenser – Minimum Efficiency Requirements*

Equipment Type	**Energy Recovery**	**Subcategory or Rating Condition**	**Minimum Efficiency**	**Test Procedure[a]**
Water cooled (dehumidification mode)	With energy recovery	Cooling tower condenser water	5.1 ISMRE2	AHRI 920
Water source heat pump (dehumidification mode)	With energy recovery	Ground source, closed and open loop	5.0 ISMRE2	AHRI 920
Water source heat pump (dehumidification mode)	With energy recovery	Water source	4.6 ISMRE2	AHRI 920
Air source heat pumps (heating mode)	With energy recovery		3.2 ISCOP2	AHRI 920
Water source heat pump (heating mode)	With energy recovery	Ground source, closed and open loop	3.5 ISCOP2	AHRI 920
Water source heat pump (heating mode)	With energy recovery	Water source	4.04 ISCOP2	AHRI 920

a Applicable test procedure and reference year are provided under the definitions.

TABLE 110.2-I Heat Pump and Heat Recovery Chiller Packages, Cooling Operation - Minimum Efficiency Requirements

Equipment Type	Size Category Refrigerating Capacity[a], ton_R	Cooling Operation Efficiency[b,c,d,e], Air Source EER (FL/IPLV), Btu/W h, Liquid Source Power Input per Capacity (FL/IPLV), kW/ton_R Path A	Cooling Operation Efficiency[b,c,d,e], Air Source EER (FL/IPLV), Btu/W h, Liquid Source Power Input per Capacity (FL/IPLV), kW/ton_R Path B	Test Procedure
Air Source	< 150	> 5.595 FL > 13.02 IPLV.IP	> 9.215 FL > 15.01 IPLV.IP	AHRI/550/590
Air Source	> 150	> 5.595 FL > 13.30 IPLV.IP	> 9.215 FL > 15.30 IPLV.IP	AHRI/550/590
Liquid source electrically operated positive displacement	> 11.25[f] and < 150	< 0.7895 FL < 0.6316 IPLV.IP	< 0.8211 FL < 0.5263 IPLV.IP	AHRI/550/590
Liquid source electrically operated positive displacement	> 150 and < 300	< 0.7579 FL < 0.5895 IPLV.IP	< 0.7895 FL < 0.5158 IPLV.IP	AHRI/550/590
Liquid source electrically operated positive displacement	> 300 and < 400	< 0.6947 FL < 0.5684 IPLV.IP	< 0.7158 FL < 0.4632 IPLV.IP	AHRI/550/590
Liquid source electrically operated positive displacement	> 400 and < 600	< 0.6421 FL < 0.5474 IPLV.IP	< 0.6579 FL < 0.4316 IPLV.IP	AHRI/550/590
Liquid source electrically operated positive displacement	> 600	< 0.5895 FL < 0.5263 IPLV.IP	< 0.6158 FL < 0.4000 IPLV.IP	AHRI/550/590
Liquid source electrically operated centrifugal	> 11.25[f] and < 150	< 0.6421 FL < 0.5789 IPLV.IP	< 0.7316 FL < 0.4632 IPLV.IP	AHRI/550/590
Liquid source electrically operated centrifugal	> 150 and < 300	< 0.6190 FL < 0.5748 IPLV.IP	< 0.6684 FL < 0.4211 IPLV.IP	AHRI/550/590
Liquid source electrically operated centrifugal	> 300 and < 400	< 0.5895 FL < 0.5526 IPLV.IP	< 0.6263 FL < 0.4105 IPLV.IP	AHRI/550/590
Liquid source electrically operated centrifugal	> 400 and < 600	< 0.5895 FL < 0.5263 IPLV.IP	< 0.6158 FL < 0.4000 IPLV.IP	AHRI/550/590

Liquid source electrically operated centrifugal	> 600	< 0.5895 FL < 0.5263 IPLV.IP	< 0.6158 FL < 0.4000 IPLV.IP	AHRI/550/590

a. The size category is the full-load net refrigeration cooling mode capacity, which is the capacity of the evaporator available for cooling of the thermal load external to the chilling package.

b. Cooling rating conditions are standard rating conditions defined in AHRI 550/590 (I-P), Table 4, except for liquid cooled centrifugal chilling packages which can adjust cooling efficiency for nonstandard rating conditions using K_{adj} procedure in accordance with Section 110.2(a).

c. For cooling operation, compliance with both the FL and IPLV is required, but only compliance with Path A or Path B cooling efficiency is required.

d. For units that operate in both cooling and heating, compliance with both the cooling and heating efficiency is required.

e. For heat recovery heating chilling package applications where there is simultaneous cooling and heating, compliance with the heating performance heat recover COP_{HR} is only required at one of the four heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, Hot-Water 1 or Hot-Water 2. Compliance with the cooling only performance is required as defined in footnotes b and c.

f. Water to water heat pumps with capacity less than 135,000 Btu/h are included in Table 110.2-B Heat Pumps, Minimum Efficiency Requirements.

TABLE 110.2-J Heat Pump and Heat Recovery Chiller Packages, Heat Pump, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Air Source

Size Category Refrigerating Capacity[a], Ton_R	**Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F**	**Test Procedure**
< 150	47 db 43 wb	> 3.29	> 2.77	> 2.31	NA[j]	AHRI 550/590
< 150	17 db 15 wb	> 2.029	> 1.775	> 1.483	NA[j]	AHRI 550/590
> 150	47 db 43 wb	> 3.29	> 2.77	> 2.31	NA[j]	AHRI 550/590
> 150	17 db 15 wb	> 2.029	> 1.775	> 1.483	NA[j]	AHRI 550/590

(CONTINUED) TABLE 110.2-J Heat Pump and Heat Recovery Chiller Packages, Heat Pump, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Liquid source electrically operated positive displacement

Size Category Refrigerating Capacity[a], Ton_R	**Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F**	**Test Procedure**
> 11.25[h] and < 150	44[i]	> 4.64	> 3.68	> 2.68	NA[j]	AHRI 550/590
> 11.25[h] and < 150	65[i]	NA[j]	NA[j]	NA[j]	> 3.55	AHRI 550/590
> 150 and < 300	44[i]	> 4.64	> 3.68	> 2.68	NA[j]	AHRI 550/590
> 150 and < 300	65[i]	NA[j]	NA[j]	NA[j]	> 3.55	AHRI 550/590
> 300 and < 400	44[i]	> 4.64	> 3.68	> 2.68	NA[j]	AHRI 550/590
> 300 and < 400	65[i]	NA[j]	NA[j]	NA[j]	> 3.55	AHRI 550/590
> 400 and < 600	44[i]	> 4.93	> 3.96	> 2.97	NA[j]	AHRI 550/590
> 400 and < 600	65[i]	NA[j]	NA[j]	NA[j]	> 3.9	AHRI 550/590
> 600	44[i]	> 4.93	> 3.96	> 2.97	NA[g]	AHRI 550/590
> 600	65[i]	NA[j]	NA[j]	NA[j]	> 3.9	AHRI 550/590

(CONTINUED) TABLE 110.2-J Heat Pump and Heat Recovery Chiller Packages, Heat Pump, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Liquid source electrically operated centrifugal

Size Category Refrigerating Capacity[a], Ton_R	**Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H)[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H)[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H)[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H)[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F**	**Test Procedure**
> 11.25[h] and < 150	44[i]	> 4.64	> 3.68	> 2.68	NA[j]	AHRI 550/590
> 11.25[h] and < 150	65[i]	NA[j]	NA[j]	NA[j]	> 3.55	AHRI 550/590
> 150 and < 300	44[i]	> 4.64	> 3.68	> 2.68	NA[j]	AHRI 550/590
> 150 and < 300	65[i]	NA[j]	NA[j]	NA[j]	> 3.55	AHRI 550/590
> 300 and < 400	44[i]	> 4.64	> 3.68	> 2.68	NA[j]	AHRI 550/590
> 300 and < 400	65[i]	NA[g]	NA[g]	NA[g]	> 3.55	AHRI 550/590
> 400 and < 600	44[i]	> 4.93	> 3.96	> 2.97	NA[j]	AHRI 550/590
> 400 and < 600	65[i]	NA[j]	NA[j]	NA[j]	> 3.9	AHRI 550/590
> 600	44[i]	> 4.93	> 3.96	> 2.97	NA[j]	AHRI 550/590
> 600	65[i]	NA[j]	NA[j]	NA[j]	> 3.9	AHRI 550/590

a. The size category is the full-load net refrigeration cooling mode capacity, which is the capacity of the evaporator available for cooling of the thermal load external to the chilling package.

b. For air source heat pumps, compliance with both the 47 F and 17 F heating source outdoor air temperature (OAT) rating efficiency is required for heating.

c. Heating full load rating conditions are at standard rating conditions defined in AHRI 550/590 (I-P), Table 4, includes the impact of defrost for air source heating ratings.
d. For units that operate in both cooling and heating, compliance with both the cooling and heating efficiency is required.
e. For heat recovery heating chilling package applications where there is simultaneous cooling and heating, compliance with the heating performance heat recover COP_{HR} is only required at one of the four heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, Hot-Water 1 or Hot-Water 2. Compliance with the cooling only performance is required as defined in footnotes b and c of Table 110.2-I.
f. For applications where the chilling package is installed to operate only in heating, compliance only with the heating performance COP_H is required at only one of the heating AHRI 550/590 (I-P) standard rating conditions of Low, Medium, High, or Boost. Compliance with cooling performance is not required.
g. For heat pump chilling package applications where the cooling capacity is not being used for conditioning, compliance with the heating performance COP_H is only required at one of the heating AHRI 550/590 (I-P) standard rating conditions of Low, Medium, High, or Boost. Compliance with the cooling performance is required as defined in footnotes b and c of Table 110.2-I, except as noted in footnote f.
h. Water to water heat pumps with capacity less than 135,000 Btu/h are included in Table 110.2-B Heat Pumps, Minimum Efficiency Requirements.
i. Source leaving liquid temperature.
    1. The cooling evaporator liquid flow rate used for the heating rating for a reverse cycle air to water heat pump shall be the flow rate determined during the full load cooling rating.
    2. The cooling evaporator liquid flow rate for the simultaneous cooling and heating and heat recovery liquid cooled chilling packages rating shall be the liquid flow rates from the cooling operation full load rating.
    3. For heating only fluid to fluid chiller packages, the evaporator flow rate obtained with an entering liquid temperature of 54 F and a leaving liquid temperature of 44 F shall be used.
j. NA means the requirements are not applicable.

TABLE 110.2-K Heat Pump and Heat Recovery Chiller Packages, Simultaneous Cooling and Heating, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Air Source

Size Category Refrigerating Capacity[a], Ton_R	Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F	Test Procedure
< 150	47 db 43 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
< 150	17 db 15 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 150	47 db 43 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 150	17 db 15 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590

(CONTINUED) TABLE 110.2-K Heat Pump and Heat Recovery Chiller Packages, Simultaneous Cooling and Heating, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Liquid source electrically operated positive displacement

Size Category Refrigerating Capacity[a], Ton_R	Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F	Test Procedure
> 11.25[h] and < 150	44[i]	> 8.33	> 6.41	> 4.42	NA[j]	AHRI 550/590
> 11.25[h] and < 150	65[i]	NA[j]	NA[j]	NA[j]	> 6.150	AHRI 550/590
> 150 and < 300	44[i]	> 8.33	> 6.41	> 4.42	NA[j]	AHRI 550/590
> 150 and < 300	65[i]	NA[j]	NA[j]	NA[j]	> 6.150	AHRI 550/590
> 300 and < 400	44[i]	> 8.33	> 6.41	> 4.42	NA[j]	AHRI 550/590
> 300 and < 400	65[i]	NA[j]	NA[j]	NA[j]	> 6.150	AHRI 550/590
> 400 and < 600	44[i]	> 8.9	> 6.98	> 5	NA[j]	AHRI 550/590
> 400 and < 600	65[i]	NA[j]	NA[j]	NA[j]	> 6.85	AHRI 550/590
> 600	44[i]	> 8.9	> 6.98	> 5	NA[j]	AHRI 550/590
> 600	65[i]	NA[j]	NA[j]	NA[j]	> 6.85	AHRI 550/590

(CONTINUED) TABLE 110.2-K Heat Pump and Heat Recovery Chiller Packages, Simultaneous Cooling and Heating, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Liquid source electrically operated centrifugal

Size Category Refrigerating Capacity[a], Ton_R	Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F	Test Procedure
> 11.25[h] and < 150	44[i]	> 8.33	> 6.41	> 4.42	NA[j]	AHRI 550/590
> 11.25[h] and < 150	65[i]	NA[j]	NA[j]	NA[j]	> 6.150	AHRI 550/590
> 150 and < 300	44[i]	> 8.33	> 6.41	> 4.42	NA[j]	AHRI 550/590
> 150 and < 300	65[i]	NA[j]	NA[j]	NA[j]	> 6.150	AHRI 550/590
> 300 and < 400	44[i]	> 8.33	> 6.41	> 4.42	NA[j]	AHRI 550/590
> 300 and < 400	65[i]	NA[j]	NA[j]	NA[j]	> 6.150	AHRI 550/590
> 400 and < 600	44[i]	> 8.9	> 6.98	> 5	NA[j]	AHRI 550/590
> 400 and < 600	65[i]	NA[j]	NA[j]	NA[j]	> 6.85	AHRI 550/590
> 600	44[i]	> 8.9	> 6.98	> 5	NA[j]	AHRI 550/590
> 600	65[i]	NA[j]	NA[j]	NA[j]	> 6.85	AHRI 550/590

a. The size category is the full-load net refrigeration cooling mode capacity, which is the capacity of the evaporator available for cooling of the thermal load external to the chilling package.

b. For air source heat pumps, compliance with both the 47 F and 17 F heating source outdoor air temperature (OAT) rating efficiency is required for heating.

c. Heating full load rating conditions are at standard rating conditions defined in AHRI 550/590 (I-P), Table 4, includes the impact of defrost for air source heating ratings.
d. For units that operate in both cooling and heating, compliance with both the cooling and heating efficiency is required.
e. For heat recovery heating chilling package applications where there is simultaneous cooling and heating, compliance with the heating performance heat recover COP_{HR} is only required at one of the four heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, Hot-Water 1 or Hot-Water 2. Compliance with the cooling only performance is required as defined in footnotes b and c of Table 110.2-I.
f. Heating full load rating conditions are at standard rating conditions defined in AHRI 550/590 (I-P), Table 4, includes the impact of defrost for air source heating ratings.
g. For simultaneous cooling and heating chillers applications where there is simultaneous cooling and heating, compliance with the simultaneous cooling performance heat recovery COP_{SHC} is only required at one of the heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, High, or Boost. Compliance with cooling performance is required as defined in footnotes b and c of Table 110.2-I.
h. Water to water heat pumps with capacity less than 135,000 Btu/h are included in Table 110.2-B Heat Pumps, Minimum Efficiency Requirements.
i. Source leaving liquid temperature.
   1. The cooling evaporator liquid flow rate used for the heating rating for a reverse cycle air to water heat pump shall be the flow rate determined during the full load cooling rating.
   2. The cooling evaporator liquid flow rate for the simultaneous cooling and heating and heat recovery liquid cooled chilling packages rating shall be the liquid flow rates from the cooling operation full load rating.
   3. For heating only fluid to fluid chiller packages, the evaporator flow rate obtained with an entering liquid temperature of 54 F and a leaving liquid temperature of 44 F shall be used.
j. NA means the requirements are not applicable.

TABLE 110.2-L Heat Pump and Heat Recovery Chiller Packages, Heat Recovery, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Air Source

Size Category Refrigerating Capacity[a], Ton_R	Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F	Heat Recovery Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F	Heat Recovery Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F	Heat Recovery Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F	Heat Recovery Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F	Test Procedure
< 150	47 db 43 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
< 150	17 db 15 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 150	47 db 43 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 150	17 db 15 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590

(CONTINUED) TABLE 110.2-L Heat Pump and Heat Recovery Chiller Packages, Heat Recovery, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Liquid source electrically operated positive displacement

Size Category Refrigerating Capacity[a], Ton$_R$	**Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F**	**Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F**	**Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F**	**Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F**	**Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F**	**Test Procedure**
> 11.25[h] and < 150	44[i]	> 8.33	> 6.41	> 4.862	> 4.42	AHRI 550/590
> 11.25[h] and < 150	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 150 and < 300	44[i]	> 8.33	> 6.41	> 4.862	> 4.42	AHRI 550/590
> 150 and < 300	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 300 and < 400	44[i]	> 8.33	> 6.41	> 4.862	> 4.42	AHRI 550/590
> 300 and < 400	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 400 and < 600	44[i]	> 8.9	> 6.98	> 5.5	> 5	AHRI 550/590
> 400 and < 600	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 600	44[i]	> 8.9	> 6.98	> 5.5	> 5	AHRI 550/590
> 600	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590

(CONTINUED) TABLE 110.2-L Heat Pump and Heat Recovery Chiller Packages, Heat Recovery, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Liquid source electrically operated centrifugal

Size Category Refrigerating Capacity[a], Ton_R	Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F	Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F	Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F	Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F	Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F	Test Procedure
> 11.25 [h] and < 150	44[i]	> 8.33	> 6.41	> 4.862	> 4.42	AHRI 550/590
> 11.25 [h] and < 150	65 [i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 150 and < 300	44[i]	> 8.33	> 6.41	> 4.862	> 4.42	AHRI 550/590
> 150 and < 300	65 [i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 300 and < 400	44[i]	> 8.33	> 6.41	> 4.862	> 4.42	AHRI 550/590
> 300 and < 400	65 [i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 400 and < 600	44[i]	> 8.9	> 6.98	> 5.5	> 5	AHRI 550/590
> 400 and < 600	65 [i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 600	44[i]	> 8.9	> 6.98	> 5.5	> 5	AHRI 550/590
> 600	65 [i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590

a. The size category is the full-load net refrigeration cooling mode capacity, which is the capacity of the evaporator available for cooling of the thermal load external to the chilling package.

b. For air source heat pumps, compliance with both the 47 F and 17 F heating source outdoor air temperature (OAT) rating efficiency is required for heating.

c. Heating full load rating conditions are at standard rating conditions defined in AHRI 550/590 (I-P), Table 4, includes the impact of defrost for air source heating ratings.

d. For units that operate in both cooling and heating, compliance with both the cooling and heating efficiency is required.

e. For heat recovery heating chilling package applications where there is simultaneous cooling and heating, compliance with the heating performance heat recover COP_{HR} is only required at one of the four heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, Hot-Water 1 or Hot-Water 2. Compliance with the cooling only performance is required as defined in footnotes b and c of Table 110.2-I.

f. For liquid source heat recovery chilling packages that have capabilities for heat rejection to a heat recovery condenser and a tower condenser the COP_{HR} applies to operation at full load with 100 percent heat recovery (no tower rejection). Units that only have capabilities for partial heat recovery shall meet the requirements of Table 110.2-D Water Chilling Packages Minimum Efficiency.

g. For heat recovery heating chilling package applications where there is simultaneous cooling and heating, compliance with the heating performance heat recover COP_{HR} is only required at one of the four heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, Hot-Water 1 or Hot-Water 2. Compliance with the cooling only performance is required as defined in footnotes b and c of Table 110.2-I.

h. Water to water heat pumps with capacity less than 135,000 Btu/h are included in Table 110.2-B Heat Pumps, Minimum Efficiency Requirements.

i. Source leaving liquid temperature.

   1. The cooling evaporator liquid flow rate used for the heating rating for a reverse cycle air to water heat pump shall be the flow rate determined during the full load cooling rating.
   2. The cooling evaporator liquid flow rate for the simultaneous cooling and heating and heat recovery liquid cooled chilling packages rating shall be the liquid flow rates from the cooling operation full load rating.
   3. For heating only fluid to fluid chiller packages, the evaporator flow rate obtained with an entering liquid temperature of 54 F and a leaving liquid temperature of 44 F shall be used.

j. NA means the requirements are not applicable.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.8, and 25943, Public Resources Code

SECTION 110.5 – NATURAL GAS CENTRAL FURNACES, COOKING EQUIPMENT, POOL AND SPA HEATERS, AND FIREPLACES: PILOT LIGHTS PROHIBITED

Any natural gas system or equipment listed below may be installed only if it does not have a continuously burning pilot light:

(a) Fan-type central furnaces.

(b) Household cooking appliances.

> **Exception to Section 110.5(b):** Household cooking appliances without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/hr.

(c) Pool heaters.

(d) Spa heaters.

(e) Indoor and outdoor fireplaces.

Note**:** Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.8, and 25943, Public Resources Code.

SECTION 110.9 – MANDATORY REQUIREMENTS FOR LIGHTING CONTROLS

(b) All lighting controls. Lighting controls listed in Section 110.9(b) shall comply with the requirements listed below; and all components of the system considered together as installed shall meet all applicable requirements for the application for which they are installed as required in Sections 130.0 through 130.5, Sections 140.6 through 140.8, Section 141.0, and Section 150.0(k).

4. **Occupant sensing controls.** Occupant sensing controls include occupant sensors, motion sensors, and vacancy sensors, including those with a partial-ON or partial-OFF function. Occupant sensing controls shall:
   A. Be capable of automatically turning the controlled lights in the area either off or down no more than 20 minutes after the area has been vacated;
   B. For manual-on controls, have a grace period of no less than 15 seconds and no more than 30 seconds to turn on lighting automatically after the sensor has timed out; and
   C. Provide a visible status signal that indicates that the device is operating properly, or that it has failed or malfunctioned. The visible status signal may have an override that turns off the signal.

Exception to Section 110.9(b)4: Occupant sensing control systems may consist of a combination of single or multilevel occupant, motion or vacancy sensor controls, provided that components installed to comply with manual-on requirements shall not be capable of conversion by occupants from manual-on to automatic-on functionality.

5. Reserved.
6. **Sensors used to detect occupants.** Sensors that are used by occupant sensing controls to detect occupants shall meet all of the following requirements:
   A. Sensors shall not incorporate switches or mechanical devices that allow the sensor to be disabled without changing the settings of the control.
   B. Sensors that utilize ultrasonic radiation for detection of occupants shall:
      i. comply with 21 C.F.R. part 1002.12;
      ii. not emit audible sound; and
      iii. not emit ultrasound in excess of the decibel levels shown in Table 110.9-A measured no more than 5 feet from the source, on axis.
   C. Sensors that utilize microwave radiation for detection of occupants shall:
      i. comply with 47 C.F.R. parts 2 and 15; and

ii. not emit radiation in excess of 1 milliwatt per square centimeter measured at no more than 5 centimeters from the emission surface of the device.

«» Commentary for Section 110.9(b):

The use of occupant sensor ventilation control devices is mandated for spaces that are also required to use occupant sensing controls to meet the requirements for lighting shut-off controls per Section 160.2(c)5E. Example spaces include offices, multipurpose rooms 1,000 sq. ft. or less, classrooms, conference rooms, and other spaces where the space ventilation is allowed to be reduced to zero. See the commentary below in Section 160.2 for more information on occupant sensor ventilation control devices. **«»**

SECTION 110.12 – MANDATORY REQUIREMENTS FOR DEMAND MANAGEMENT

Buildings, other than healthcare facilities, that install or are required to install demand responsive controls shall comply with the applicable demand responsive control requirements of Sections 110.12(a) through 110.12(e).

(a) Demand responsive controls.

1. All demand responsive controls shall be either:
   A. A certified OpenADR 2.0a or OpenADR 2.0b Virtual End Node (VEN), as specified under Clause 11, Conformance, in the applicable OpenADR 2.0 Specification; or a certified Baseline Profile OpenADR 3.0 Virtual End Node; or
   B. Certified to the Energy Commission as being capable of responding to a demand response signal from a certified OpenADR 2.0b or a certified Baseline Profile OpenADR 3.0 Virtual End Node by automatically implementing the control functions requested by the Virtual End Node for the equipment it controls.
2. All demand responsive controls shall be capable of communicating with the VEN using a wired or wireless bidirectional communication protocol.
3. RESERVED
4. When the demand response signal is disabled or unavailable, all demand responsive controls shall continue to perform all other control functions provided by the control.
5. Demand responsive control thermostats shall comply with Reference Joint Appendix 5 (JA5), Technical Specifications for Occupant Controlled Smart Thermostats.

(b) Demand Responsive Zonal HVAC Controls. Nonresidential HVAC systems with DDC to the Zone level shall be programmed to allow centralized demand shed for noncritical zones as follows:

1. The controls shall have a capability to remotely increase the operating cooling temperature set points by 4 degrees or more in all noncritical zones on signal from a centralized contact or software point within an Energy Management Control System (EMCS).
2. The controls shall have a capability to remotely decrease the operating heating temperature set points by 4 degrees or more in all noncritical zones on signal from a centralized contact or software point within an EMCS.
3. The controls shall have capabilities to remotely reset the temperatures in all noncritical zones to original operating levels on signal from a centralized contact or software point within an EMCS.

4. The controls shall be programmed to provide an adjustable rate of change for the temperature increase, decrease, and reset.
5. The controls shall have the following features:
   A. Disabled. Disabled by authorized facility operators; and
   B. Manual control. Manual control by authorized facility operators to allow adjustment of heating and cooling set points globally from a single point in the EMCS; and
   C. Automatic Demand Shed Control. Upon receipt of a demand response signal, the space-conditioning systems shall conduct a centralized demand shed, as specified in Sections 110.12(b)1 and 110.12(b)2, for noncritical zones during the demand response period.

«» Commentary for Section 110.12(b):

HVAC systems with direct digital controls (DDC) to the zone level in multifamily common use areas must be programmed to allow centralized demand shed for non-critical zones during the demand response period.

The Energy Code defines a critical zone as a zone serving a process where reset of the zone temperature set point during a demand shed event might disrupt the process, including but not limited to data centers, telecom/private branch exchange rooms, and laboratories.

To comply with this requirement, each non-critical zone temperature-control loop will control option that adds in an offset on the cooling temperature set point from a central demand shed signal. A rate of change limiter can either be built into the zone control or into the functional block for the central offset value. The central demand shed signal can be activated either through a global software point or a hardwired digital contact.

«»

SECTION 160.2 – MANDATORY REQUIREMENTS FOR VENTILATION AND INDOOR AIR QUALITY

(a) General requirements.

1. Attached dwelling units in multifamily buildings shall comply with the applicable requirements of Subsection 160.2(b) below. Occupiable spaces in multifamily buildings other than attached dwelling units shall comply with the applicable requirements of Section 160.2(c). When field verification and diagnostic testing of attached dwelling units is required by Section 160.2, buildings with three habitable stories or fewer shall use the applicable procedures in the Residential Appendices, and buildings with four or more habitable stories shall use the applicable procedures in Nonresidential Appendices NA1 and NA2.

   NOTE: Section 160.2 is not applicable to townhouses or dwellings that contain two dwelling units.

2. The required outdoor air-ventilation rate and the air-distribution system design shall be clearly identified on the building design plans submitted to the enforcement agency in accordance with Section 10-103 of Title 24, Part 1.

«» Commentary for Section 160.2:

The standard is structured such that requirements for the dwelling units are separate from requirements for common use areas of the multifamily building (e.g., corridors, parking garages, community rooms, etc.). The dwelling unit requirements are in Section 160.2(b) and generally follow ASHRAE Standard 62.2-2022, with some amendments. They include both ventilation rates and other IAQ requirements, including compartmentalization (air sealing dwelling units to reduce pollutant transfer from the outdoors and from neighboring units and common areas). The common use area requirements are in Section 160.2(c) and follow ASHRAE Standard 62.1-2022 for ventilation rates. «»

(b) Attached dwelling units. Attached dwelling units shall comply with the requirements of Subsections 1 and 2 below**.**

1. **Air filtration.**

   A. System types specified in Subsections i, ii and iii shall be provided with air filters in accordance with Sections 160.2(b)1B, 160.2(b)1C and 160.2(b)1D. System types specified in Subsection i shall also comply with Section 160.2(b)1E.

      i. Mechanical space-conditioning systems that supply air to an occupiable space through ductwork exceeding 10 ft (3 m) in length.

      ii. Mechanical supply-only ventilation systems and makeup air systems that provide outside air to an occupiable space.

iii. The supply side of mechanical balanced ventilation systems, including heat recovery ventilation systems, and energy recovery ventilation systems that provide outside air to an occupiable space.

B. **System design and installation.**

i. The system shall be designed to ensure that all recirculated air and all outdoor air supplied to the occupiable space are filtered before passing through any system's thermal conditioning components.

Exception to Section 160.2(b)1Bi: For heat recovery ventilators and energy recovery ventilators, the location of the filters required by Section 160.2(b)1 may be downstream of a system thermal conditioning component, provided the system is equipped with ancillary filtration upstream of the system’s thermal conditioning component.

ii. All systems shall be designed to accommodate the clean-filter pressure drop imposed by the system air filter(s). The design airflow rate, and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter, shall be determined and reported on labels according to Subsection iv below.

Systems specified in Section 160.2(b)1Ai shall be equipped with air filters that meet either Subsection a or b below:

a. Nominal two-inch minimum depth filter(s) shall be sized by the system designer, or

b. Nominal one-inch minimum depth filter(s) shall be allowed if the filter(s) are sized according to Equation 160.2-A, based on a maximum face velocity of 150 ft per minute and according to the maximum allowable clean-filter pressure drop specified in Section 160.2(b)1Dii.

$A_{face} = Q_{filter} / V_{face}$ (Equation 160.2-A)

where:

A_{face} = air filter face area, the product of air filter nominal length × nominal width, ft^2.

Q_{filter} = design airflow rate for the air filter, ft^3/min

V_{face} = air filter face velocity $\leq$ 150 ft/min

iii. All system air filters shall be located and installed in such a manner as to be accessible for regular service by the system owner.

iv. All system air filter installation locations shall be labeled to disclose the applicable design airflow rate and the maximum allowable clean-filter pressure drop. The labels shall be permanently affixed to the air filter installation location, readily legible, and visible to a person replacing the air filter.

v. Filter racks or grilles shall use gaskets, sealing or other means to close gaps around inserted filters and prevent air from bypassing the filter.

C. **Air filter efficiency**. The system shall be provided with air filters having a designated efficiency equal to or greater than MERV 13 when tested in accordance with ASHRAE Standard 52.2, or a particle size efficiency rating equal to or greater than 50 percent in the 0.30–1.0 μm range, and equal to or greater than 85 percent in the 1.0–3.0 μm range when tested in accordance with AHRI Standard 680.

D. **Air filter pressure drop**. All systems shall be provided with air filters that conform to the applicable maximum allowable clean-filter pressure drop specified in Subsection i, ii, iii or iv below, when tested using ASHRAE Standard 52.2, or as rated using AHRI Standard 680, for the applicable design airflow rates for the system air filters.

i. The maximum allowable clean-filter pressure drop shall be determined by the system design for the nominal two-inch minimum depth air filter required by Section 160.2(b)1Biia, or

ii. A maximum of 25 Pa (0.1 inches water) clean-filter pressure drop shall be allowed for a nominal 1-inch depth air filter sized according to Section 160.2(b)1Biib, or

iii. For systems specified in Sections 160.2(b)1Aii and 160.2(b)1Aiii, the maximum allowable clean filter pressure drop shall be determined by the system design.

iv. If Exception 1 to Section 160.3(b)5Lii or iv is utilized for compliance with cooling system airflow rate and fan efficacy requirements, the clean-filter pressure drop for the system air filter shall conform to the requirements given in Table 160.3-A or 160.3-B.

E. **Air filter product labeling.** Systems described in Section 160.2(b)1Ai shall be equipped with air filters that have been labeled by the manufacturer to disclose the efficiency and pressure drop ratings that demonstrate conformance with Sections 160.2(b)1C and 160.2(b)1D.

Exception to Section 160.2(b)1: Evaporative coolers are not required to comply with the air filtration requirements in Section 160.2(b)1.

«» Commentary for Section 160.2(b)1:

The air filtration requirements in forced air systems serve two purposes:

1. Protects the equipment from dust accumulation that could reduce the capacity or efficiency of the system. Preventing dust buildup may also prevent the system from becoming a host to biological contaminants such as mold, especially if dust is deposited on cooling coils that become wet from water condensation during comfort cooling operation. Air filter efficiencies of Minimum Efficiency Reporting Value (MERV) 6 to MERV 8 are sufficient for protection from these large airborne dust particles.
2. Remove airborne particles which can harm human health. Air filter efficiencies of at least MERV 13 protect occupants from exposure to the smaller airborne particles that are known to adversely affect respiratory health. These smaller particles are often referred to as PM 2.5, which refers to particulate matter of 2.5 microns or smaller. PM2.5 is produced from several sources including combustion from cooking and from exhaust from motor vehicles that enters a dwelling through ventilation openings and infiltration.

All filters used in all system types must be accessible to facilitate replacement, since regular filter replacement is important for proper equipment functioning and energy efficiency.

The intent of the requirement for a 2-inch depth filter or a 1-inch depth filter with a maximum face velocity of 150 ft per minute and a maximum pressure drop of 25 Pa is to reduce the pressure drop across the filter that could result in increased energy use from higher filtration.

Air Filter Grille Sticker

The design airflow rate and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter grille/rack must be determined by the designer/installer and posted on a sticker placed by the installer inside or near the filter grille/rack. The design airflow and initial resistance posted on this sticker should correspond to the conditions used in the system design calculations. This requirement applies to space conditioning systems and also to the ventilation system types described in Section 160.2(b)1A.

An example of an air filter grille sticker showing the design airflow and pressure drop for the filter grille/rack is shown in Table 4-2: Example of Installer's Filter Grille Sticker.

Air Filter Manufacturer Label

Space-conditioning system filters are required to be labeled by the manufacturer to indicate the pressure drop across the filter at several airflow rates. For the system to comply, and to ensure adequate airflow for efficient heating and cooling equipment operation, the manufacturer's air filter label must display information that indicates the filter can meet the design airflow rate for that return grille/rack at a pressure drop less than or equal to the value shown on the installer's filter grille sticker. This requirement does not apply to the ventilation system types described in Section 160.2(b)1A.

Table 4-2: Example of Installer's Filter Grille Sticker

Air Filter Performance Requirement	Air Filter Performance Requirement	Maintenance Instructions
Airflow Rate (CFM) Must be greater than or equal to the value shown	Initial Resistance (IWC) Must be less than or equal to the value shown	Use only replacement filters that are rated to simultaneously meet both of the performance requirements specified on this sticker:
750	0.1	Left Blank

Source: California Energy Commission

Figure 4-4: Example Manufacturer's Filter Label

MERV	(μm)	0.30-1.0	1.0-3.0	3.0-10	Airflow Rate (CFM)	615	925	1230	1540	2085*	*Max Rated Airflow
13	PSE (%)	62	87	95	Initial Resistance (IWC)	0.07	0.13	0.18	0.25	0.38	

Source: California Energy Commission

Air filters manufactured on and after July 1, 2024, are required to comply with the testing, marking, and certification requirements listed in Sections 1601-1609 of Title 20 to be sold or offered for sale in California.

All regulated products are required to be listed on the Energy Commission’s Modernized Appliance Efficiency Database System (MAEDBS), available at (https://cacertappliances.energy.ca.gov/Login.aspx) a publicly available database that contains all regulated products that may legally be sold or offered for sale in California. «»

2. **Ventilation and indoor air quality for attached dwelling units**. All attached dwelling units shall meet the requirements of ASHRAE Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Residential Buildings subject to the amendments specified in Section 160.2(b)2A below. All dwelling units shall comply with Section 160.2(b)2B below.

   Exception to Section 160.2(b)2 The following sections of ASHRAE 62.2 shall not be required for compliance: Section 4.1.1, Section 4.1.2, Section 4.1.4, Section 4.2, Section 4.3, Section 4.6, Section 5, Section 6.1.1, Section 6.1.3 and Normative Appendix A.

   A. **Amendments to ASHRAE 62.2 requirements.**

      i. **Window operation**. Window operation is not a permissible method of providing the dwelling unit ventilation airflow specified in Subsection iv or v below.

      ii. **Central fan integrated (CFI) ventilation systems**.

         a. Continuous operation prohibition. Continuous operation of a dwelling unit's central forced air system air handlers used in CFI ventilation systems is not a permissible method of providing the whole-dwelling unit ventilation airflow required by Section 160.2(b)2Aiv.

            Exception to Section 160.2(b)2Aiia: The Energy Commission may approve continuous operation of central fan integrated ventilation systems pursuant to Section 10-109(h).

         b. Outdoor air damper(s). A motorized damper(s) shall be installed on the connected ventilation duct(s) of CFI systems that prevents all airflow into or out of the space-conditioning duct system when the damper(s) is closed.

         c. Damper control. The required motorized damper(s) shall be controlled to be in an opened position when outdoor air ventilation is required for compliance, and shall be in the closed position when ventilation air is not required. The damper(s) shall be closed whenever the space-conditioning system air handling unit is not operating. If the outdoor airflow for the CFI ventilation system is fan-powered, then the outdoor air fan shall not operate when the required motorized damper(s) on the outdoor air ventilation duct(s) is closed.

         d. Variable ventilation. CFI ventilation systems shall incorporate controls that track outdoor air ventilation run time, and either open or close the required motorized damper(s) depending on whether or not outdoor air ventilation is required for compliance with Section 160.2(b)2Aiv. During periods when comfort conditioning is not called for by the space-conditioning thermostat, the CFI ventilation system controls shall operate the space-conditioning system central fan and outdoor air damper(s) when necessary to ensure compliance with the minimum outdoor air ventilation required by Section

160.2(b)2Aiv in accordance with applicable variable mechanical ventilation methods specified in ASHRAE 62.2 Section 4.5.

iii. **Air filtration.** Air filtration shall conform to the specifications in Section 160.2(b)1. Compliance with ASHRAE 62.2 Sections 6.7 (Minimum Filtration) and 6.7.1 (Filter Pressure Drop) shall not be required.

iv. **Whole-dwelling unit mechanical ventilation**. Multifamily attached dwelling units shall comply with Subsections a and b below.

a. Mechanical ventilation airflow shall be provided at rates greater than or equal to the value determined in accordance with Equation 160.2-B.

Total Required Ventilation Rate [ASHRAE 62.2:4.1.1].

$$Qtot = 0.03Afloor + 7.5(Nbr + 1) \qquad \text{(Equation 160.2-B)}$$

WHERE:

Qtot = total required ventilation rate, cfm

Afloor = dwelling-unit floor area, ft^2

Nbr = number of bedrooms (not to be less than 1)

b. All dwelling units in a multifamily building shall use the same whole-dwelling unit ventilation system type. The dwelling unit shall comply with Subsections 1 and 2 below.

1. **Balanced or supply ventilation**. A balanced or supply ventilation system shall provide the required whole-dwelling-unit ventilation airflow. Balanced systems with heat recovery or energy recovery that serve a single dwelling unit shall have a fan efficacy of ≤1.0 W/cfm; and

2. **Compartmentalization Testing**. The air leakage rate shall not exceed 0.3 cubic feet per minute at 50 Pa (0.2 inch water) per ft^2 of dwelling unit envelope surface area as confirmed by ECC-rater field verification and diagnostic testing in accordance with the procedures specified in Reference Appendix RA3.8 or NA2.3 as applicable. In multifamily buildings with four or more habitable stories, the field verification and diagnostic testing which requires an ECC-Rater may alternatively be performed by a certified Mechanical Acceptance Test Technician according to the requirements specified in Reference Appendix NA1.9.

«» Commentary for Section 160.2(b)2A:

Whole Dwelling Unit Mechanical Ventilation

As an overview of dwelling unit ventilation requirements, dwelling units must have whole dwelling unit mechanical ventilation to provide outdoor air to the unit for dilution of contaminants, for which Section 160.2(b)2Ai through 160.2(b)2Av include requirements. There are also requirements for local mechanical exhaust for spot ventilation to remove polluted air generated within the unit from kitchens, bathrooms, and clothes dryers before the polluted air mixes with other air in the unit, which are specified in 160.2(b)2Avi. While the Standard allows the use of Central fan integrated (CFI) ventilation systems, it prohibits inefficient systems, including those that continuously operate the central forced air system for ventilation air.

Dwelling Unit Ventilation Strategies

This section provides typical strategies for providing outdoor air for whole-dwelling unit ventilation.

There are generally two system types available for meeting the mandatory whole-dwelling unit ventilation requirements:

1. When supply ventilation is used, filtered outdoor air is supplied directly to the dwelling unit.
2. When balanced ventilation is used, a combination of exhaust and supply in which air is exhausted from a dwelling unit and filtered outdoor air is supplied directly to the dwelling unit at the same rate (within 20%).

For the mandatory requirements of the Energy Code, Section 160.2(b)2Aivb requires the whole-dwelling unit ventilation system to either be a balanced system or a supply system. Exhaust-only ventilation is prohibited for new construction multifamily units, because it may not meet the minimum outdoor airflow rates for ventilation. In an exhaust-only system, air is drawn from the dwelling unit and exhausted to the outdoors, and air from outside the dwelling unit enters through infiltration, which includes both outdoor air and air from adjacent spaces (e.g., corridor, adjacent units) and may be polluted. Because exhaust-only ventilation systems may not meet the minimum outdoor air ventilation rates in multifamily units, they are prohibited in new construction. However, local exhaust systems can be used in existing dwelling units, to meet local exhaust requirements such as in bathrooms, kitchens, and dryers. Exhaust fans can be used as a part of a balanced ventilation system.

Natural ventilation does not satisfy requirements for dwelling unit ventilation. All dwelling unit ventilation systems need to have a mechanical fan.

Multifamily projects can use either of the following strategies to provide supply or balanced ventilation:

1. Unitary ventilation system, in which each dwelling unit has its own ventilation system. These are often simpler designs and use packaged equipment, but present more systems to maintain, may require maintenance by the resident (or at least their cooperation to provide access), and can require more wall penetrations.
2. Central ventilation systems, in which a centrally located (typically rooftop) fan and centralized ductwork serves multiple dwelling units. These can streamline maintenance and reduce exterior wall penetrations. For energy recovery ventilation (ERV) and heat recovery ventilation (HRV) systems, centralized equipment provides economies of scale for features such as bypass, which provides significant energy savings during the cooling season. However, centralized ventilation systems reduce the occupiable square footage in a building and can increase penetrations between units, which should be sealed for indoor air quality (IAQ) concerns.

This section provides more detail on each of these strategies.

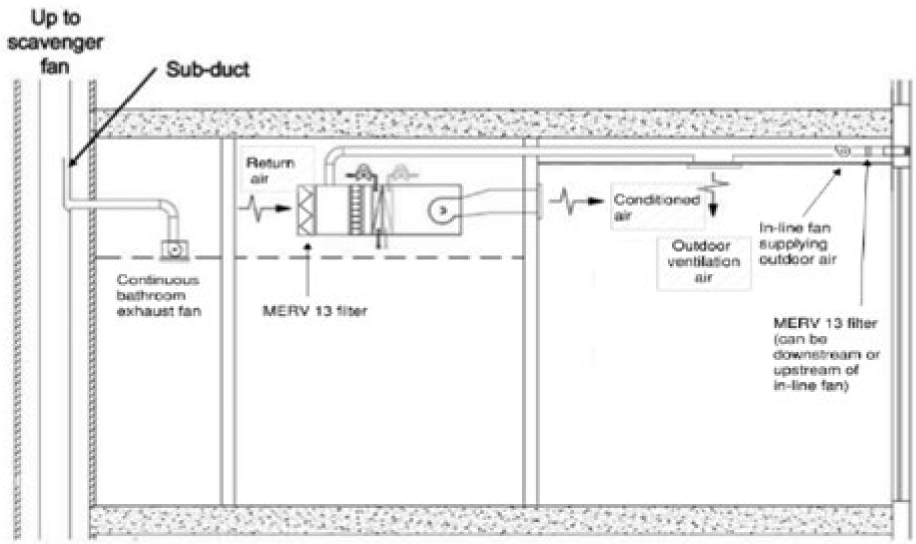
Supply Ventilation

Supply ventilation systems draw outdoor air into the unit using a dedicated supply fan. Indoor air escapes through leaks in the building envelope (exfiltration) and local mechanical exhaust such as range hood fans or bathroom fans. Space conditioning system air handling units cannot be used to provide supply ventilation, unless they meet the Central Fan-Integrated Ventilation approach described below.

Continuously operating ventilation fans must meet mandatory sound requirement of one sone or less. For larger dwelling units, more than one fan may be used. Remotely located fans (fans mounted outside habitable space, bathrooms, toilets, and hallways) are exempt from the sound requirements if there is at least four feet of ductwork between the fan and the interior grille.

Section 160.2(b)1 requires that outside air be filtered using MERV 13 (or greater) particle removal efficiency rated air filters. The filters must be accessible to facilitate replacement. Supply systems may locate the MERV 13 air filter either upstream or downstream of the fan as long as the incoming outdoor air is filtered prior to delivery to the dwelling unit’s occupiable space. An example of MERV 13 filter placement in air handling units is shown in Figure 4-5: MERV 13 Locations for Ventilation and Space Conditioning Air Handler Unit in Example Scenario. Fans may be located in dropped ceiling spaces, mechanical closets, or other spaces dedicated for installation of mechanical equipment. As required in Section 10-103(b), builders must provide information to building operators and occupants for the operation of any equipment that requires filter replacement.

Figure 4-5: MERV 13 Locations for Ventilation and Space Conditioning Air Handler Unit in Example Scenario



Source: California Energy Commission

The outdoor air inlet should be located to avoid areas with contaminants such as smoke produced in barbeque areas, products of combustion emitted from gas appliance vents, and vehicle emissions from parking lots or garages. Air may not be drawn from attics or crawlspaces.

To minimize drafts and optimize distribution, supply air can be ducted directly to bedrooms and living areas using an appropriately sized and sealed ventilation- only duct system or by connecting to the HVAC supply plenum. However, distribution of supply air is best practice but not required.

Balanced Ventilation

Balanced systems use an exhaust fan and a supply fan to move approximately the same volume of air into and out of the dwelling. To be considered a balanced ventilation system, the total supply airflow and the total exhaust airflow must be within 20 percent of each other. Specifics on measuring airflows to determine compliance are found in RA3.7.4.1.2. Balanced ventilation may be a single packaged unit containing supply and exhaust fans that moves approximately the same airflow, or it may use separate fans. In both cases, air supplied from outdoors must be filtered. (See Section 160.2(b) for dwelling unit air filter requirements.)

Balanced ventilation can incorporate HRV or ERV systems. HRV and ERV systems temper incoming air with outgoing air, which reduces the thermal effect of ventilation on heating and cooling loads. However, the dual fans increase electrical energy use. Heat recovery is required in certain climate zones under the prescriptive path.

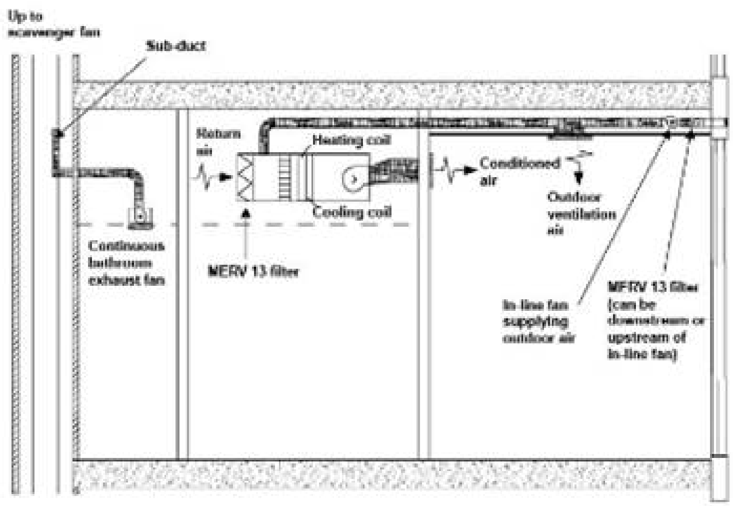
Like supply ventilation systems, balanced systems are required to be equipped with MERV 13 or better filters to remove particles from the intake airflow prior to delivery to the dwelling unit’s occupiable space per Section 160.2(b)1. Balanced systems must comply with the same minimum separation distance between intake and exhaust (and other sources of contaminants) as supply-ventilation systems. Air may not be drawn from attics or crawlspaces.

Balanced ventilation systems may be either unitary or central systems. Examples of unitary and central balanced systems are provided below.

Unitary Balanced Ventilation

An example of a balanced ventilation system which couples a continuous exhaust fan with an in-line fan that directly supplies outdoor air is shown in Figure 4-6: Example of Balanced Ventilation Without Heat Recovery: Discrete Supply In-Line Fan with Continuous Bath Exhaust.

Figure 4-6: Example of Balanced Ventilation Without Heat Recovery: Discrete Supply In-Line Fan with Continuous Bath Exhaust



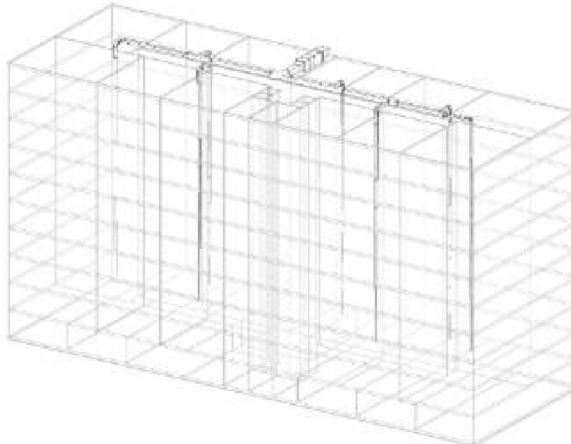
Source: California Energy Commission

Strategies other than an inline fan for providing outdoor air include packaged terminal unit (or packaged terminal air conditioning - PTAC) or supply fans.

Central Balanced Ventilation

A central balanced ventilation system provides supply-air to and exhaust air from multiple dwelling units. A central balanced ventilation approach could use a dedicated outdoor air system (DOAS) for supplying outdoor air to units and unitary bathroom exhaust. Figure 4-7: Dedicated Outdoor Air System (DOAS) for Supplying Fresh Air to Dwelling Units shows an example schematic of DOAS; note, the unitary bathroom exhaust is not shown. Because the building in this diagram assumes that the bottom floor is commercial space, the system does not serve this floor.

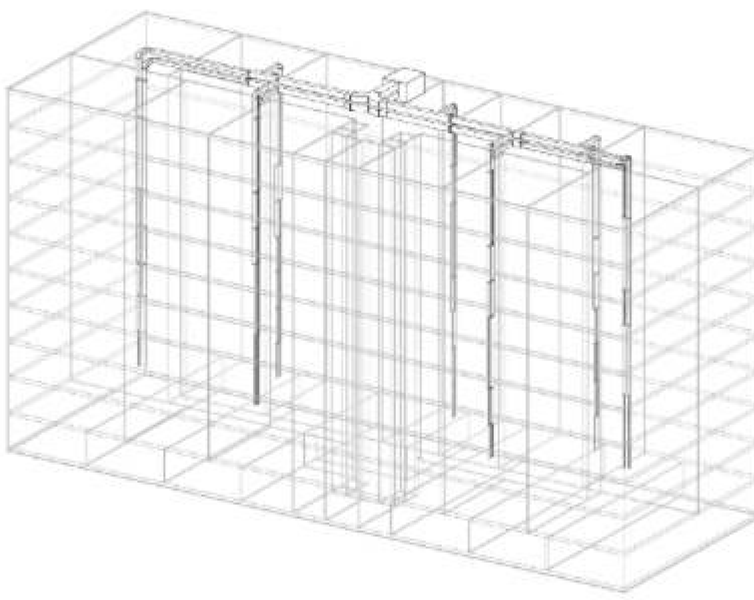
Figure 4-7: Dedicated Outdoor Air System (DOAS) for Supplying Fresh Air to Dwelling Units



Source: California Energy Commission

Alternatively, balanced ventilation could be provided by a rooftop HRV or ERV systems. For the prescriptive path in climate zones 1, 2, 4, 11 – 14 and 16, the Energy Code requires that a central HRV or ERV systems include a bypass or free cooling function that enables the HRV or ERV systems to bring in fresh air from the outdoors. This function allows incoming air to bypass the heat or energy recovery component when the enthalpy of the outdoor air is within certain temperature and relative humidity limits.

Figure 4-8: Central Balanced Ventilation Strategies: DOAS and Central ERV



Source: California Energy Commission

As shown in the figures above, each rooftop supply fan, HRV system, or ERV system would connect (via rooftop ductwork) to vertical shafts. In the example, six vertical shafts serve two dwelling unit from each floor, and one vertical shaft serves one dwelling unit per floor. While not shown in the figure for simplicity, each shaft would need a short horizontal run-out to the dwelling units on each floor and fire smoke dampers (FSDs) at the entry of this duct to the dwelling unit.

Alternatively, central ERV or HRV systems could be located throughout the building (such as one on each floor or for each wing) and serve a cluster of units.

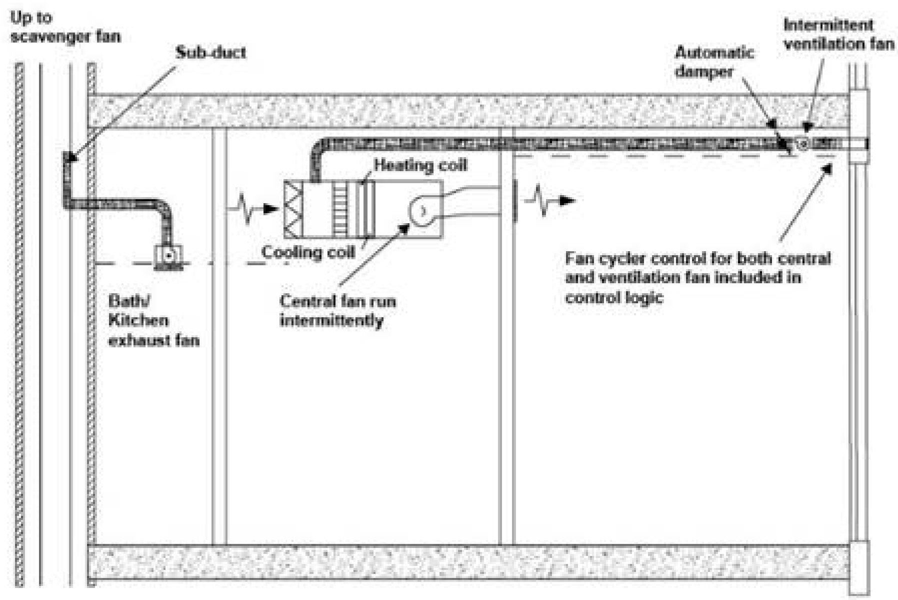
Central Fan-Integrated Ventilation

A CFI ventilation system is a configuration where the ventilation ductwork is connected to the space conditioning duct system, to enable distribution of ventilation air to the dwelling unit when the space conditioning system air handler is operating. This strategy mixes the outdoor air with the large volume of return air from the dwelling unit before being distributed. CFI ventilation systems consume a relatively high amount of energy compared to the other ventilation types because it uses the air handler fan. The Energy Code includes the following requirements specific to CFI ventilation systems:

1. Continuous Operation is Prohibited – The continuous operation of a space conditioning air handler is prohibited in providing whole-dwelling unit ventilation.
2. Outdoor Air Damper(s) – A motorized damper must be installed on any ventilation duct that connects outdoor air to the space conditioning duct system and must prevent airflow into or out of the space conditioning duct system when the damper is in the closed position.
3. Damper Control – The outdoor air damper must be controlled to be in the open position only when outdoor air is required for whole-dwelling unit ventilation and must be in the closed position when outdoor air is not required. The damper must be in the closed position when the air handler is not operating. If the outdoor airflow is fan-powered, then the outdoor air fan must not operate when the outdoor air damper is in the closed position.

Variable Ventilation Control – CFI ventilation systems must have controls that track outdoor air ventilation run time, and open or close the motorized damper depending on whether the required whole-dwelling unit ventilation airflow rate is being met. During periods when space conditioning is not called for by the space conditioning thermostat, the controls must operate the air handler fan and the outdoor air damper(s) when necessary to ensure the required whole-dwelling unit ventilation airflow rate is met. This control strategy must be in accordance with ASHRAE 62.2 section 4.5 which requires controls to operate the fan at least once every three hours, and the average whole-dwelling unit ventilation airflow rate over any 3-hour period must be greater than or equal to the required whole-dwelling unit ventilation airflow rate.

Figure 4-9: Example of Central Fan-Integrated (CFI) Ventilation with MERV 13 Filtration



Source: California Energy Commission

Section 160.2(b)1 requires that outside air be filtered using minimum MERV 13 particle removal efficiency rated air filters. Filters must be accessible to simplify replacement. For CFI systems, the filters must be installed upstream of the cooling or heating coil; thus, the filter rack provided at the inlet to the air handler may be used. In this case, it is not necessary to provide another MERV 13 or greater filter within the outdoor air duct. Otherwise, filters must be provided at the return grill(s) for the central fan, and another filter must be provided in the outside air ductwork before the point the outside air enters the return plenum of the central fan.

For a CFI ventilation system, both the central forced-air system fan total airflow and the much smaller outdoor ventilation airflow rate must be verified by an Energy Code Compliance (ECC)-Rater.

CFI ventilation systems, devices, and controls may be approved for use for compliance with the ECC field verification requirements for whole-dwelling unit mechanical ventilation in accordance with RA3.7.4.2. CFI ventilation systems are considered intermittent mechanical ventilation systems and must be certified to the Energy Commission that the CFI ventilation system will meet the minimum whole-dwelling unit ventilation requirements.

A listing of certified CFI ventilation systems is posted at the Energy Commission webpage, https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment/int-mech-ventilation.

Because CFI ventilation systems can use a large amount of electricity annually compared to other ventilation system types, the air handlers used in CFI ventilation systems are required to meet the fan watt draw requirements given in Section 150.0(m)13B in all climate zones.

Outside Air Intake Location Requirements

Projects using balanced or supply ventilation systems must meet the outdoor air (OA) intake requirements in the California Mechanical Code (CMC). CMC Section 405.2 allows ASHRAE 62.1-2022 Normative Appendix B to be used to calculate a minimum separation distance specific to the project instead of these default values. For multifamily projects using unitary ventilation (i.e., one ventilation system per dwelling unit), this calculation typically results in a shorter separation than the default separation distances for Class 2 air (10 ft) or Class 3 air (15 ft), as described below.

ASHRAE 62.1-2022 Normative Appendix B stipulates the following equation for the minimum separation distance (L) between an OA intake and exhaust air outlets described in ASHRAE 62.1: B-1.

$$L = 0.09 \times Q^{0.5} \times (\sqrt{DF} - \frac{U}{400})$$

Where,

1. L = minimum separation distance in feet
2. Q = exhaust airflow (cfm)
3. DF = dilution factor. For Class 3 air, DF = 15. ASHRAE 62.1 does not specify a DF for Class 2 air, but the engineering standard of care would be to use the same DF as what is specified for Class 3: DF = 15.
4. U = Exhaust air discharge velocity modifier. For exhaust that is capped or that is not directed towards the OA intake, U is zero (or positive, if directed away from the OA intake). See Table B-2 in Standard 62.1-2022 for more detail for determining U.

Dwelling Unit Compartmentalization, Adjacent Spaces and Transfer Air

Compartmentalization (i.e., sealing of the dwelling unit air barrier) is important for maintaining the indoor air quality of multifamily dwelling units because it limits transfer air. Compartmentalization reduces exposure to gaseous pollutants, and noise transfer from exterior and neighboring units. Transfer air is the airflow between adjacent dwelling units or between a dwelling unit and other nearby spaces (e.g., garage or crawlspace) in a multifamily building, that can contribute to poor IAQ in the dwelling units. Transfer airflow is caused by differences in pressure between adjacent spaces that force air to flow through leaks in the dwelling unit enclosure. The pressure differences may be due to stack effects (hot air rising in taller buildings when outside air temperature is low, leading to air pressing upward and exiting the building through upper floors), wind effects, unbalanced mechanical ventilation, and other reasons. Compartmentalization minimizes leaks in all the dwelling enclosures in the building to prevent pollutants such as tobacco smoke, pollution generated from food preparation in the kitchen, odors, and other pollutants from being transferred between adjacent dwellings and other spaces in the building. Drawing ventilation air from the garage could introduce carbon monoxide or volatile organic compounds into the indoor air. Drawing ventilation air from an unconditioned crawlspace could cause elevated allergen concentrations in the dwelling. In addition to maintaining good IAQ, compartmentalization provides energy benefits, by reducing leakage of conditioned air to the exterior. The reduction in indoor air losses means less makeup air needs to be conditioned to replace the lost condition air.

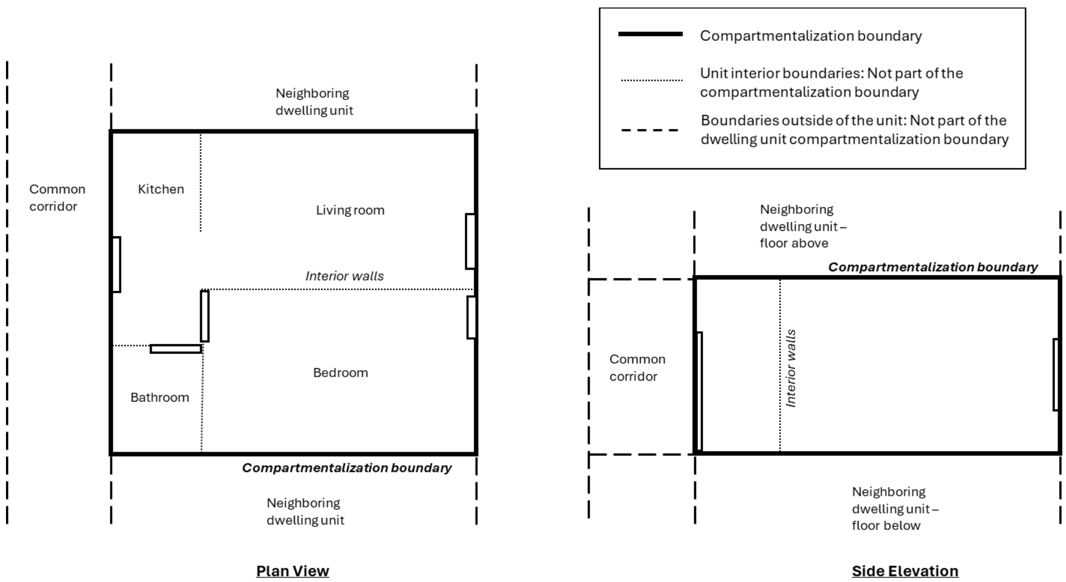
The 2025 Energy Code in Section 160.2(b)2Aiv requires that each dwelling unit be compartmentalized such that the dwelling unit leakage is not greater than 0.3 CFM per sq. ft of dwelling unit enclosure area as verified using a blower door test. The procedure for a compartmentalization blower door test is described in RA3.8 (blower door test for multifamily buildings with up to three habitable stories) and NA2.3 (blower door test for multifamily buildings with four or more habitable stories). When reporting dwelling unit leakage for compartmentalization blower door testing, whole dwelling unit enclosure surface area should be recorded and used. Whole dwelling unit enclosure surface area (to be included in the calculation for compartmentalization) include areas of walls, ceilings, floors shared with exterior spaces or with adjacent spaces (e.g., corridor, neighboring units) in the building. Sampling is allowed for the blower door testing, according to RA2.6 and NA1.6.

To compartmentalize the unit, project teams should seal areas that include, but are not limited to the following:

1. Vent and pipe penetrations, including those from water piping, drain waste and vent piping
2. HVAC piping and sprinkler heads
3. Electrical penetrations, including those for receptacles, lighting, communications wiring, and smoke alarms
4. HVAC penetrations, including those for fans and for exhaust, supply, transfer, and return air ducts

In addition, project teams should seal leaks and gaps in the dwelling-unit air barrier, including but not limited to the intersections of baseboard trim and floor, the intersections of walls and ceilings, around window trim and dwelling-unit doors, and the termination points of internal chases in attics, between floors, and crawlspaces.

Figure 4-10: Example of compartmentalization boundary in a common-entry multifamily dwelling unit – plan view and side elevation



Source: California Energy Commission

The requirements for balanced or supply ventilation works hand-in-hand with the requirement for compartmentalization; the first ensures that outdoor air is provided at the required rates, and the second reduces pollutant transfer between dwelling units. Similarly, the loss of conditioned air to the outside environment is reduced.«»

v. **Multifamily building central ventilation system airflow rate tolerance.** Multifamily building central ventilation systems that serve multiple dwelling units shall have airflow rates in each dwelling unit served that meet or exceed a design ventilation airflow rate specification.

   a. Designers shall specify a design ventilation airflow rate for each dwelling unit that is equal to or greater than the rate specified by Equation 160.2-B.

   b. The design ventilation airflow rate for each dwelling unit shall be stated on the building design plans approved by the enforcement agency.

   c. Airflow in each dwelling unit shall be no more than twenty percent greater than the specified design ventilation airflow rate. Ventilation systems shall utilize mechanical or software airflow control means to ensure each of the dwelling-unit airflows can be maintained at the design ventilation airflow within this tolerance at all times. System airflow control-means may include but are not limited to constant air regulation devices, orifice plates and variable speed central fans.

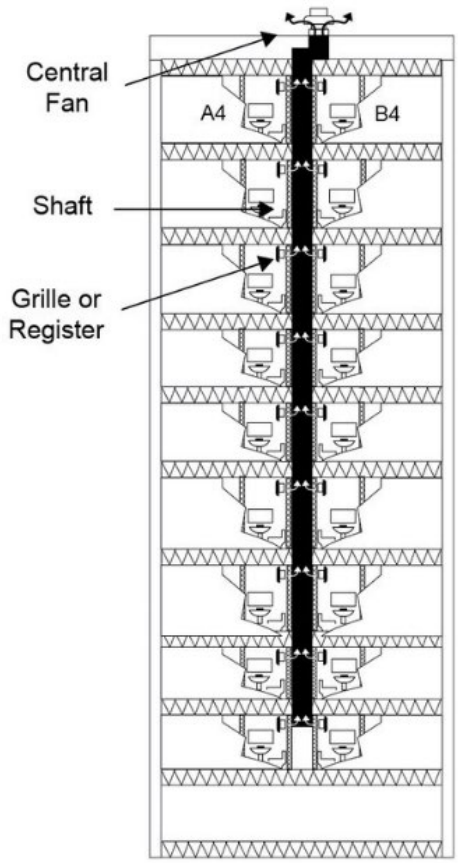
Commentary for Section 160.2(b)2Av:

Requirements for Multifamily building central ventilation system airflow tolerance

Central ventilation systems serving multiple dwelling units are sometimes used, particularly in tall buildings, to provide supply air (such as in a dedicated outdoor air system [DOAS] system), local exhaust, or balanced ventilation (such as a central ERV or HRV systems). These systems reduce the number of fans that must be maintained and the number of envelope penetrations for supply intakes or exhaust discharges.

The central ventilation system is typically comprised of a central fan (often located at the rooftop), a central ventilation duct (shaft) that runs between floors, horizontal branches to connect the dwelling units to the shaft, and in-unit connection points such as grilles to deliver (for supply) or remove (for exhaust) air from each dwelling unit. Figure 4-11: Diagram of Central Exhaust Ventilation Duct System Components illustrates an example with no horizontal branches.

Figure 4-11: Diagram of Central Exhaust Ventilation Duct System Components



Source: Center for Energy and Environment 2016

The intent of this requirement is to ensure that each dwelling unit meets minimum ventilation airflow rates for IAQ, but does not exceed that rate by more than twenty percent for energy conservation reasons. Requirements ensure that ventilation significantly greater than what is designed for does not occur, reducing the amount of conditioned air ventilated outside. These systems must use balancing devices to ensure the dwelling-unit airflows can be adjusted to meet this balancing requirement. These system balancing devices may include, but are not limited to, constant air-regulation devices (often referred to as "CAR dampers"), orifice plates, and variable-speed central fans.

The specified rate for the systems that share a common fan/shaft may be the minimum rate required for compliance, in which case each of the dwellings receiving airflow from a common fan/shaft must have ventilation airflow no more than 20% greater than the minimum dwelling unit ventilation airflow required. If the lowest airflow provided to any of the dwellings served by the common fan/shaft is a specific percent value greater than the minimum required for compliance, then each of the dwellings receiving airflow from that common fan/shaft must have ventilation airflow no more than 20% greater than that lowest dwelling unit ventilation airflow. For example, if the lowest ventilation airflow among all dwellings served by the common fan/shaft is 2% greater than the minimum required for compliance, then all dwellings served by the common fan/shaft must be balanced to have ventilation airflow that is no more than 22% greater than the minimum ventilation airflow required for compliance. **«»**

vi. **Local mechanical exhaust.** A local mechanical exhaust system shall be installed in each kitchen and bathroom. Systems shall be rated for airflow in accordance with ASHRAE 62.2 Section 7.1.

a. **Nonenclosed kitchens** shall have a demand-controlled mechanical exhaust system meeting the requirements of Section 160.2(b)2Avic.

b. **Enclosed kitchens and all bathrooms** shall have either one of the following options 1 or 2:

1. A demand-controlled mechanical exhaust system meeting the requirements of Section 160.2(b)2Avic; or

2. A continuous mechanical exhaust system meeting the requirements of Section 160.2(b)2Avid.

c. **Demand-controlled mechanical exhaust.** A local mechanical exhaust system shall be designed to be operated as needed.

1. **Control and operation.** Demand-controlled mechanical exhaust systems shall be provided with at least one of the following controls:

A. A readily accessible occupant-controlled ON-OFF control.

B. An automatic control that does not impede occupant ON control.

2. **Ventilation rate and capture efficiency.** The system shall meet or exceed either the minimum airflow in accordance with Table 160.2-E or the minimum capture efficiency in accordance with Table 160.2-E, and Table 160.2-G. Capture efficiency ratings shall be determined in accordance with ASTM E3087, and listed in a product directory approved by the Energy Commission.

«» Commentary for Section 160.2(b)2Avi:

Requirements for Kitchen Exhaust

Kitchen exhaust is important to remove pollution created during cooking processes, including fine particles ($PM_{2.5}$) and relative humidity; combustion gases such as nitrogen dioxide (NO_2) and carbon monoxide (CO) from natural gas and propane-fueled cooktops and ovens; and odors. One option for removing pollutants generated from cooking is to use a vented kitchen range hood, which removes pollutants above the cooking surface before they mix with the air in the rest of the home. The Energy Code incorporates a metric for local exhaust called capture efficiency. Capture efficiency is determined in accordance with ASTM E3087 as the fraction of emitted tracer gas that is directly exhausted by a range hood.

The Energy Code allows different options for kitchen exhaust including intermittent (typically demand-controlled) range hoods, a continuously operating fan in the kitchen, or a downdraft fan. For the demand-controlled option, the Energy Code allows the traditional airflow (in cubic feet per minute, or CFM) path for compliance or a capture efficiency path.

Under the Energy Code, dwelling units can use any one of the following options for kitchen exhaust:

1. A demand-controlled, vented range hood with at least one setting with a capture efficiency (CE) that meets or exceeds the values shown in Table 4-3: Kitchen Range Hood Airflow Rates (CFM) and ASTM E3087 Capture Efficiency (CE) Ratings According to Dwelling Unit Floor Area and Kitchen Range Fuel Type.
2. A demand-controlled, vented range hood with an airflow that meets or exceeds the exhaust rates shown in Table 4-3: Kitchen Range Hood Airflow Rates (CFM) and ASTM E3087 Capture Efficiency (CE) Ratings According to Dwelling Unit Floor Area and Kitchen Range Fuel Type.
3. A demand-controlled, vented downdraft kitchen exhaust fan (not represented in the table below) in enclosed kitchens with a minimum airflow of 300 cfm or a capacity of 5 air changes per hour. In a nonenclosed kitchen, the fan must have a minimum airflow of 300 cfm (no air changes per hour option).
4. For enclosed kitchens only: Continuous exhaust system with a minimum airflow equal to five kitchen air changes per hour.

Table 4-3: Kitchen Range Hood Airflow Rates (CFM) and ASTM E3087 Capture Efficiency (CE) Ratings According to Dwelling Unit Floor Area and Kitchen Range Fuel Type

Dwelling Unit Floor Area (sq. ft)	Hood Over Electric Range	Hood Over Natural Gas Range
>1500	50% CE or 110 CFM	70% CE or 180 CFM
>1000 - 1500	50% CE or 110 CFM	80% CE or 250 CFM
750-1000	55% CE or 130 CFM	85% CE or 280 CFM
<750	65% CE or 160 CFM	85% CE or 280 CFM

Source: from Table 160.2-G in the Energy Code

The minimum capture efficiency or airflow requirement for the range hood is the minimum required to adequately capture the moisture, particulates, and other products of cooking and/or combustion. While many products do not have published capture efficiency results as of the time of the publication of this manual, the captur efficiency path is intended to be a forward-looking approach and will support future listings.

While capture efficiency is the metric that directly measures pollutant removal, the airflow path (Option 2) is provided because capture efficiency generally increases with airflow, and the HVI and AHAM databases list airflow for kitchen exhaust appliances. ASHRAE Standard 62.2 includes a similar path as Option 2, but with lower required airflows (minimum 100 CFM). Because there is less air available for dilution in small dwelling units, the Energy Code set higher minimum requirements for smaller dwelling units. Because gas ranges emit NO2 and CO, in addition to the PM2.5 released from cooking processes, the capture efficiency and airflow requirements are higher for hoods over gas ranges.

The vented downdraft compliance option (Option 3) and continuous kitchen exhaust option (Option 4) are taken directly from ASHRAE Standard 62.2. The definition of an "enclosed kitchen", which must be met to use continuous kitchen exhaust, is also taken from ASHRAE Standard 62.2, and is defined as "permanent openings to interior adjacent spaces do not exceed a total of 60 square feet". Only in enclosed kitchens, the exhaust requirement can also be met with either a ceiling or wall-mounted exhaust fan or with a ducted fan or ducted ventilation system that can provide at least five air changes of the kitchen volume per hour.

Recirculating range hoods that do not exhaust pollutants to the outside cannot be used to meet the Energy Code requirements, unless paired with an exhaust system exhausting to the outside that can provide at least one of the following:

1. Continuous operation in an enclosed kitchen providing five air changes of the kitchen volume per hour, or
2. Demand-controlled operation in an enclosed or unenclosed kitchen providing at least 300 cfm of exhaust.

Generally, HRV/ERV manufacturers do not recommend that kitchen exhaust pass through HRV or ERV equipment, because the heat, moisture, grease, and particulates could damage heat exchange core.

The Energy Code does not explicitly specify a static pressure at which range hoods should be measured for airflow. However, the Energy Code requires that range hoods be listed in the HVI or AHAM product directories, and both of those directories list range hood airflows at 0.1" w.c. (and some at 0.25" w.c.), since 0.1" is the basic rating point for range hoods in HVI Standard 920. Note that some product airflows are listed at working-speed at lower static pressures, but working-speed airflows can only be used for compliance with the sound requirement, not airflow requirement. «»

d. **Continuous mechanical exhaust.** A mechanical exhaust system shall be installed to operate continuously. The system may be part of a balanced mechanical ventilation system.

   1. **Control and operation**. A manual ON-OFF control shall be provided for each continuous mechanical exhaust system. The system shall be designed to operate during all occupiable hours. For multifamily dwelling units, the manual ON-OFF control may be accessible to the dwelling unit

occupant; however, the manual ON-OFF control shall not be required to be accessible to the dwelling unit occupant.

2. **Ventilation rate.** The minimum delivered ventilation shall be at least the amount indicated in Table 160.2-F during each hour of operation.

«» Commentary for Section 160.2(b)2Avid:

Dwelling unit ventilation systems may operate continuously or on a short-term basis. If fan operation is not continuous, the average ventilation rate over any three-hour period must be greater than or equal to the ventilation rate calculated using Equation 160.2-B.

The Energy Code allows for scheduled ventilation and real-time control. A control method must be chosen so that the relative exposure does not exceed specified peak and average relative exposure limits of ASHRAE Standard 62.2. Normative Appendix C provides direction on calculating the relative exposure and provides standardized calculations for complex ventilation controls implemented by use of digital controls that rely on the manufacturer's product-specific algorithms or software. Users installing any type of intermittent ventilation control system (scheduled or real-time) must submit an application to the Energy Commission to have the control approved. The manufacturers must provide documentation that the system will perform to provide the required whole-dwelling unit mechanical ventilation. Listings of systems approved by the Energy Commission and certified by the manufacturer are located at the following link: www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment-6.

While dwelling unit ventilation systems should operate (i.e., be in the ON position) in almost all circumstances, the Energy Code requires a manual ON-OFF control, with the purpose of allowing occupants or staff to temporarily turn off the system for extreme events, such as during wildfires. The dwelling unit ventilation system dilutes pollutants that can worsen IAQ such as particulate matter; combustion gases due to imperfect exhaust systems; volatile organic compounds from personal care products, dry cleaning, and other sources; and other pollutants. The dwelling unit ventilation system also reduces relative humidity, which can cause mold or damage the building.

In alignment with ASHRAE Standard 62.2, while the Energy Code requires that the manual ON-OFF control be accessible to the occupants in single-family units, there is an exception for multifamily units; it is not required to be readily accessible to the dwelling unit occupants. For multifamily buildings, manual ON-OFF control may be accessible to occupants or only to building maintenance staff. The control strategy where it is only accessible to maintenance staff may be appropriate for multifamily buildings that use central ventilation systems. Continuous operation of all ventilation fans in the building tends to minimize ventilation fan-induced pressure differences between adjoining dwellings, thus, reducing the leakage of transfer air between dwelling units. However, designers should consider the possibility of wildfire smoke or other outdoor air pollution events that could impact the IAQ of dwelling units and ensure there is a means for occupants or maintenance staff to quickly turn off dwelling unit ventilation systems in the circumstances when these systems may inadvertently degrade IAQ. The ventilation system should be returned to the ON position after the extreme event passes. **«»**

e. **Airflow measurement of local mechanical exhaust by the system installer.** The airflow required by Section 160.2(b)2Avi is the quantity of indoor air exhausted by the ventilation system as installed in the dwelling unit. When a vented range hood utilizes a capture efficiency rating to demonstrate compliance with Section 160.2(b)2Avic2, the airflow listed in the approved directory corresponding to the compliant capture efficiency rating point shall be met by the installed system. The as-installed airflow shall be verified by the system installer to ensure compliance by use of either Subsection 1 or 2 below:

1. The system installer shall measure the airflow by using a flow hood, flow grid or other airflow measuring device at the mechanical ventilation fan's inlet terminals/grilles or outlet terminals/grilles in accordance with the procedures in Reference Appendix RA3.7 or NA2.2 as applicable.
2. As an alternative to performing an airflow measurement of the system as installed in the dwelling unit, compliance may be demonstrated by installing an exhaust fan and duct system that conforms to the specifications of Table 160.2-H. Visual inspection shall verify the installed system conforms to the requirements of Table 160.2-H.

   When using Table 160.2-H for demonstrating compliance, the airflow rating shall be greater than or equal to the value required by Section 160.2(b)2Avi at a static pressure greater than or equal to 0.25 in. of water (62.5 Pa). When a vented range hood utilizes a capture efficiency rating to demonstrate compliance with Section 160.2(b)2Avic2, a static pressure greater than or equal to 0.25 in. of water at the rating point shall not be required, and the airflow listed in the approved directory corresponding to the compliant capture efficiency rating point shall be applied to Table 160.2-H for determining compliance.

   Use of Table 160.2-H is limited to ventilation systems that conform to all of the following three specifications:

   A. Total duct length is less than or equal to 25 feet (8 m),
   B. Duct system has no more than three elbows, and
   C. Duct system has exterior termination fitting with a hydraulic diameter greater than or equal to the minimum duct diameter and not less than the hydraulic diameter of the fan outlet.

«» Commentary for Section 160.2(b)2Avie:

For local exhaust systems, there are two ways to demonstrate compliance with airflow requirements of Section 160.2(b)2Avie:

1. Test the ventilation system using an airflow measuring device after completion of the installation to confirm that the delivered ventilation airflow meets the requirement.
2. Follow a prescriptive duct sizing table. Use a fan that has a certified airflow rating that meets or exceeds the required ventilation airflow and ventilation ducts that meet the duct design requirements given in Table 160.2-H of the Energy Code. This option is limited to ventilation systems with a total duct length less than or equal to 25 ft (8m), with no more than three elbows, and has exterior termination fitting with a hydraulic diameter greater than or equal to the minimum duct diameter and not less than the hydraulic diameter of the fan outlet. This path recognizes the challenge of testing airflow, particularly from range hoods which can be irregularly shaped.

When using the duct sizing table or manufacturer's design criteria for compliance, the certified airflow rating of the fan must be based on tested performance at the 0.25 inches water column (w.c.) static pressure. The airflow rating of a fan is available from the HVI Certified Products Directory at the HVI website (www.hvi.org/hvi-certified-products-directory).

If the manufacturer's duct system design specifications are used for compliance, the enforcement agency may require that the manufacturer's published system design documentation be provided for use for inspection of the installation(s).

The duct design criteria provided in Table 160.2-H of the Energy Code identifies the minimum exhaust duct diameter based on airflow. The higher the airflow, the larger the required diameter. Smooth rigid duct can be used to reduce pressure losses for longer duct runs. Interpolation and extrapolation of Table 160.2-H of the Energy Code are not allowed. **«»**

f. **Sound ratings for local mechanical exhaust**. Local mechanical exhaust systems shall be rated for sound in accordance with Section 7.3 of ASHRAE 62.2 at no less than the minimum airflow rate required by Section 160.2(b)2Avi.

   Exception to Section 160.2(b)2Avif: Kitchen range hoods may be rated for sound at a static pressure determined at working speed as specified in HVI 916 Section 7.2.

«» Commentary for Section 160.2(b)2Avif:

Studies have shown that many occupants do not operate their demand-controlled ventilation fans because of excessive noise, or complain about continuously operating fans that are too noisy. Air-moving equipment used to meet the whole-dwelling unit ventilation requirement and the local exhaust requirement, including kitchen local mechanical exhaust, must be rated by HVI or AHAM, which provides ratings for kitchen local mechanical exhaust, for airflow and sound. The sone metric for sound accounts for both the level and frequency of the sound, since these both impact occupant comfort.

1. Whole-dwelling unit ventilation and continuously operating local exhaust fans must be rated at a maximum of 1.0 sone (measurement of sound).
2. Demand-controlled local exhaust fans must be rated at a maximum of 3.0 sone.
3. Kitchen exhaust fans must be rated at a maximum of 3.0 sone at one or more airflow settings greater than or equal to 100 CFM. (The Energy Code requires kitchen range hoods to have a higher airflow than 100 CFM, but the range hoods must be tested for sound at a minimum of 100 CFM.) Range hoods that have a minimum airflow setting exceeding 400 CFM are exempt from the sound requirement. HVI listings are available at https://www.hvi.org/hvi-certified-products-directory. AHAM listings are available at: https://www.aham.org/AHAM/What_We_Do/Kitchen_Range_Hood_Certification.
4. Remotely located air-moving equipment (mounted outside habitable space, bathrooms, toilets, and hallways) is exempt from the sound requirements provided there is at least 4 ft. of ductwork between the fan and the interior grille. Kitchen range hoods are also exempt from the sound requirements provided they have a minimum airflow setting exceeding 400 cfm. «»

vii. **Airflow measurement of whole-dwelling unit ventilation**. The airflow required by Section 160.2(b)2Aiv or 160.2(b)2Av is the quantity of outdoor ventilation air supplied or indoor air exhausted by the mechanical ventilation system as installed and shall be measured by using a flow hood, flow grid or other airflow measuring device at the mechanical ventilation fan's inlet terminals/grilles or outlet terminals/grilles in accordance with the procedures in Reference Appendix Section RA3.7.4.1.1 or NA2.2.4.1.1 as applicable for supply and exhaust systems or RA3.7.4.1.2 or NA2.2.4.1.2 as applicable for balanced systems. Balanced mechanical ventilation system airflow shall be the average of the supply fan and exhaust fan flows.

«» Commentary for Section 160.2(b)2Avii:

Section 160.2(b)2Avii requires airflow measurement of the whole-dwelling unit ventilation system. The purpose is to ensure that the specified ventilation rate is delivered to the unit.

All whole-dwelling unit ventilation systems must demonstrate compliance by direct airflow measurement using a flow hood (such as shown in Figure 4-12: System Airflow Rate Measurement Using Flow Capture Equipment), flow grid, or other approved measuring device. ECC verification of whole-dwelling unit ventilation airflow is required for newly constructed buildings and existing buildings with additions greater than 1,000 sq. ft or an increase in the number of dwelling units.

Residential Appendix RA3.7.4 (for multifamily buildings up to three habitable stories) and Nonresidential Appendix NA2.2.4.1.1 (for multifamily buildings four or more habitable stories) provide guidance for measurement of supply, exhaust, and balanced system types. These measurement procedures are applicable when there is a fixed airflow rate required for compliance, such as for systems that operate continuously at a specific airflow rate or systems that operate intermittently at a fixed speed (averaged over any three-hour period), according to a fixed programmed pattern that is verifiable by a ECC-Rater on site. (Refer to ASHRAE Standard 62.2 Section 4.5.1 Short Term Average Ventilation.)

For exhaust-only systems, measurement of the whole-dwelling unit ventilation airflow should be done by measuring airflow of the exhaust fan(s). While this approach will over-represent the airflow from the outdoors, it is difficult to determine the fraction of the infiltration from the outdoors versus adjacent spaces in the building.

For whole-dwelling unit ventilation systems that use scheduled ventilation or real-time controls, the Energy Commission may consider the ventilation system for approval, if the manufacturer provides a method that can be used by a ECC-Rater or Acceptance Test Technician (ATT) to verify that an installed system is operating as designed. Figure 4-12: System Airflow Rate Measurement Using Flow Capture Equipment shows examples of an airflow rate measuring device.

Figure 4-12: System Airflow Rate Measurement Using Flow Capture Equipment

Source: California Statewide CASE Team

«»

viii. **Sound ratings for whole-dwelling unit ventilation systems.** Whole-dwelling unit ventilation systems shall be rated for sound in accordance with Section 7.3 of ASHRAE 62.2 at no less than the minimum airflow rate required by Section 160.2(b)2Aiv or 160.2(b)2Av as applicable.

«» Commentary for Section 160.2(b)2Aviii:

Whole-dwelling unit ventilation and continuously operating local exhaust fans must be rated at a maximum of 1.0 sone (measurement of sound). This is to reduce discomfort from continuously operating fans that are excessively noisy, causing occupant discomfort. However, the equipment must also meet requirements in Section 160.2(b)2Aiv or 160.2(b)2Av to reduce excess ventilation.«»

ix. **Label for whole-dwelling unit ventilation system on-off control**. Compliance with ASHRAE 62.2 Section 4.4 (Control and Operation) shall require manual ON-OFF control switches associated with whole-dwelling unit ventilation systems to have a label clearly displaying the following text, or equivalent text: "This switch controls the indoor air quality ventilation for the home. Leave switch in the 'on' position at all times unless the outdoor air quality is very poor."

«» Commentary for Section 160.2(b)2Aix:

As noted above, Section 160.2(b)2Avic1 and Section 160.2(b)2Avid1 require a readily accessible manual ON-OFF control, except in multifamily buildings. The requirement for a label is so that controls include text or an icon indicating the system's function by stating that the switch controls the indoor air quality and ventilation for the home and that the switch must always be 'on' unless outdoor air quality is very poor. The purpose of the label is to educate the occupants and building manager so they will be more likely to keep the ventilation system running during typical conditions, and turn it back on if it is temporarily turned off due to wildfires or other events. «»

x. **Combustion air and compensating outdoor air or makeup air.**

a. All dwelling units shall conform to the applicable requirements specified in California Mechanical Code Chapter 7, Combustion Air.

b. All dwelling units shall conform to the requirements in ASHRAE 62.2 Section 6.4, Combustion and Solid-Fuel-Burning Appliances.

xi. Balanced and supply ventilation component accessibility. Balanced and supply ventilation systems shall meet the following requirements for accessibility:

a. IAQ filter and HRV/ERV accessibility. System air filters and HRV/ERV heat/energy recovery cores shall be located such that they are accessible for service from within occupiable spaces, basements, garages, balconies, mechanical closets or accessible rooftops. Filters and heat/energy recovery cores behind access panels, access doors, or grilles located no more than 10 feet above a walking surface inside a space specified above comply with this requirement.

Exception to Section 160.2(b)2Axia: Systems that require servicing from inside the attic shall have the following:

1. A Fault Indicator Display (FID) meeting the requirements of Reference Appendix JA 17; and
2. An attic access door located in a wall or, where attic access is provided through a ceiling, an attic access hatch that includes an integrated ladder; and
3. A walkway from the attic access door to the HRV/ERV.

b. IAQ system component accessibility. Fans, motors, heat exchangers, filters and recovery cores shall meet all applicable requirements of California Mechanical Code 304.0 accessibility of service.

«» Commentary for Section 160.2(b)2Axi:

Ventilation systems need periodic maintenance, including removal of debris from intakes and replacement of filters. The intent of this requirement is to ensure that ventilation system components can be serviced easily to maintain acceptable indoor air quality and energy performance. The ventilation system components should be accessible from within the building, including occupiable spaces, basements, garages, balconies, mechanical closets or accessible rooftops. If servicing is to be done from inside an accessible attic, the system should have a Fault Indicator Display (FID). **«»**

B. **Dwelling unit field verification and diagnostic testing.**

i. The whole-dwelling unit ventilation airflow required by Section 160.2(b)2Aiv or 160.2(b)2Av shall be confirmed through field verification and diagnostic testing in accordance with Reference Appendix RA3.7.4.1.1 or NA2.2.4.1.1 as applicable for supply and exhaust systems or RA3.7.4.1.2 or NA2.2.4.1.2 as applicable for balanced systems. Balanced mechanical ventilation system airflow shall be the average of the supply fan and exhaust fan flows. Ventilation airflow of systems with multiple operating modes shall be tested in all modes designed to comply with the required ventilation airflows.

ii. **Kitchen local mechanical exhaust—vented range hoods.** Vented range hoods installed to comply with local mechanical exhaust requirements specified in Section 160.2(b)2Avi shall be field verified in accordance with Reference Appendix RA3.7.4.3 or NA2.2.4.1.4 as applicable to confirm the model is rated by HVI or AHAM to comply with the following requirements:

a. The minimum ventilation airflow rate as specified by Section 160.2(b)2Avi, or alternatively the minimum capture efficiency as specified by Section 160.2(b)2Avi; and

b. The maximum sound rating as specified in Section 160.2(b)2Avif.

«» Commentary for Section 160.2(b)2Bi-ii:

The dwelling unit ventilation airflow and the rated airflow rate for the kitchen range hood fans are required to be verified by an ECC-Rater. The dwelling unit ventilation airflow should be field tested, as described in the Commentary for Section 160.2(b)2A, and as illustrated in Figure 4-12: System Airflow Rate Measurement Using Flow Capture Equipment. To verify the range hood model, the rater shall compare the installed model to ratings in the Home Ventilating Institute (HVI) or Association of Home Appliance Manufacturers (AHAM) directory of certified ventilation products to confirm the installed range hood is rated to meet the required airflow in the Energy Code, as well as the sound requirements specified in ASHRAE Standard 62.2. See the section, Requirements for Kitchen Exhaust below for more detail.

Kitchen range hood fans that exhaust more than 400 CFM at minimum speed are exempt from the sound requirement. «»

iii. **Heat recovery ventilation (HRV) and energy recovery ventilation (ERV) system fan efficacy.** At a minimum, systems with heat or energy recovery serving a single dwelling unit shall have a fan efficacy of ≤1.0 W/cfm as confirmed by field verification in accordance with Reference Appendix RA3.7.4.4 or NA2.2.4.1.5 as applicable. If Section 170.2(c)3Biva requirements are applicable to the dwelling unit, then field verification shall instead confirm compliance with the maximum fan efficacy and minimum sensible recovery efficiency specified in Section 170.2(c)3Biva in accordance with the procedures specified in Reference Appendix RA3.7.4.4 or NA2.2.4.1.5 as applicable.

iv. In multifamily buildings with four or more habitable stories, the field verification and diagnostic testing required in Section 160.2(b)2Bi, ii and iii which requires an ECC-Rater may alternatively be performed by a certified Mechanical Acceptance Test Technician according to the requirements specified in Reference Appendix NA1.9.

«» Commentary for Section 160.2(b)2Biii-iv:

There is a mandatory requirement that all HRV and ERV systems serving a single dwelling unit must have a fan efficacy of one W/CFM or less. Under the prescriptive requirement of Section 170.2(c)3Biv, HRV and ERV systems serving individual multifamily dwelling units using balanced ventilation in climate zones 1, 2, 4, 11 – 14 and 16 must meet more stringent fan efficacy requirements of 0.6 W/CFM or less.

Fan efficacy is calculated as the Power Consumed in Watts divided by the Net Airflow in CFM. If the HVI database or other Energy Commission approved directories do not list the fan energy for the installed model or the proposed product is a large central ERV/HRV systems whose airflow rate exceeds the maximum listed in the HVI database, use information from the manufacturer's published documentation.

In multifamily buildings with four or more habitable stories, certified Mechanical ATTs may perform the field verification and diagnostic testing required in Section 160.2(b)2Bi,ii and iii according to Reference Appendix NA1.9. ATTs are not allowed to use sampling for this testing. «»

C. **Multifamily building central ventilation system field verification.**

i. **Central ventilation system duct sealing.** Ventilation ducts that conform to Subsections a and b below shall meet the duct sealing requirements in California Mechanical Code Section 603.10 and have leakage that is no greater than six percent of the rooftop fan or central fan design airflow rate as confirmed by field verification in accordance with the procedures in Reference Appendix NA7.18.3. The leakage test shall be conducted using a test pressure of 25 Pa (0.1 inches) for ducts serving six or fewer dwelling units and 50 Pa (0.2 inches) for ducts serving more than six dwelling units, and shall measure the leakage of all ductwork between the central fan and the connection point to the in-unit grille or fan.

a. The ventilation ducts serve multiple dwelling units.

b. The ventilation ducts provide continuous airflows or airflows to provide balanced ventilation to meet the requirements specified in Section 160.2(b)2Aiv or 160.2(b)2Av as applicable.

Exception to Section 160.2(b)2C: Multifamily buildings with three or fewer habitable stories in Climate Zone 6 are not required to comply with Section 160.2(b)2C.

«» Commentary for Section 160.2(b)2C:

In addition to the requirement for central ventilation system airflow tolerance limits specified in Section 160.2(b)2Av, the Energy Code includes a mandatory sealing and leakage testing requirement for central ventilation systems providing continuous airflow or an airflow to meet the balanced ventilation path in Section 160.2(b)2Aiv. The requirement saves energy. For central ventilation ducts that are excessively leaky, if the units furthest from the fan receive sufficient airflow, the units closer to the fan are overventilated. This results in wasted fan energy use, and conditioned air that is displaced from overventilation. To avoid this, the Energy Code requires sealing and testing of these ducts.

An ATT must conduct a fan pressurization test to show that central shaft leakage is no greater than 6% compared to a nominal airflow rate of the central fan at 0.2 inches water column (inch w.c.) (50 Pa) for ducts serving more than six dwelling units. For ducts serving six or fewer dwelling units, the maximum leakage is the same, but the test must be conducted at 0.1 inches w.c. (25 Pa), since these systems typically have a lower operating pressure. As described in the NA1.6 procedures, sampling may be used for this duct testing requirement, and the ATT may conduct the leakage test at rough-in.

Central ventilation systems providing intermittent flows, such as demand-controlled exhaust from kitchens, bathrooms, or driers, are exempt from this testing requirement (since their operation has lower energy impacts), although careful sealing is still recommended.

The airflow, sealing, and leakage testing requirements for central ventilation ducts work in tandem to provide better control of airflow to each unit so that units are not overventilated (which would waste energy) or under-ventilated (which would degrade IAQ). **«»**

(c) Common use areas. All occupiable spaces shall comply with the requirements of Subsection 1 and shall also comply with either Subsection 2 or Subsection 3:

1. **Air filtration.**

A. Mechanical system types specified in Subsections i, ii and iii below shall be designed to ensure that all recirculated air and all outdoor air supplied to the occupiable space are filtered before passing through any system's thermal conditioning components. Air filters shall conform to the requirements of Sections 160.2(c)1B, 160.2(c)1C and 160.2(c)1D.

i. Mechanical space-conditioning systems that supply air to an occupiable space through ductwork exceeding 10 ft (3 m) in length.

ii. Mechanical supply-only ventilation systems and makeup air systems that provide outside air to an occupiable space.

iii. The supply side of mechanical balanced ventilation systems, including heat recovery ventilation systems and energy recovery ventilation systems that provide outside air to an occupiable space.

Exception to Section 160.2(c)1A: For heat recovery ventilators and energy recovery ventilators, the location of the filters required by Section 160.2(c)1A may be downstream of a system's thermal conditioning component, provided the system is equipped with ancillary filtration upstream of the system's thermal conditioning component.

«» Commentary for Section 160.2(c)1A:

Ventilation and Indoor Air Quality Requirements for Common Use Areas

Within a building, all occupied space that is normally used by humans must be continuously ventilated during occupied hours with outdoor air, using either natural or mechanical ventilation.

"Spaces normally used by humans" refers to spaces where people can be reasonably expected to remain for an extended period of time. Spaces where occupancy will be brief and intermittent that do not have any unusual sources of air contaminants do not need to be directly ventilated. For example:

1. A closet, provided it is not normally occupied
2. A storeroom that is only infrequently or briefly occupied. However, a storeroom that can be expected to be occupied for extended periods for clean-up or inventory must be ventilated, preferably with systems controlled by a local switch so that the ventilation system operates only when the space is occupied.

For common use areas, there are three types of ventilation requirements:

1. Natural ventilation where openings on the wall allow outside air to come into the building,
2. Mechanical ventilation that constantly or intermittently provide outdoor air, and
3. Mechanical exhaust for certain spaces that are expected to have contaminants with the intent of removing the polluted air.

«»

B. **Air filter efficiency**. The filters shall have a designated efficiency equal to or greater than MERV 13 when tested in accordance with ASHRAE Standard 52.2, or a particle size efficiency rating equal to or greater than 50 percent in the 0.30–1.0 μm range, and equal to or greater than 85 percent in the 1.0–3.0 μm range when tested in accordance with AHRI Standard 680; and

«» Commentary for Section 160.2(c)1B:

Occupied spaces may be subjected to poor indoor air quality if poor quality outdoor air is brought in without first being cleaned. Particles less than 2.5 μm are referred to as "fine" particles, and because of their small size, can lodge deeply into the lungs. MERV 13 filters remove the majority of fine particles. There is a strong correlation between exposure to fine particles and premature mortality. Other effects of particulate matter exposure include respiratory and cardiovascular disease. Because of these adverse health effects, advances in filtration technology and market availability, removal of fine particulate contaminants by use of filtration is reasonable and achievable. «»

C. Systems shall be equipped with air filters that meet either Subsection i or ii below.

   i. Nominal two inch minimum depth filter(s); or

   ii. Nominal one inch minimum depth filter(s) shall be allowed if the filter(s) are sized according to Equation 160.2-A, based on a maximum face velocity of 150 ft per minute.

D. Filter racks or grilles shall be gasketed or sealed to eliminate any gaps around the filter to prevent air from bypassing the filter.

2. **Natural ventilation.** Naturally ventilated spaces shall be designed in accordance with Sections 160.2(c)2A through 160.2(c)2D.

A. Floor area to be ventilated. Spaces or portions of spaces to be naturally ventilated shall be located within a distance based on the ceiling height, as specified in i, ii and iii. The ceiling height (H) to be used in i, ii or iii shall be the minimum ceiling height in the space, or for ceilings that are increasing in height as distance from the operable openings is increased, the ceiling height shall be determined as the average height of the ceiling within 20 ft from the operable opening. [ASHRAE 62.1:6.4.1.1]

   i. Single side opening. For spaces with operable opening on one side of the zone, the naturally ventilated area shall extend to a distance not greater than two times the height (H) of the ceiling from the openings. [ASHRAE 62.1:6.4.1.3]

   ii. Double side opening. For zones with openings on two opposite sides of the zone, the naturally ventilated area shall extend between the openings separated by a distance not greater than five times the height of the ceiling. [ASHRAE 62.1:6.4.1.4]

   iii. Corner opening. For zones with operable openings on two adjacent sides of a zone, the naturally ventilated area shall extend to a distance not greater than five times the height of the ceiling along a line drawn between the outside edges of the two openings that are the farthest apart. Floor area outside that line shall comply with i as having openings on only one side of the zone. [ASHRAE 62.1:6.4.1.5]

Informative Note: "Floor area outside that line" refers to the remaining area of the zone that is not bounded by the walls that have the openings and the line drawn between the openings.

iv. Ceiling height. The ceiling height (H) to be used in Sections 160.2(c)2Ai through 160.2(c)2Aiii shall be the minimum ceiling height in the space.

Exception to Section 160.2(c)2Aiv: For ceilings that are increasing in height as distance from the opening is increased, the ceiling height shall be determined as the average height of the ceiling within 20 feet from the operable openings. [ASHRAE 62.1:6.4.1.1]

B. Location and size of openings. Zones or portions of zones to be naturally ventilated shall have a permanently open airflow path to openings directly connected to the outdoors. The openable area shall be not less than 4 percent of the net occupiable floor area. Where openings are covered with louvers or otherwise obstructed, the openable area shall be based on the net free unobstructed area through the opening. Where interior rooms, or portions of rooms, without direct openings to the outdoors are ventilated through adjoining rooms, the opening between rooms shall be permanently unobstructed and have a free area of not less than 8 percent of the area of the interior room or less than 25 square feet. [ASHRAE 62.1:6.4.1.6]

C. Control and accessibility. The means to open the required operable opening shall be readily accessible to building occupants whenever the space is occupied. Controls shall be designed to coordinate operation of the natural and mechanical ventilation systems. [ASHRAE 62.1:6.4.3]

D. Naturally ventilated spaces shall also include a mechanical ventilation system designed in accordance with 160.2(c)3.

Exception 1 to Section 160.2(c)2D: Spaces not served by a space-conditioning system.

Exception 2 to Section 160.2(c)2D: Spaces where natural ventilation openings complying with 120.1(c)2 are either permanently open or have controls that prevent the openings from being closed during periods of expected occupancy.

«» Commentary for Section 160.2(c)2:

The way naturally ventilated spaces are calculated in the Energy Code aligns with ASHRAE 62.1. Under these requirements, naturally ventilated spaces or portions of spaces must be permanently open to and within certain distances of operable wall openings to the outdoors. The space being ventilated, the size of the operable opening, and the control of the opening are all considered under these new requirements. Naturally ventilated spaces must also include a mechanical ventilation system designed in accordance with Section 160.2(c)3 except when the spaces are not served by a space-conditioning system or the opening to the outdoors is permanently open or has controls that prevent the opening from being closed during periods of expected occupancy. This requirement for mechanical ventilation back-up to a naturally ventilated space protects the occupants from times or events where the outdoor air is not adequate for ventilation and does not rely on an individual to open the opening.

The space to be naturally ventilated is determined based on the configuration of the walls (cross-ventilation, single-sided or adjacent walls) and the ceiling height. For spaces with an operable opening on only one side of the space, only the floor area within two times the ceiling height from the opening is permitted to be naturally ventilated. For spaces with operable openings on two opposite sides of the space, only the floor areas within five times the ceiling height from the openings are permitted to be naturally ventilated. For spaces with operable openings on two adjacent sides of the space (two sides of a corner), only the floor areas along lines connecting the two openings that are within five times the ceiling height meet the requirement. Floor areas not along these lines connecting the windows must meet the one side opening calculation to be permitted to be naturally ventilated. The ceiling height for all of these cases is the minimum ceiling height, except for when the ceiling is sloped upwards from the opening. In that case, the ceiling height is calculated as the average within 20 feet of the opening.

Zones or portions of zones being naturally ventilated must have a permanently open airflow path to openings directly connected to the outdoors. The minimum openable area is required to be 4 percent of the net occupiable floor area being naturally ventilated. Where openings are covered with louvers or otherwise obstructed, the openable area must be based on the free unobstructed area through the opening. Where interior spaces without direct openings to the outdoors are ventilated through adjoining rooms, the opening between rooms must be permanently unobstructed and have a free area of not less than 8 percent of the area of the interior room nor less than 25 sq. ft.

The means to open required operable openings must be readily accessible to building occupants whenever the space is occupied. The operable opening must be monitored to coordinate the operation of the operable opening and the mechanical ventilation system. **«»**

3. **Mechanical ventilation.** Occupiable spaces shall be ventilated with a mechanical ventilation system capable of providing an outdoor airflow rate (V_z) to the zone no less than the Equation 160.2-H as described below:

   V_z = The larger of $R_p \times P_z$ or $R_a \times A_z$ (Equation 160.2-H)

   Where:

   R_p = 15 cubic feet per minute of outdoor airflow per person

   P_z = The expected number of occupants. For spaces without fixed seating, the expected number of occupants shall be the expected number specified by the building designer or the default occupancy density in Table 160.2-B times the occupiable floor area of the zone, whichever is greater. For spaces with fixed seating, the expected number of occupants shall be determined in accordance with the California Building Code Section 1004.6.

R_a = The area-based minimum ventilation airflow rate in Table 160.2-B.

A_z = The net occupiable floor area of the ventilation zone in square feet.

Exception to Section 160.2(c)3: Transfer air. The rate of outdoor air required by Section 160.2(c)3 may be provided with air transferred from other ventilated space if:

i. Use of transfer air is in accordance with Section 160.2(c)8; and

ii. The outdoor air that is supplied to all spaces combined is sufficient to meet the requirements of Section 160.2(c)3 for each space individually.

«» Commentary for Section 160.2(c)3:

Mechanical outdoor ventilation must be provided for all spaces normally occupied. The Energy Code requires that a mechanical ventilation system provide outdoor air equal to or exceeding the ventilation rates required for each of the spaces that it serves. At the space, the required ventilation can be provided either directly through supply air or indirectly through transfer of air from the plenum or an adjacent space. The required minimum ventilation airflow at the space can be provided by an equal quantity of supply or transfer air. At the air-handling unit, the minimum outside air must be the sum of the ventilation requirements of each of the spaces that it serves. The designer may specify higher outside air ventilation rates based on the owner's preference or specific ventilation needs associated with the space. However, specifying more ventilation air than the minimum allowable ventilation rates increases energy consumption and electrical peak demand and increases the costs of operating the HVAC equipment. Thus, the designer should have a compelling reason to specify higher design minimum outside air rates than the calculated minimum outside air requirements.

The minimum outside air (OSA) as measured by acceptance testing, is required to be within 10 percent of the design minimum for both variable air volume (VAV) and constant volume units. The design minimum outside air can be no less than the calculated minimum outside air.

For each space requiring mechanical ventilation, the ventilation rates must be the larger of:

1. The net occupiable floor area (A_z) floor area of the space multiplied by the area outdoor air rate (R_a) from Table 160.2-B of the Energy Code. This provides dilution for the building-borne contaminants like off-gassing of paints and carpets, or
2. For spaces without fixed seating, the expected number of occupants (P_z) is either the number specified by the building designer or the default occupancy density in Table 160.2-B times the occupiable floor area of the zone, whichever is greater. For spaces with fixed seating (such as a theater or auditorium), the expected number of occupants (P_z) is the number of fixed seats or as determined by the California Building Code Section 1004.6. The amount of ventilation is determined by multiplying P_z by the outdoor air rate per person (R_p) of 15 cfm.

Direct Air Transfer

The Energy Code allows air to be directly transferred from one space to another to meet part of the ventilation supply, provided the total outdoor quantity required by all spaces served by the building's ventilation system is supplied by the mechanical systems. This method can be used for any space, but is particularly applicable to conference rooms, toilet rooms, and other rooms that have high ventilation requirements. Transfer air may be a mixture of air from multiple spaces or locations, in which case the air mixture must be classified at the mixed highest classification. Transfer air must meet the requirements of air classification and recirculation limitations, as described in Section 160.2(c)8.

Air may be transferred using any method that ensures a positive airflow. Examples include dedicated transfer fans, exhaust fans, and fan powered VAV boxes. A system having a ducted return may be balanced so that air naturally transfers into the space. Exhaust fans serving the space may discharge directly outdoors, or into a return plenum. Transfer systems should be designed to minimize recirculation of transfer air back into the space; duct work should be arranged to separate the transfer air intake and return points.

When each space in a two-space building is served by a separate constant volume system, the calculation and application of ventilation rate is straightforward, and each space will always receive its design outdoor air quantity. However, a central system serving both spaces does not deliver the design outdoor air quantity to each space. Instead, one space receives more than its allotted share, and the other less. This is because some spaces have a higher design outdoor ventilation rate and/or a lower cooling load relative to the other space. **«»**

4. **Exhaust ventilation.** The design exhaust airflow shall be determined in accordance with the requirements in Table 160.2-C. Exhaust makeup air shall be permitted to be any combination of outdoor air, recirculated air or transfer air. [ASHRAE 62.1:6.5.1]

«» Commentary for Section 160.2(c)4:

The exhaust ventilation requirements are aligned with ASHRAE 62.1 and require certain occupancy categories to be exhausted to the outdoors. Exhaust flow rates must meet or exceed the minimum rates specified in Table 160.2-C of the Energy Code. The spaces listed are expected to have contaminants not generally found in adjacent occupied spaces. Therefore, the air supplied to the space to replace the air exhausted may be any combination of outdoor air, recirculated air, and transfer air – all of which are expected to have low or zero concentration of the pollutants generated in the listed spaces. For example, the exhaust from a toilet room can draw air from either the outdoors, adjacent spaces, or from a return air duct or plenum. Because these sources of makeup air have essentially zero concentration of toilet-room odors, they are equally good at diluting odors in the toilet room.

The rates specified must be provided during all periods when the space is expected to be occupied, similar to the requirement for ventilation air. **«»**

5. **Operation and control requirements for minimum quantities of outdoor air**.

   A. **Times of occupancy.** The minimum rate of outdoor air required by Section 160.2(c) shall be supplied to each space at all times when the space is usually occupied.

   Exception 1 to Section 160.2(c)5A: Demand control ventilation. In intermittently occupied spaces that do not have processes or operations that generate dusts, fumes, mists, vapors or gases and are not provided with local exhaust ventilation (such as indoor operation of internal combustion engines or areas designated for unvented food service preparation), the rate of outdoor air may be reduced if the ventilation system serving the space is controlled by a demand control ventilation device complying with Section 160.2(c)5D or by an occupant sensor ventilation control device complying with Section 160.2(c)5E.

   Exception 2 to Section 160.2(c)5A: Temporary reduction. The rate of outdoor air provided to a space may be reduced below the level required by Section 160.2(c) for up to 30 minutes at a time if the average rate for each hour is equal to or greater than the required ventilation rate.

«» Commentary for Section 160.2(c)5A:

While Section 160.2(c)5A requires that ventilation be continuous during normally occupied hours when the space is usually occupied, Exception 2 allows the ventilation to be disrupted for not more than 30 minutes at a time. In this case, the ventilation rate during the time the system is ventilating must be increased so the average rate over the hour is equal to the required rate.

It is important to review any related ventilation and fan cycling requirements in Title 8, which is the Division of Occupational Safety and Health (Cal/OSHA) regulations. Section 5142 specifies the operational requirements related to HVAC minimum ventilation. It states:

Operation:

1. The HVAC system shall be maintained and operated to provide at least the quantity of outdoor air required by the State Building Standards Code, Title 24, Part 2, California Administrative Code, in effect at the time the building permit was issued.
2. The HVAC system shall be operated continuously during working hours except:
3. During scheduled maintenance and emergency repairs.

Title 8, California Code of Regulations, Section 5142(a)(1) refers to Title 24, Part 2 (the California Building Code) for the minimum ventilation requirements. Section 1203 in the California Building Code specifies the ventilation requirements, but simply refers to the California Mechanical Code, which is Title 24, Part 4.

Chapter 4 in the California Mechanical Code specifies the ventilation requirements. Section 402.3 states, “The system shall operate so that all rooms and spaces are continuously provided with the required ventilation rate while occupied.” Section 403.5.1 states, “Ventilation systems shall be designed to be capable of providing the required ventilation rates in the breathing zone whenever the zones served by the system are occupied, including all full and part-load conditions." In addition, Section 403.6 states, "The system shall be permitted to be designed to vary the design outdoor air intake flow or the space or zone airflow as operating conditions change." This provides further validation to fan cycling as operating conditions change between occupied and unoccupied. A vacant zone has no workers present and is thus not subject to working hours requirements until the zone is actually occupied by a worker. Finally, Title 24, Part 4, states; "Ventilation air supply requirements for occupancies regulated by the California Energy Commission are found in the California Energy Code." Thus, it refers to Title 24, Part 6 as the authority on ventilation.

Title 8 Section 5142(a)(2) states, "The HVAC system shall be operated continuously during working hours." This regulation does not indicate that the airflow, cooling, or heating needs to be continuous. If the HVAC system is designed to maintain average ventilation with a fan cycling algorithm and is active in that mode providing average ventilation air as required during working hours, it is considered to be operating continuously per its mode and sequence. During unoccupied periods, the HVAC system is turned off except for setback and it no longer operates continuously. During the occupied period, occupant sensors or CO_2 sensors in the space provide continuous monitoring and the sequence is operating, cycling the fan and dampers as needed to maintain the ventilation during the occupied period. The HVAC system is operating with the purpose of providing ventilation, heating, and cooling continuously during the working hours. The heater, air conditioner, fans, and dampers all cycle on and off subject to their system controls to meet the requirements during the working hours.

Title 8 Section 5142(a)(2)A, B, and C all refer to a complete system shutdown where the required ventilation is not maintained. **«»**

B. **Preoccupancy.** The lesser of the minimum rate of outdoor air required by Section 160.2(c) or three complete air changes shall be supplied to the entire building during the 1-hour period immediately before the building is normally occupied.

«» Commentary for Section 160.2(c)5B:

Since many indoor air pollutants are out gassed from the building materials and furnishings, the Energy Code ventilation options are described for preoccupancy per Section 160.2(c)5B. Immediately prior to occupancy, outdoor ventilation must be provided in an amount equal to the lesser of:

1. The minimum required ventilation rate for 1 hour
2. Three complete air changes

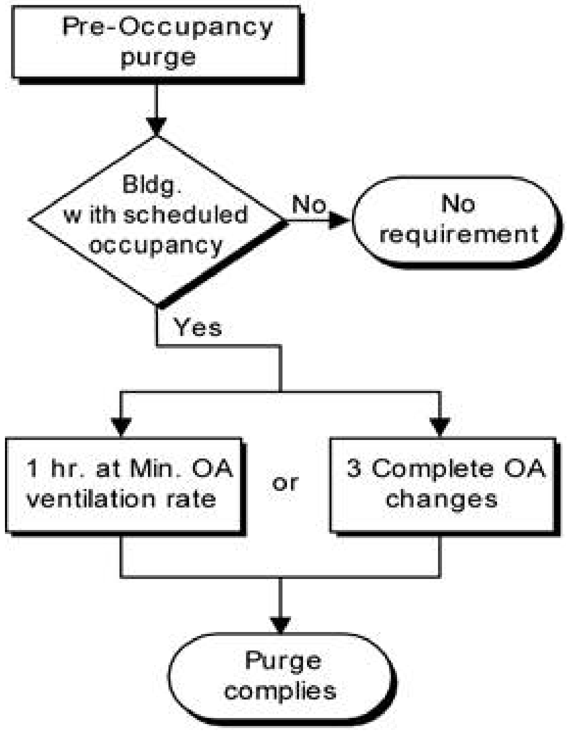
Either criterion can be used to comply with the Energy Code. This air may be introduced at any rate provided for and allowed by the system, so that the actual purge period may be less than an hour.

Pre-occupancy ventilation is not required for buildings or spaces that are not occupied on a scheduled basis, such as storage rooms. Also, a this is not required for spaces provided with natural ventilation.

Where pre-occupancy purge is required, it does not have to be coincident with morning warm-up (or cool-down). The simplest way to integrate the two controls is to schedule the system to be occupied one hour prior to the actual time of anticipated occupancy. This allows the optimal start, warm-up, or pull-down routines to bring the spaces up to (or down to) desired temperatures before opening the outdoor air damper for ventilation. This will reduce the required system heating capacity and ensure that the spaces will be at the desired temperatures and fully purged at the start of occupancy.

However, for spaces with occupancy controls which turn ventilation off when occupancy is not sensed, care must be taken in specifying controls and control sequences that the lack of sensed occupancy does not disable or override ventilation during the pre-occupancy purge period.

Figure 4-13: Pre-Occupancy Purge Flowchart



Source: California Energy Commission

«»

C. **Required demand control ventilation.** Demand ventilation controls complying with Section 160.2(c)5D are required for a space with a design occupant density, or a maximum occupant load factor for egress purposes in the CBC, greater than or equal to 25 people per 1000 square feet (40 square feet or less per person) if the system serving the space has one or more of the following:

i. an air economizer; or

ii. modulating outside air control; or

iii. design outdoor airflow rate > 3,000 cfm.

«» Commentary for Section 160.2(c)5C:

Demand control ventilation (DCV) systems reduce the amount of ventilation supply air in response to a measured level of carbon dioxide (CO2) in the breathing zone, thereby saving energy. The Energy Code only permits CO2 sensors, as discussed below, for the purpose of meeting this requirement; volatile organic compounds (VOC) and so-called “indoor air quality (IAQ)” sensors are not approved as alternative devices to meet this requirement. The Energy Code only permits DCV systems to vary the ventilation component that corresponds to occupant bioeffluents (this is the basis for the 15 cfm/person portion of the ventilation requirement in Section 160.2(c)3). The purpose of CO2 sensors is to track occupancy in a space; however, there are many factors that must be considered when designing a DCV system. There is often a lag time in the detection of occupancy through the build-up of CO2.

This lag time may be increased by any factors that affect mixing, such as short circuiting of supply air or inadequate air circulation, as well as sensor placement and sensor accuracy. Build-up of odors, bioeffluents, and other health concerns may also delay changes in occupancy. Therefore, the designers must be careful to specify CO2 based DCV systems that are designed to provide adequate ventilation to the space by ensuring proper mixing, avoiding short circuiting, and proper placement and calibration of the sensors. **«»**

Exception 1 to Section 160.2(c)5C: Where space exhaust is greater than the design ventilation rate specified in Section 160.2(c)3 minus 0.2 cfm per ft² of conditioned area.

«» Commentary for Section 160.2(c)5C:

This exception relates to the fact that spaces with high exhaust requirements won't be able to provide sufficient turndown to justify the cost of the DCV controls. An example of this is a restaurant seating area where the seating area air is used as make-up air for the kitchen hood exhaust. **«»**

Exception 2 to Section 160.2(c)5C: Spaces that have processes or operations that generate dusts, fumes, mists, vapors or gases and are not provided with local exhaust ventilation, such as indoor operation of internal combustion engines or areas designated for unvented food service preparation, daycare sickrooms, science labs, barber shops or beauty and nail salons, shall not install demand control ventilation.

«» Commentary for Section 160.2(c)5C:

This exception recognizes that some spaces may need additional ventilation due to contaminants that are not occupant borne. It addresses spaces like theater stages where theatrical fog may be used or movie theater lobbies where unvented popcorn machines may be emitting odors and vapors into the space in either case justifying the need for higher ventilation rates. DCV devices shall not be installed in spaces included in this exception. **«»**

Exception 3 to Section 160.2(c)5C: Spaces with an area of less than 150 square feet or a design occupancy of less than 10 people as specified by Section 160.2(c)3.

«» Commentary for Section 160.2(c)5C:

This recognizes the fact that DCV devices may not be cost effective in small spaces such as a 15 ft. by 10 ft. conference room or spaces with only a few occupants at design conditions. **«»**

D. **Demand control ventilation devices.**

i. For each system with demand control ventilation (DCV), CO_2 sensors shall be installed in each room that meets the criteria of Section 160.2(c)5C with no less than one sensor per 10,000 ft² of floor space. When a zone or a space is served by more than one sensor, a signal from any sensor indicating that CO_2 is near or at the setpoint within the zone or space shall trigger an increase in ventilation.

«» Commentary for Section 160.2(c)5Di:

When a zone or a space is served by more than one sensor, signals from any sensor indicating that CO2 is near or at the set point within a space, must trigger an increase in ventilation to the space. This requirement ensures that the space is adequately ventilated in case a sensor malfunctions. Design professionals should ensure that sensors are placed throughout a large space, so that all areas are monitored by a sensor. «»

ii. CO_2 sensors shall be located in the room between 3 ft and 6 ft above the floor or at the anticipated height of the occupants' heads.

iii. Demand ventilation controls shall maintain CO_2 concentrations less than or equal to 600 ppm plus the outdoor air CO_2 concentration in all rooms with CO_2 sensors.

Exception to Section 160.2(c)5Diii: The outdoor air ventilation rate is not required to be larger than the design outdoor air ventilation rate required by Section 160.2(c)3 regardless of CO_2 concentration.

iv. Outdoor air CO_2 concentration shall be determined by one of the following:

a. CO_2 concentration shall be assumed to be 400 ppm without any direct measurement; or

b. CO_2 concentration shall be dynamically measured using a CO_2 sensor located within 4 ft of the outdoor air intake.

«» Commentary for Section 160.2(c)5Dii-iv:

The ambient levels of CO2 can either be assumed to be 400 ppm or dynamically measured by a sensor that is installed within four feet of the outdoor air intake. At 400 ppm outside CO2 concentration, the resulting DCV CO2 set point would be 1000 ppm. (A 600-ppm differential is less than the 700 ppm that corresponds to the 15 cfm/person ventilation rate. This provides a margin of safety against sensor error, and because 1000 ppm CO2 is a commonly recognized guideline value and referenced in earlier versions of ASHRAE Standard 62.) Note that the 1,000 ppm setpoint required by Title 24 is not the same approach to DCV as specified in the current version of ASHRAE 62.1 or ASHRAE 90.1 which do not have a fixed CO2 target for all spaces, and ASHRAE Standards 90.1 and 62.1 have lower ventilation rates per person. «»

v. When the system is operating during hours of expected occupancy, the controls shall maintain system outdoor air ventilation rates no less than $Ra \times Az$ per Equation 160.2-H for each space with a CO_2 sensor(s), plus the greater of either the exhaust air rate or the rate required by Section 160.2(c)3 for other spaces served by the system.

«» Commentary for Section 160.2(c)5Dv:

Regardless of the CO_2 sensor's reading, the system is not required to provide more than the minimum ventilation rate required by Section 160.2(c)3. This prevents a faulty sensor reading from causing a system to provide more than the code required ventilation for system without DCV control. This high limit can be implemented in the controls.

The system shall always provide a minimum ventilation of the sum of the minimum air rate for all spaces served by the system. This is a low limit setting that must be implemented in the controls. «»

vi. CO_2 sensors shall be certified by the manufacturer to be accurate within plus or minus 75 ppm at a 600 and 1000 ppm concentration when measured at sea level and 25°C, factory calibrated, and certified by the manufacturer to require calibration no more frequently than once every 5 years. Upon detection of sensor failure, the system shall provide a signal that resets to supply the minimum quantity of outside air to levels required by Section 160.2(c)3 to the zone serviced by the sensor at all times that the zone is occupied.

«» Commentary for Section 160.2(c)5Dvi:

A number of manufacturers now have self-calibrating sensors that either adjust to ambient levels during unoccupied times or adjust to the decrease in sensor bulb output through use of dual sources or dual sensors. For all systems, sensor manufacturers must provide a document to installers that their sensors meet these requirements. The installer must make this certification information available to the builder, building inspectors and, if specific sensors are specified on the plans, to plan checkers.

The sensor failure reset signal ensures that the space is adequately ventilated in case a sensor malfunctions. A sensor that provides a high CO2 signal on sensor failure will comply with this requirement. «»

vii. The CO_2 sensor(s) reading for each zone shall be displayed continuously, and shall be recorded on systems with digital direct controls (DDC) to the zone level.

«» Commentary for Section 160.2(c)5Dvii:

The energy management control system (EMCS) may be used to display and record the sensors' readings. The display(s) must be readily available to maintenance staff so they can monitor the system's performance. «»

E**. Occupied-Standby Zone Controls.**

i. Space conditioning zones shall include occupied standby controls complying with Table 160.2-B when all of the following are true:

a. All rooms served by the zone are permitted to have their ventilation air reduced to zero while in occupied-standby mode per Table 160.2-B; and

b. Occupant sensors are required by Section 160.5(b)4Cv and vi; and

c. The zone and ventilation system is not served by a pneumatic controls.

ii. Occupied-standby zone controls shall comply with the following:

a. Occupant sensors shall have suitable coverage and placement to detect occupants in the entire space. In 20 minutes or less after no occupancy is detected by any sensors covering the room, occupant sensing controls shall indicate a room is vacant.

b. When occupant sensors controlling lighting are also used for ventilation, the ventilation signal shall be independent of daylighting, manual lighting overrides or manual control of lighting.

c. When a single zone damper or a single zone system serves multiple spaces, there shall be an occupant sensor in each space and the zone shall not be considered vacant until all spaces in the zone are vacant.

d. One hour prior to normal scheduled occupancy, the occupant sensor ventilation control shall allow preoccupancy purge as described in Section 160.2(c)5B.

e. When the zone is scheduled to be occupied and occupant sensing controls in all spaces served by the zone indicate the spaces are unoccupied, the zone shall be placed in occupied- standby mode.

f. In 5 minutes or less after entering occupied-standby mode, mechanical ventilation to the zone shall be shut off until the space becomes occupied or until ventilation is needed to provide space heating or conditioning. When mechanical ventilation is shut off to the zone, the ventilation system serving the zone shall reduce the system outside air rate by the amount of outside air required for the zone.

g. Where the system providing space conditioning also provides ventilation to the zone, in 5 minutes or less after entering occupied-standby mode, space-conditioning zone setpoints shall be reset in accordance with Section 120.2(e)3.

«» Commentary for Section 160.2(c)5E:

The use of occupied-standby zone controls is mandated for spaces that are also required to use occupant sensing controls to meet the requirements for lighting shut-off controls per Section 160.5(b)4Cv and vi. Example spaces include offices, multipurpose rooms 1,000 sq. ft. or less, conference rooms, and other spaces where the space ventilation is allowed to be reduced to zero in Table 160.2-B. (See note F in the right-hand column of the table).

The HVAC system shall be controlled by an occupancy sensing control that resets temperature setpoints and ventilation air in accordance with Section 160.2(c)5E and 160.3(a)2Diii when a space meets both the following conditions.

1. Section 160.5(b)4Cv and vi specify that occupant sensing, as opposed to time-switch, is required to implement shutoff controls.
2. Table 160.2-B specifies that ventilation air in the space is allowed to be reduced to zero when the space is in occupied standby mode.
3. The zone and ventilation system are not served by pneumatic controls.

Table 4-4: Multifamily Common Use Occupancy Categories Qualifying for Occupied Standby Control Requirements lists all the occupancy categories that meet the conditions above and thus are required to install occupied standby controls if the ventilation zone is serving only qualifying spaces.

Table 4-4: Multifamily Common Use Occupancy Categories Qualifying for Occupied Standby Control Requirements

Occupancy Category
Multiuse assembly (only those less than 1,000 square feet)
Corridors
Office Space
Conference/meeting

Source: California Energy Commission

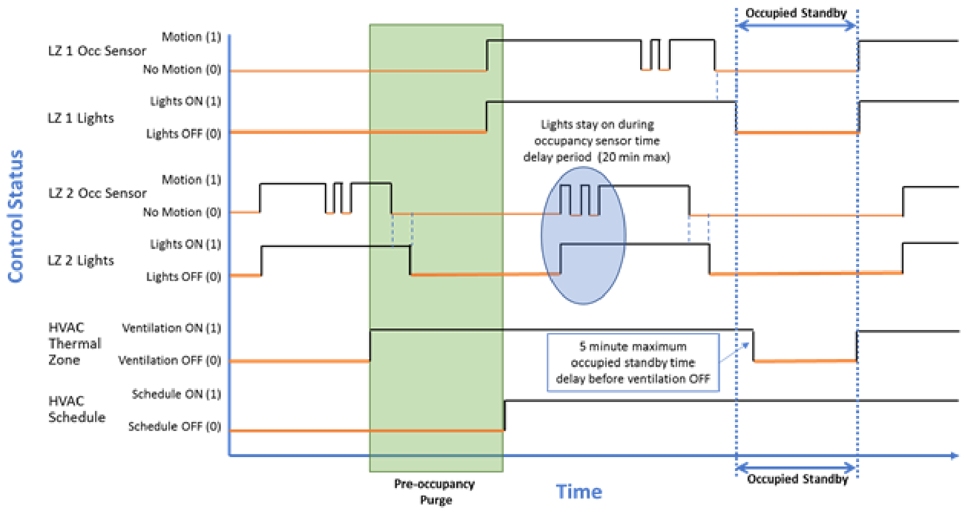
Occupied-standby zone controls are used to implement "occupied standby control." This control is used when the HVAC is scheduled to be ON, but occupancy sensors do not detect any activity in the spaces served by the HVAC zone. Occupant sensing controls must indicate the zone to be vacant within 20 min of the occupancy sensors covering the zone detects no occupancy. During occupied standby, zone temperatures are reset (higher cooling setpoint and lower heating setpoint) and during times when there is neither a call for cooling nor heating the ventilation air is shut off to the zone. When ventilation air is shut off to the zone, the ventilation system serving the zone shall reduce the system outside air by the same amount of outside air reduced at the individual zone.

For example, if a DOAS unit is used to ventilate multiple spaces without any downstream modulation controls then the entire DOAS unit is treated as one ventilation zone for the purposes of the occupied standby requirement and would only be subject to use occupied-standby controls if all ventilated spaces were listed under Table 4-4: Multifamily Common Use Occupancy Categories Qualifying for Occupied Standby Control Requirements. To comply, the unit would be required to implement occupied standby controls to reduce ventilation to zero (i.e., shut off the DOAS unit) and operate independent of the space-conditioning setpoints.

Additionally, if a DOAS unit features any ventilation modulation controls downstream of the DOAS unit, then any branches of ventilation air with modulation control shall be considered a separate ventilation zone for the purposes of this requirement.

The ventilation zone may be serving more than one room, in which case all rooms served by the space conditioning zone must be sensed as unoccupied before the system is placed in occupied standby mode. The illustration below (Figure 4-14 Control Sequence Diagram of Occupied Standby Control of HVAC Thermal Zone Serving Two Lighting Zones (LZ1 and LZ2)) provides an example of the sequence of events for two rooms (LZ1 and LZ2) served by one ventilation zone and how the occupant-sensing lighting controls relate to the HVAC ventilation controls.

Figure 4-14 Control Sequence Diagram of Occupied Standby Control of HVAC Thermal Zone Serving Two Lighting Zones (LZ1 and LZ2)



Source: California Energy Commission

«»

6. **Ducting for zonal heating and cooling units.** Where a return plenum is used to distribute outdoor air to a zonal heating or cooling unit that then supplies the air to a space in order to meet the requirements of Section 160.2(c)3, the outdoor air shall be ducted to discharge either:

   A. Within 5 feet of the unit; or

   B. Within 15 feet of the unit, substantially toward the unit and at a velocity not less than 500 feet per minute.

«» Commentary for Section 160.2(c)6B:

Water source heat pumps and fan coils are the most common application of this configuration. The unit fans should be controlled to run continuously during occupancy in order for the ventilation air to be circulated to the occupied space.

Not all spaces are required to have a direct source of outdoor air. Transfer air is allowed from adjacent spaces with direct outdoor air supply if the system supplying the outdoor air is capable of supplying the required outdoor air to all spaces at the same time. Air classification and recirculation limitations will apply, as explained above. An example of an appropriate use of transfer would be in buildings having central interior space-conditioning systems with outdoor air supply, and zonal units on the perimeter without a direct outdoor air supply. «»

7. **Design and control requirements for quantities of outdoor air**.

   A. All mechanical ventilation and space-conditioning systems shall be designed with and have installed ductwork, dampers and controls to allow outside air rates to be operated at the minimum levels specified in Section 160.2(c)3 or the rate required for make-up of exhaust systems that are required for an exempt or covered process, for control of odors or for the removal of contaminants within the space.

B. All variable air volume mechanical ventilation and space-conditioning systems shall include dynamic controls that maintain measured outside air ventilation rates within 10 percent of the required outside air ventilation rate at both full and reduced supply airflow conditions. Fixed minimum damper position is not considered to be dynamic and is not an allowed control strategy.

C. Measured outdoor air rates of constant volume mechanical ventilation and space-conditioning systems shall be within 10 percent of the required outside air rate.

8. **Air classification and recirculation limitations.** Air classification and recirculation limitations of air shall be based on the air classification as listed in Table 160.2-B or Table 160.2-D, in accordance with the following:

   A. Class 1 air is air with low contaminant concentration, low sensory-irritation intensity or inoffensive odor. Recirculation or transfer of Class 1 air to any space shall be permitted; [ASHRAE 62.1:5.13.3.1]

   B. Class 2 air is air with moderate contaminant concentration, mild sensory-irritation intensity or mildly offensive odor (Class 2 air also includes air that is not necessarily harmful or objectionable but that is inappropriate for transfer or recirculation to spaces used for different purposes). Recirculation or transfer of Class 2 air shall be permitted in accordance with Sections 160.2(c)8Bi through 160.2(c)8Bv:

      i. Recirculation of Class 2 air within the space of origin shall be permitted [ASHRAE 62.1:5.13.3.2.1].

      ii. Recirculation or transfer of Class 2 to other Class 2 or Class 3 spaces shall be permitted, provided that the other spaces are used for the same or similar purpose or task and involve the same or similar pollutant sources as the Class 2 space [ASHRAE 62.1:5.13.3.2.2]; or

      iii. Transfer of Class 2 air to toilet rooms [ASHRAE 62.1:5.13.3.2.3]; or

      iv. Recirculation or transfer of Class 2 air to Class 4 spaces [ASHRAE 62.1:5.13.3.2.4]; or

      v. Class 2 air shall not be recirculated or transferred to Class 1 spaces. [ASHRAE 62.1:5.13.3.2.5]

      Exception to Section 160.2(c)8Bv: When using any energy recovery device, recirculation from leakage, carryover or transfer from the exhaust side of the energy recovery device is permitted. Recirculated Class 2 air shall not exceed 10 percent of the outdoor air intake flow.

«» Commentary for Section 160.2(c)8B:

Some examples spaces that might use class 2 air include warehouses, restaurants, and auto repair rooms. «»

C. Class 3 air is air with significant contaminant concentration, significant sensory-irritation intensity or offensive odor. Recirculation or transfer of Class 3 air shall be permitted in accordance with Sections 160.2(c)8Ci and 160.2(c)8Cii:

   i. Recirculation of Class 3 air within the space of origin shall be permitted. [ASHRAE 62.1:5.13.3.3.1]

   ii. Class 3 air shall not be recirculated or transferred to any other space. [ASHRAE 62.1:5.13.3.3.2].

   Exception to Section 160.2(c)8Cii: When using any energy recovery device, recirculation from leakage, carryover or transfer from the exhaust side of the energy recovery device is permitted. Recirculated Class 3 air shall not exceed 5 percent of the outdoor air intake flow.

«» Commentary for Section 160.2(c)8C:

Some examples of spaces that might use Class 3 air include general manufacturing, excluding heavy industrial and processes using chemicals and janitor closets. «»

D. Class 4 air is air with highly objectionable fumes or gases or with potentially dangerous particles, bioaerosols or gases at concentrations high enough to be considered as harmful. Class 4 air shall not be recirculated or transferred to any space or recirculated within the space of origin. [ASHRAE 62.1:5.13.3.4]

«» Commentary for Section 160.2(c)8D:

Some examples of spaces that might use Class 4 air include spray paint booths and chemical storage rooms. «»

E. Ancillary spaces. Redesignation of Class 1 air to Class 2 air shall be permitted for Class 1 spaces that are ancillary to Class 2 spaces. [ASHRAE 62.1:5.13.2.3]

F. Transfer. A mixture of air that has been transferred through or returned from spaces or locations with different air classes shall be redesignated with the highest classification among the air classes mixed. [ASHRAE 62.1:5.13.2.2]

G. Classification. Air leaving each space or location shall be designated at an expected air-quality classification not less than that shown in Table 160.2-B, 160.2-C or 160.2-D. Air leaving spaces or locations that are not listed in Table 160.2-B, 160.2-C or 160.2-D shall be designated with the same classification as air from the most similar space or location listed in terms of occupant activities and building construction.

«» Commentary for Section 160.2(c)8G:

This section contains air classification, a process that assigns an air class number based on the occupancy category then sets limits on transferring or recirculating that air. This offers designers clear guidance on what can and cannot be used for transfer, makeup, or recirculation air. «»

(d) Parking garages. Mechanical ventilation systems for enclosed parking garages in multifamily buildings shall comply with Section 120.6(c).

TABLE 160.2-B – Minimum Occupant Load Density and Ventilation Rates for Multifamily Common Use Areas

Space Type	Minimum Occupant Load Density (p/1000 ft^2)[1]	Area-based Minimum Ventilation Ra (cfm/ft^2)	Air Class	Notes
Bars, cocktail lounges	33	0.2	2	
Break rooms	33	0.15	1	F
Coffee stations	33	0.15	1	F
Conference/meeting	33	0.15	1	F
Corridors	5	0.15	1	F
Computer (not printing)	5	0.15	1	F
Daycare (through age 4)	14	0.15	2	
Dining rooms	33	0.15	2	
Disco/dance floors	100	0.15	2	F
Freezer and refrigerated spaces (<50oF)	0	0	2	E
Game arcades	45	0.15	1	
Gym, sports arena (play area)	10	0.15	2	E
Health club/aerobics room/weight rooms	10	0.15	2	
Kitchen (cooking)	3	0.15	2	
Laundry rooms, central	5	0.15	2	
Lobbies/pre-function	33	0.15	1	F
Multiuse assembly	33	0.15	1	F
Occupiable storage	2	0.15	1	

rooms for dry materials				
Occupiable storage rooms for liquids or gels	2	0.15	2	B
Office space	5	0.15	1	F
Reception areas	5	0.15	1	F
Shipping/receiving	2	0.15	2	B
Spectator areas	33	0.15	1	F
Swimming (deck)	33	0.15	2	C
Swimming (pool)	10	0.15	2	C
Telephone/data entry	33	0.15	1	F
All others	5	0.15	2	

General:

1. The minimum occupant density is one half of the maximum occupant load assumed for egress purposes in the CBC.
2. If this column specifies a minimum cfm/ft^2 then it shall be used to comply with Section160.2(c)5E.
3. For spaces not included in this table, the spaces in Table 120.1-A shall apply.

Specific Notes:

A – RESERVED
B – Rate may not be sufficient where stored materials include those having potentially harmful emissions.
C – Rate does not allow for humidity control. “Deck area” refers to the area surrounding the pool that is capable of being wetted during pool use or when the pool is occupied. Deck area that is not expected to be wetted shall be designated as an occupancy category.
D – RESREVED.
E – Where combustion equipment is intended to be used on the playing surface or in the space, additional dilution ventilation, source control, or both shall be provided.
F – Ventilation air for this occupancy category shall be permitted to be reduced to zero when the space is in occupied-standby mode.

TABLE 160.2-C – Minimum Exhaust Rates
[ASHRAE 62.1: TABLE 6-2]

Occupancy Category[3]	**Exhaust Rete, cfm/unit**	**Exhaust Rate, cfm/ft^2**	**Air Class**	**Notes**
Copy, printing rooms	-	0.50	2	-
Janitor closets, trash rooms, recycling	-	1.00	3	-
Kitchenettes	-	0.30	2	-
Kitchens – commercial	-	0.70	2	-
Locker rooms for athletic or industrial facilities	-	0.50	2	-
All other locker rooms	-	0.25	2	-
Shower rooms	20/50	-	2	G, H
Parking garages	-	0.75	2	C
Pet shops (animal areas)	-	0.90	2	-
Soiled laundry storage rooms	-	1.00	3	F
Storage rooms, chemical	-	1.50	4	F
Toilets – private	25/50	-	2	E
Toilets – public	50/70	-	2	D

General:

3 For spaces not included in this table, the spaces in Table 120.1-B shall apply.

Notes:

A –Reserved
B –Reserved
C – Exhaust shall not be required where two or more sides comprise walls that are at least 50% open to the outside.
D – Rate is per water closet, urinal, or both. Provide the higher rate where periods of heavy use are expected to occur. The lower rate shall be permitted to be used otherwise.
E – Rate is for a toilet room intended to be occupied by one person at a time. For continuous systems operation during hours of use, the lower rate shall be permitted to be used. Otherwise the higher rate shall be used.
F – See other applicable standards for exhaust rate.
G – For continuous system operation, the lower rate shall be permitted to be used. Otherwise the higher rate shall be used.
H – Rate is per showerhead.

TABLE 160.2-D – Airstreams or Sources
[ASHRAE 62.1:Table 6-3]

Description	**Air Class**
Commercial kitchen grease hoods	4
Commercial kitchen hoods other than grease	3
Hydraulic elevator machine room	2
Refrigerating machinery rooms	3

Table 160.2-E: Demand-Controlled Local Ventilation Exhaust Airflow Rates and Capture Efficiency

Application	Compliance Criteria
Enclosed Kitchen or Nonenclosed Kitchen	Vented range hood, including appliance-range hood combinations shall meet either the capture efficiency (CE) or the airflow rate specified in Table 160.2-G as applicable.
Enclosed Kitchen or Nonenclosed Kitchen	Other kitchen exhaust fans, including downdraft: 300 cfm (150 L/s).
Bathroom	50 cfm (25 L/s)

Table 160.2-F: Continuous Local Ventilation Exhaust Airflow Rates

Application	Airflow
Enclosed kitchen	5 ach, based on kitchen volume
Bathroom	20 cfm (10 L/s)

Table 160.2-G: Kitchen Range Hood Airflow Rates (cfm) and ASTM E3087 Capture Efficiency (CE) Ratings According to Dwelling Unit Floor Area and Kitchen Range Fuel Type

Dwelling Unit Floor Area (ft^2)	Hood Over Electric Range	Hood Over Natural Gas Range
>1500	50% CE or 110 cfm	70% CE or 180 cfm
>1000 - 1500	50% CE or 110 cfm	80% CE or 250 cfm
750 - 1000	55% CE or 130 cfm	85% CE or 280 cfm
<750	65% CE or 160 cfm	85% CE or 280 cfm

Table 160.2-H: Prescriptive Ventilation System Duct Sizing [ASHRAE 62.2:Table 5-3]

Fan Airflow Rating, cfm at minimum static pressure[f] 0.25 in. water (L/s at minimum 62.5 Pa)	≤50 (25)	≤80 (40)	≤100 (50)	≤125 (60)	≤150 (70)	≤175 (85)	≤200 (95)	≤250 (120)	≤350 (165)	≤400 (190)	≤450 (210)	≤700 (330)	≤800 (380)
Minimum Duct Diameter, in. (mm) a,b For Rigid duct	4[e] (100)	5 (125)	5 (125)	6 (150)	6 (150)	7 (180)	7 (180)	8 (205)	9 (230)	10 (255)	10 (255)	12 (305)	12 d (305)
Minimum Duct Diameter, in. (mm) a,b For Flex duct c	4 (100)	5 (125)	6 (150)	6 (150)	7 (150)	7 (180)	8 (205)	8 (205)	9 (230)	10 (255)	NP	NP	NP

Footnotes for Table 150.0-H:

a. For noncircular ducts, calculate the diameter as four times the cross-sectional area divided by the perimeter.

b. NP = application of the prescriptive table is not permitted for this scenario.

c. Use of this table for verification of flex duct systems requires flex duct to be fully extended and any flex duct elbows to have a minimum bend radius to duct diameter ratio of 1.0.

d. For this scenario, use of elbows is not permitted.

e. For this scenario, 4 in. (100 mm) oval duct shall be permitted, provided the minor axis of the oval is greater than or equal to 3 in. (75 mm)

f. When a vented range hood utilizes a capture efficiency rating to demonstrate compliance with 160.2(b)2Avic2, a static pressure greater than or equal to 0.25 in. of water at the rating point shall not be required, and the airflow listed in the approved directory corresponding to the compliant capture efficiency rating point shall be applied to Table 160.2-H for determining compliance.

Note: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 160.3 – MANDATORY REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS IN MULTIFAMILY BUILDINGS

Space conditioning systems serving multifamily dwelling units and common use areas shall comply with the applicable requirements of Sections 160.3(a) through 160.3(c).

(a) Controls. Space-conditioning systems serving dwelling units and common use areas in multifamily buildings shall comply with applicable requirements of Section 160.3(a)1 or 160.3(a)2.

1. **Dwelling unit thermostats.** All heating or cooling systems, including heat pumps, not controlled by a central energy management control system (EMCS) shall have a setback thermostat, as specified in Section 110.2(c).
2. **Common use area controls**. Heating or cooling systems serving common use areas of multifamily buildings shall comply with application requirements of Sections 160.3(a)2A through 160.3(a)2J.

   Exception to Section 160.3(a)2: Heating or cooling systems exclusively serving dwelling units and common use areas providing shared provisions for living, eating, cooking or sanitation to dwelling units that would otherwise lack these provisions may instead comply with Section 160.3(a)1.

   A. **Thermostatic controls for each zone.** The supply of heating and cooling energy to each space-conditioning zone shall be controlled by an individual thermostatic control that responds to temperature within the zone and that meets the applicable requirements of Section 160.3(a)2B. An energy management control system (EMCS) may be installed to comply with the requirements of one or more thermostatic controls if it complies with all applicable requirements for each thermostatic control.

   Exception to Section 160.3(a)2A: An independent perimeter heating or cooling system may serve more than one zone without individual thermostatic controls if:

   i. All zones are also served by an interior cooling system; and

   ii. The perimeter system is designed solely to offset envelope heat losses or gains; and

   iii. The perimeter system has at least one thermostatic control for each building orientation of 50 feet or more; and

   iv. The perimeter system is controlled by at least one thermostat located in one of the zones served by the system.

   B. **Criteria for zonal thermostatic controls.** The individual thermostatic controls required by Section 160.3(a)2A shall meet the following requirements as applicable:

i. Where used to control comfort heating, the thermostatic controls shall be capable of being set, locally or remotely, down to 55°F or lower.

ii. Where used to control comfort cooling, the thermostatic controls shall be capable of being set, locally or remotely, up to 85°F or higher.

iii. Where used to control both comfort heating and comfort cooling, the thermostatic controls shall meet Items i and ii and shall be capable of providing a temperature range or deadband of at least 5°F within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

Exception to Section 160.3(a)2Biii: Systems with thermostats that require manual changeover between heating and cooling modes.

iv. Thermostatic controls for all single zone air conditioners and heat pumps shall comply with the requirements of Sections 110.2(c) and 110.12(a) and, if equipped with DDC to the zone level, with the automatic demand shed controls of Section 110.12(b).

Exception to Section 160.3(a)2Biv: Package terminal air conditioners, package terminal heat pumps, room air conditioners and room air-conditioner heat pumps.

C. **Heat pump controls.**

All heat pumps with supplementary electric resistance heaters shall be installed with controls that comply with Section 110.2(b).

D. **Shut-off and reset controls for space-conditioning systems.** Each space-conditioning system shall be installed with controls that comply with the following:

i. The control shall be capable of automatically shutting off the system during periods of nonuse and shall have:

a. An automatic time switch control device complying with Section 110.9, with an accessible manual override that allows operation of the system for up to 4 hours; or

b. An occupancy sensor; or

c. A 4-hour timer that can be manually operated.

ii. The control shall automatically restart and temporarily operate the system as required to maintain:

a. A setback heating thermostat setpoint if the system provides mechanical heating; and

Exception to Section 160.3(a)2Diia: Thermostat setback controls are not required in multifamily buildings in areas where the Winter Median of Extremes outdoor air temperature determined in accordance with Section **170.2(c)1C** is greater than 32°F.

b. A setup cooling thermostat setpoint if the system provides mechanical cooling.

Exception to Section 160.3(a)2Diib: Thermostat setup controls are not required in multifamily buildings in areas where the summer design dry-bulb 0.5-percent temperature determined in accordance with Section 170.2(c)1C is less than 100°F.

iii. **Occupant sensing zone controls**. Where the system providing space conditioning also provides the ventilation required by Section 160.2(c)3 and includes occupant sensor ventilation control as specified in Section 160.2(c)5E, the occupant sensing zone controls shall additionally comply with the following:

a. Occupant sensing zone controls shall comply with the occupant sensor ventilation control device requirements of Section 160.3(c)5E and allow preoccupancy ventilation requirements of Section 160.3(c)5B; and

b. In 5 minutes or less after entering occupied-standby mode as described in Section 160.2(c)5:

I. Automatically set up the operating cooling temperature setpoint by 2°F or more and set back the operating heating temperature setpoint by 2°F or more; or

II. For multiple zone systems with Direct Digital Controls (DDC) to the zone level, set up the operating cooling temperature setpoint by 0.5°F or more and set back the operating heating temperature setpoint by 0.5°F or more.

c. In 5 minutes or less after entering occupied-standby mode, mechanical ventilation to the zone shall remain off whenever the space temperature is between the active heating and cooling setpoints.

Exception to Section 160.3(a)2Diii: Zones that are only ventilated by a natural ventilation system in accordance with Section 120.1(c)2.

Exception 1 to Sections 160.3(a)2Di, ii and iii: Where it can be demonstrated to the satisfaction of the enforcing agency that the system serves an area that must operate continuously.

Exception 2 to Sections 160.3(a)2Di, ii and iii: Systems with full load demands of 2 kW or less, if they have a readily accessible manual shut-off switch.

E. **Dampers for air supply and exhaust equipment.** Outdoor air supply and exhaust equipment shall be installed with dampers that automatically close upon fan shutdown.

Exception 1 to Section 160.3(a)2E: Equipment that serves an area that must operate continuously.

Exception 2 to Section 160.3(a)2E: Gravity and other nonelectrical equipment that has readily accessible manual damper controls.

Exception 3 to Section 160.3(a)2E: At combustion air intakes and shaft vents.

Exception 4 to Section 160.3(a)2E: Where prohibited by other provisions of law.

F. **Isolation area devices**. Each space-conditioning system serving multiple zones with a combined conditioned floor area of more than 25,000 square feet shall be designed, installed and controlled to serve isolation areas.

   i. Each zone, or any combination of zones not exceeding 25,000 square feet, shall be a separate isolation area.

   ii. Each isolation area shall be provided with isolation devices, such as valves or dampers that allow the supply of heating or cooling to be reduced or shut off independently of other isolation areas.

   iii. Each isolation area shall be controlled by a device meeting the requirements of Section 160.3(a)2Di.

   Exception to Section 160.3(a)2F: Zones designed to be conditioned continuously.

G. **Automatic demand shed controls.** See Section 110.12 for requirements for automatic demand shed controls.

H. **Economizer Fault Detection and Diagnostics (FDD).** All newly installed air handlers with a mechanical cooling capacity over 33,000 Btu/hr and an installed air economizer shall include a stand-alone or integrated Fault Detection and Diagnostics (FDD) system in accordance with Subsections 160.3(a)2Hi through 160.3(a)2Hviii.

   i. The following temperature sensors shall be permanently installed to monitor system operation: outside air, supply air and, when required for differential economizer operation, a return air sensor; and

   ii. Temperature sensors shall have an accuracy of ±2°F over the range of 40°F to 80°F; and

   iii. The controller shall have the capability of displaying the value of each sensor; and

   iv. The controller shall provide system status by indicating the following conditions:

      a. Free cooling available;

      b. Economizer enabled;

      c. Compressor enabled;

      d. Heating enabled, if the system is capable of heating; and

      e. Mixed air low limit cycle active.

v. The unit controller shall allow manual initiation of each operating mode so that the operation of cooling systems, economizers, fans and heating systems can be independently tested and verified; and

vi. Faults shall be reported in one of the following ways:

a. Reported to an Energy Management Control System regularly monitored by facility personnel.

b. Annunciated locally on one or more zone thermostats, or a device within five feet of zone thermostat(s), clearly visible, at eye level and meeting the following requirements:

I. On the thermostat, the device or an adjacent written sign, display instructions to contact appropriate building personnel or an HVAC technician; and

II. In buildings with multiple tenants, the annunciation shall either be within property management offices or in a common space accessible by the property or building manager.

c. Reported to a fault management application that automatically provides notification of the fault to remote HVAC service provider.

vii. The FDD system shall detect the following faults:

a. Air temperature sensor failure/fault;

b. Not economizing when it should;

c. Economizing when it should not;

d. Damper not modulating; and

e. Excess outdoor air.

viii. The FDD system shall be certified to the Energy Commission as meeting the requirements of Sections 160.3(a)2Hi through 160.3(a)2Hvii in accordance with Section 110.0 and JA6.3.

Exception to Section 160.3(a)2Hviii: FDD algorithms based in direct digital control systems are not required to be certified to the Energy Commission.

I. **Direct Digital Controls (DDC).** Direct digital controls to the zone shall be provided as specified by Table 160.3-C.

i. The provided DDC system shall meet the control logic requirements of Sections 160.3(a)2E and 160.3(a)2G, and be capable of the following:

ii. Monitoring zone and system demand for fan pressure, pump pressure, heating and cooling;

iii. Transferring zone and system demand information from zones to air distribution system controllers and from air distribution systems to heating and cooling plant controllers;

iv. Automatically detecting the zones and systems that may be excessively driving the reset logic and generate an alarm or other indication to the system operator;

v. Readily allow operator removal of zone(s) from the reset algorithm;

vi. For new buildings, trending and graphically displaying input and output points; and

vii. Resetting heating and cooling setpoints in all noncritical zones upon receipt of a signal from a centralized contact or software point as described in Section 160.3(a)2G.

J. **Optimum start/stop controls.** Space-conditioning systems with DDC to the zone level shall have optimum start/stop controls. The control algorithm shall, as a minimum, be a function of the difference between space temperature and occupied setpoint, the outdoor air temperature, and the amount of time prior to scheduled occupancy. Mass radiant floor slab systems shall incorporate floor temperature onto the optimum start algorithm.

Exception to Section 160.3(a)2J: Systems that must operate continuously.

(b) Dwelling unit space-conditioning and air distribution systems.

1. **Building cooling and heating loads.** Building heating and cooling loads shall be determined using a method based on any one of the following, using cooling and heating loads as two of the criteria for equipment sizing and selection:

A. The ASHRAE Handbook, Equipment Volume, Applications Volume and Fundamentals Volume; or

B. The SMACNA Residential Comfort System Installation Standards Manual; or

C. The ACCA Manual J.

Exception to Section 160.3(b)1: Block loads, the total load for all rooms combined that are served by the central equipment, may be used for the purpose of system sizing for additions.

Note: Heating systems are required to have a minimum heating capacity adequate to meet the minimum requirements of the CBC.

«» Commentary for Section 160.3(b)1:

Equipment Sizing

The Energy Code does not set limits on the sizing of heating and cooling equipment, but does require that heating and cooling loads be calculated for new HVAC systems. Oversized equipment typically operates less efficiently and can create comfort problems due to excessive cycling and improper airflow. Ducts must be sized correctly, otherwise the system airflow rate may be restricted, adversely affecting the efficiency of the system and preventing the system from meeting the mandatory minimum airflow rate requirements.

Acceptable load calculation procedures include methods described in the following publications:

1. The ASHRAE Handbook – Equipment
2. The ASHRAE Handbook – Applications
3. The ASHRAE Handbook – Fundamentals
4. The SMACNA Residential Comfort System Installation Standards Manual
5. ACCA Manual J

«»

2. **Design conditions.** Design conditions shall be determined in accordance with the following:

   A. For the purpose of sizing the space-conditioning (HVAC) system, the indoor design temperatures shall be 68°F for heating and 75°F for cooling.

   B. Outdoor design conditions shall be selected from one of the following:

      i. Reference Joint Appendix JA2, which is based on data from the ASHRAE Climatic Data for Region X; or

      ii. The ASHRAE Handbook Fundamentals Volume; or

      iv. The ACCA Manual J

   C. The outdoor design temperatures for heating shall be no lower than the 99.0 percent Heating Dry Bulb or the Heating Winter Median of Extremes values.

   D. The outdoor design temperatures for cooling shall be no greater than the 1.0 percent Cooling Dry Bulb and Mean Coincident Wet Bulb values.

«» Commentary for Section 160.3(b)2:

The Energy Code requires that the outdoor design conditions for heating load calculations be selected from JA2, the ASHRAE Fundamentals Volume, or ACCA Manual J and that the indoor design temperature for heating load calculations must be 68°F. The outdoor design temperature must be no lower than the "Heating Winter Median of Extremes," as listed in JA2. In the case of the "99.0 percent Dry Bulb," the phrase "no lower than" does not refer to the design temperature itself, but rather to the "99.0%" value, meaning the 99.6% dry bulb heating value could be selected, but not the 97.5% dry bulb heating value. The outdoor design conditions for cooling load calculations must be selected from JA2, Table 2-3, The ASHRAE Fundamentals Volume, or ACCA Manual J using values no greater than the "1.0 percent Cooling Dry Bulb" and "Mean Coincident Wet Bulb" values listed. In the case of the "1.0 percent Cooling Dry Bulb," the phrase "no greater than" does not refer to the design temperature itself, but rather to the 1.0% value. The indoor design temperature for cooling load calculations must be 75°F.

If the actual city location for a project is not included in JA2, or if the data given for a particular city do not match the conditions at the actual site as well as that given for another nearby city, consult the local building department for guidance.

The load calculations may be submitted with the compliance documentation when requested by the building department.

The load calculations may be prepared by a mechanical engineer, the mechanical contractor who is installing the equipment or someone who is qualified to do so in the State of California according to Division 3 of the Business and Professions Code.

3. **Outdoor condensing units**.

   A. **Clearances.** Installed air conditioner and heat pump outdoor condensing units shall have a clearance of at least five feet (1.5 meters) from the outlet of any dryer vent.

   B. **Liquid line drier.** Installed air conditioner and heat pump systems shall be equipped with liquid line filter driers if required, as specified by manufacturer's instructions.

«» Commentary for Section 160.3(b)3:

Any obstruction of the airflow through the outdoor unit of an air conditioner or heat pump lowers efficiency. Dryer vents are prime sources for substances that clog outdoor coils and sometimes discharge substances that can cause corrosion. Therefore, condensing units must not be placed within five feet of a dryer vent. Regardless of location, condenser coils should be cleaned regularly. The manufacturer installation instructions may include requirements for minimum horizontal and vertical distance to surrounding objects that should be met if greater than the minimum distance required by the Energy Code. Figure 4-15: Noncompliant Condensing Unit Clearance from Dryer Vents shows an example when a condensing unit installed location does not meet the clearance requirement.

Figure 4-15: Noncompliant Condensing Unit Clearance from Dryer Vents

Source: California Energy Commission

Liquid line filter driers are components of split system air-conditioners and split system heat pumps that are installed in the refrigerant line to remove moisture and particles from the refrigerant stream. These contaminants may be introduced in the refrigerant as a result of improper flushing, evacuation, and charging procedures, causing the efficiency and capacity of the air conditioner to be impaired or damaging components. If required by manufacturer's instructions, liquid line filter dryers must be installed. Sometimes, liquid line filter dryers are preinstalled by manufacturers within condensing units. Some manufacturers install liquid line filter dryers outside condensers, so they can be easily serviced by technicians and more easily verified by ECC-Raters.

The quality of the filter dryer installation impacts the effectiveness of the liquid line filter dryer, as some liquid line filter dryers can be installed without regard to the direction of refrigerant flow. Heat pumps, for example, allow refrigerant flow in both directions. However, in other air conditioners where refrigerant flow occurs in only one direction, correct orientation of the liquid line filter dryer is important. «»

4. **Central forced-air heating furnaces**.

   A. **Temperature rise**. Central forced-air heating furnace installations shall be configured to operate in conformance with the furnace manufacturer's maximum inlet-to-outlet temperature rise specifications.

5. **Air-distribution and ventilation system ducts, plenums and fans.**

   A. **CMC compliance.**

      i. All air-distribution system ducts and plenums, including, but not limited to, mechanical closets and air-handler boxes, shall meet the requirements of the CMC Sections 601.0, 602.0, 603.0, 604.0 and 605.0 and ANSI/SMACNA-006-2006 HVAC Duct Construction Standards Metal and Flexible 3rd Edition, incorporated herein by reference.

      ii. Portions of supply-air and return-air ducts and plenums of a space heating or cooling system shall be insulated in accordance with either Subsection a or b below:

         a. Ducts shall have a minimum installed level of R-6.0, or

         Exception to Section 160.3(b)5Aiia: Portions of the duct system located in conditioned space below the ceiling separating the occupiable space from the attic are not required to be insulated if all of the following conditions are met:

         i. The noninsulated portion of the duct system is located entirely inside the building's thermal envelope as confirmed by visual inspection.

         ii. At all locations where noninsulated portions of the duct system penetrate into unconditioned space, the penetration shall be draft stopped compliant with CFC Sections 703.1 and 704.1 and air-sealed to the construction materials that are penetrated, using materials compliant with CMC Section E502.4.2 to prevent air infiltration into the cavity. All connections in unconditioned space are insulated to a minimum of R-6.0 as confirmed by visual inspection.

«» Commentary for Section 160.3(b)5Aiia:

Portions of supply-air and return-air ducts and plenums that are not installed entirely in conditioned space must have a minimum R-value of R-6.0. Ducts installed in conditioned space do not require insulation if the following conditions are met and verified by visual inspection by the building department:

1. The noninsulated portion of the duct system is located entirely inside conditioned space within the building's thermal envelope.
2. At all locations where noninsulated portions of the duct system penetrate unconditioned space, the penetration must be draft stopped compliant with California Fire Code (CFC) sections 703.1 and 704.1 and air-sealed with materials complaint with California Mechanical Code (CMC) section E502.4.2. All connections in unconditioned space must be insulated to at least R-6.0. «»

b. Ducts do not require insulation when the duct system is located entirely in conditioned space. For buildings with three or fewer habitable stories, duct systems located entirely in conditioned space shall be confirmed through field verification and diagnostic testing in accordance with the requirements of Reference Residential Appendix RA3.1.4.3.8.

«» Commentary for Section 160.3(b)5Aiib:

Alternatively, ducts may be uninsulated if the entire duct system is verified to be entirely in conditioned space as defined in Section 100.1 by field verification and by using the protocols of RA3.1.4.3.8.

RA3.1.4.3.8 describes the duct leakage to outside test that determines whether the ducts are within the pressure boundary of the space being served by the duct system. A basic visual inspection of the ducts ensures that no portion of the duct system is obviously outside the apparent pressure/thermal boundary.

Leakage to outside means conditioned air leaking from the ducts to anywhere outside the pressure boundary of the dwelling unit conditioned space served by the duct system, which includes leakage to outside the building and leakage to adjacent dwelling units or other interior building spaces. «»

iii. Connections of metal ducts and the inner core of flexible ducts shall be mechanically fastened.

iv. Openings shall be sealed with mastic, tape, or other duct-closure system that meets the applicable requirements of UL 181, UL 181A or UL 181B or aerosol sealant that meets the requirements of UL 723. If mastic or tape is used to seal openings greater than 1/4 inch, the combination of mastic and either mesh or tape shall be used.

v. Building cavities, support platforms for air handlers, and plenums designed or constructed with materials other than sealed sheet metal, duct board or flexible duct shall not be used for conveying conditioned air. Building cavities and support platforms may contain ducts. Ducts installed in cavities and support platforms shall not be compressed to cause reductions in the cross-sectional area of the ducts.

«» Commentary for Section 160.3(b)5Aiii-v:

Building spaces such as cavities between walls, support platforms for air handlers, and plenums defined or constructed with materials other than sealed sheet metal, duct board, or flexible duct must not be used for conveying conditioned air, including return air and supply air. Using drywall materials as the interior surface of a return plenum is not allowed. Building cavities and support platforms may contain ducts. Ducts installed in cavities and support platforms must not be compressed to cause reductions in the cross-sectional area of the ducts. Although a ECC-Rater or acceptance test technician may examine this as a part of his or her responsibilities when involved in a project, the enforcement of these minimum standards for ducts is the responsibility of the building official. **«»**

Exception to Section 160.3(b)5A: Ducts and fans integral to a wood heater or fireplace.

B. **Factory-fabricated duct systems**.

i. All factory-fabricated duct systems shall comply with UL 181 for ducts and closure systems, including collars, connections and splices, and be labeled as complying with UL 181. UL 181 testing may be performed by UL laboratories or a laboratory approved by the Executive Director.

«» Commentary for Section 160.3(b)5Bi:

The CEC has approved three cloth-backed duct tapes with special butyl synthetic adhesives rather than rubber adhesive to seal flex duct to fittings. These tapes are:

1. Polyken 558CA, manufactured by Berry Plastics Tapes and Coatings Division.
2. Nashua 558CA, manufactured by Berry Plastics Tapes and Coatings Division.
3. Shurtape PC 858CA, manufactured by Shurtape Technologies, Inc.

These tapes passed Lawrence Berkeley Laboratory tests comparable to those that cloth-backed, rubber-adhesive duct tapes failed. (The LBNL test procedure has been adopted by the American Society of Testing and Materials as ASTM E2342.) These tapes are allowed to be used to seal flex duct to fittings without being in combination with mastic. These tapes cannot be used to seal other duct system joints, such as the attachment of fittings to plenums and junction boxes. These tapes have on the backing a drawing of a fitting to plenum joint in a red circle with a slash through it (the international symbol of prohibition) to illustrate where they are not allowed to be used, installation instructions in the packing boxes that explain how to install them on duct core to fittings, and a statement that the tapes cannot be used to seal fitting to plenum and junction box joints. **«»**

ii. All pressure-sensitive tapes, heat-activated tapes and mastics used in the manufacture of rigid fiberglass ducts shall comply with UL 181 and UL 181A.

iii. All pressure-sensitive tapes and mastics used with flexible ducts shall comply with UL 181 and UL 181B.

iv. Joints and seams of duct systems and their components shall not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.

C. **Field-fabricated duct systems.**

i. Factory-made rigid fiberglass and flexible ducts for field-fabricated duct systems shall comply with UL 181. All pressure-sensitive tapes, mastics, aerosol sealants or other closure systems used for installing field-fabricated duct systems shall meet the applicable requirements of UL 181, UL 181A and UL 181B.

ii. Mastic sealants and mesh.

a. Sealants shall comply with the applicable requirements of UL 181, UL 181A and UL 181B, and be nontoxic and water resistant.

b. Sealants for interior applications shall be tested in accordance with ASTM C731 and D2202, incorporated herein by reference.

c. Sealants for exterior applications shall be tested in accordance with ASTM C731, C732 and D2202, incorporated herein by reference.

d. Sealants and meshes shall be rated for exterior use.

iii. Pressure-sensitive tape. Pressure-sensitive tapes shall comply with the applicable requirements of UL 181, UL 181A and UL 181B.

iv. Joints and seams of duct systems and their components shall not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.

v. Drawbands used with flexible duct.

a. Drawbands shall be either stainless-steel worm-drive hose clamps or UV-resistant nylon duct ties.

b. Drawbands shall have a minimum tensile strength rating of 150 pounds.

c. Drawbands shall be tightened as recommended by the manufacturer with an adjustable tensioning tool.

vi. Aerosol-sealant closures.

a. Aerosol sealants shall meet the requirements of UL 723 and be applied according to manufacturer specifications.

b. Tapes or mastics used in combination with aerosol sealing shall meet the requirements of this section.

D. **Duct insulation R-value ratings.** All duct insulation product R-values shall be based on insulation only (excluding air films, vapor retarder or other duct components) and tested C-values at 75°F mean temperature at the installed thickness, in accordance with ASTM C518 or ASTM C177, incorporated herein by reference, and certified pursuant to Section 110.8.

E. **Duct insulation thickness.** The installed thickness of duct insulation used to determine its R-value shall be determined as follows:

i. For duct board, duct liner and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used**.**

ii. For duct wrap, installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.

iii. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.

F. **Duct labeling.** Insulated flexible duct products installed to meet this requirement shall include labels, in maximum intervals of 3 feet, showing the thermal performance R-value for the duct insulation itself (excluding air films, vapor retarder or other duct components), based on the tests in Section 160.3(b)5D and the installed thickness determined by Section 160.3(b)5Eiii.

G. **Backdraft dampers.** All fan systems, regardless of volumetric capacity, that exchange air between the building conditioned space and the outside of the building shall be provided with backdraft or automatic dampers to prevent unintended air leakage through the fan system when the fan system is not operating.

«» Commentary for Section 160.3(b)5G:

Fan systems that exhaust air from the building to the outside must be provided with back draft or automatic dampers. **«»**

H. **Gravity ventilation dampers.** All gravity ventilating systems that serve conditioned space shall be provided with either automatic or readily accessible, manually operated dampers in all openings to the outside except combustion inlet and outlet air openings and elevator shaft vents.

«» Commentary for Section 160.3(b)5H:

This may clothes dryer exhaust vents when installed in conditioned space. **«»**

I. **Protection of insulation.** Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance and wind but not limited to the following: Insulation exposed to weather shall be suitable for outdoor service (e.g., protected by aluminum, sheet metal, painted canvas or plastic cover). Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.

J. **Porous inner core flex duct.** Flexible ducts having porous inner cores shall have a nonporous layer or air barrier between the inner core and the outer vapor barrier.

K. **Duct system sealing and leakage testing.** When space-conditioning systems utilize forced air duct systems to supply conditioned air to an individual dwelling unit, the ducts shall be sealed, as confirmed through field verification and diagnostic testing, in accordance with all applicable procedures specified in Reference Residential Appendix RA3.1. Air handler airflow for calculation of duct leakage rate compliance targets shall be determined according to methods specified in Reference Residential Appendix RA3.1.4.2**.**

For multifamily dwellings with the air-handling unit installed and the ducts connected directly to the air handler, regardless of duct system location:

i. The total leakage of the duct system shall not exceed 12 percent of the air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1; or

ii. The duct system leakage to outside shall not exceed 6 percent of the air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4.

Exception 1 to Section 160.3(b)5K: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four habitable stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

Exception 2 to Section 160.3(b)5K: Multifamily dwelling units in buildings four habitable stories and greater in Climate Zones 1, 3, 5 and 7.

«» Commentary for Section 160.3(b)5K:

Duct systems in newly constructed multifamily dwellings are required to comply with the sealing and leakage testing requirements regardless of the duct system location, except for buildings with four or more habitable stories in climate zones 1, 3, 5, and 7, which are exempt from the testing requirements. When the air-handling unit is installed and the ducts connected directly to the air handler, the total leakage of the duct system must not exceed 12% of the nominal system air handler airflow or the duct system leakage to outside must not exceed 6% of the nominal system air handler airflow.

The duct system leakage must be determined according to the applicable procedures outlined in RA3.1.4.3. Verification of duct leakage must be conducted by a ECC-Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings in climate zones 2, 4, 6, and 8 – 16, testing only needs to be conducted and certified by the installing contractor and neither a ECC-Rater nor registration with a ECC-Provider is required. Entirely new or complete replacement duct systems as part of an addition or alteration in all climate zones are required to comply with these mandatory maximum leakage criteria. A duct system in an existing building is considered entirely new when:

1. At least 75% of the duct material is new.
1. All remaining components from the previous system are accessible and can be sealed.**«»**

L. **System airflow rate and fan efficacy.** Space-conditioning systems that utilize forced air ducts to supply cooling to an individual dwelling unit shall:

i. **Static pressure probe.** Have a hole for the placement of a static pressure probe (HSPP), or a permanently installed static pressure probe (PSPP) in the supply plenum downstream of the air conditioning evaporator coil. The size, location and labeling of the HSPP or PSPP shall conform to the requirements specified in Reference Residential Appendix RA3.3.1.1 as confirmed by field verification and diagnostic testing; and

Exception to Section 160.3(b)5Li: Systems that cannot conform to the specifications for hole location in Reference Residential Appendix Figure RA3.3-1 shall not be required to provide holes as described in Figure RA3.3-1.

«» Commentary for Section 160.3(b)5L:

Space-conditioning systems that use forced air ducts to cool occupiable space must have a HSPP or PSPP installed downstream from the evaporator coil. The HSPP or PSPP must be installed in the required location, in accordance with the specifications detailed in Reference Residential Appendix RA3.3. The HSPP or PSPP are required to promote system airflow measurement when using devices/procedures that depend on supply plenum pressure measurements. The HSPP or PSPP allows ECC-Raters to perform the required diagnostic airflow testing in a nonintrusive manner by eliminating the necessity for the raters to drill holes in the supply plenum for placement of pressure measurement probes.

The size and placement of the HSPP/PSPP must be in accordance with RA3.3.1.1 and must be verified by a ECC-Rater. If the HSPP/PSPP cannot be installed as shown in Figure RA3.3-1 because of the configuration of the system or that the location is not accessible, an alternative location may be provided that can accurately measure the average static pressure in the supply plenum. If an alternative location cannot be provided, then the HSPP/PSPP is not required to be installed. The ECC-Rater will verify this for multifamily buildings up to three stories. Not installing an HSPP/PSPP will limit the airflow measurement method to either a powered flow hood or passive (traditional) flow hood.

The HSPP/PSPP requirement also applies when the plenum pressure matching method or the flow grid method of airflow measurement is used by either the installer or the rater to verify airflow in an altered system. The HSPP/PSPP must be installed by the installer, not the rater. **«»**

ii. **Single zone central forced air systems**. Demonstrate, in every control mode, airflow greater than or equal to 350 cfm per ton of nominal cooling capacity through the return grilles, and an air-handling unit fan efficacy less than or equal to the maximum W/cfm specified in Subsection a or b below. The airflow rate and fan efficacy requirements in this section shall be confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.

a. 0.45 W/cfm for gas furnace air-handling units.

b. 0.58 W/cfm for air-handling units that are not gas furnaces.

Exception 1 to Section 160.3(b)5Lii: Standard ducted systems without zoning dampers may comply by meeting the applicable requirements in Table 160.3-A or 160.3-B as confirmed by field verification and diagnostic testing in accordance with the procedures in Reference Residential Appendix Sections

RA3.1.4.4 and RA3.1.4.5. The design clean-filter pressure drop requirements specified by Section 160.2(b)1Div for the system air filter(s) shall conform to the requirements given in Table 160.3-A or 160.3-B.

Exception 2 to Section 160.3(b)5Lii: Multispeed compressor systems or variable speed compressor systems shall verify airflow (cfm/ton) and fan efficacy (watt/cfm) for system operation at the maximum compressor speed and the maximum air handler fan speed.

Exception 3 to Section 160.3(b)5Lii: Gas furnace air-handling units manufactured prior to July 3, 2019 shall comply with a fan efficacy value less than or equal to 0.58 w/cfm as confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.

«» Commentary for Section 160.3(b)5Lii:

Adequate airflow is critical for cooling equipment efficiency. Further, it is important to maintain adequate airflow without expending excessive fan power. Section 160.3(b)5L establishes mandatory requirements that are intended to ensure adequate cooling airflow through properly sized ducts and efficient fan motors.

There are two options allowed to ensure adequate air flow. The first option is to design and install the systems using standard design criteria and then have the airflow and fan efficacy of the system tested in the field. The second option is to size the return ducts according to Exception 1 to Section 160.3(b)5Lii and iv.

Both options require verification. Verification must be conducted by a ECC-Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings in Climate Zones 2-16, verification only needs to be conducted and certified by the installing contractor and neither a ECC-Rater nor registration with a ECC-Provider is required. Buildings with four or more habitable stories in Climate Zone 1 are exempt from these mandatory requirements.

Return Duct System Design Method

This method allows the designer to specify, and the contractor to install, a system that does not have to undergo field verification and diagnostic testing for airflow and fan efficacy. This method can be used for systems with either one or two return grilles. Each return must not exceed 30 ft. as measured from the return plenum to the filter grille. When bends are needed, sheet metal elbows are desirable. Each return can have up to 180 degrees of bend, and flex duct can have no more than 90° of bend. To use this method, the designer and installer must provide return system sizing that meets the appropriate criteria in Energy Code Tables 160.3-A and B.

Energy Code Tables 160.3-A and B allow for only one or two returns. There may be times where three returns are necessary on a single system. Furthermore, Table 160.3-B does not allow for deviation from the two sizes specified. For example, the table requires two 14-inch return ducts for a 2.5-ton system, but specific airflow requirements and architectural constraints may dictate an 18-inch and a 12-inch. In this situation, airflow and fan efficacy diagnostic testing are required.

Historically, duct systems have been sized to fit into the dwelling unit at the expense of proper airflow. The performance of these systems, in terms of efficiency and capacity, has suffered greatly because of this practice. The dwelling unit should be designed to accommodate properly sized ducts. This requires improved coordination among the architect, structural engineer, and mechanical designer early in the process.

Tables 160.3-A and B require the use of return grilles that are sized to achieve an optimal face velocity and static pressure drop. Tables 160.3-A and B also require the return grille devices to be labeled in accordance with the requirements in Section 160.2(b)1A to disclose the design airflow rate of the grille and the maximum allowable clean-filter pressure drop for the air filter media, as determined by the system design or applicable standards requirements. The nominal size of the air filter grille or air filter media should be used to calculate the return filter grille gross area for determining compliance with Tables 160.3-A and B. The nominal size of the filter grille is expected to be the same as the nominal size of the air filter media that is used in the grille and is most often the information used to identify these items for purchases. For example, a nominal 20-inch x 30-inch filter grille will use nominal 20-inch x 30-inch air filter media.

Nominal Cooling Capacity

To determine the required airflow for compliance in CFM/ton, the nominal cooling capacity of the system in tons must be known. The nominal cooling capacity system may be obtained from the manufacturer's product literature or from listings of certified product ratings from organizations such as AHRI, but the nominal capacity is usually shown in the unit model number on the manufacturers nameplate attached to the outdoor condensing unit. A two- or three-digit section of the manufacturer's model number typically indicates the nominal capacity in thousands of BTU/hour. Given that there are 12,000 BTU/hour per ton of cooling capacity, the nameplate will display something similar to one of the following number groupings: "018" which represents 1.5 tons; "024," which represents 2 tons; "030," which represents 2.5 tons; "036," which represents 3 tons; "042," which represents 3.5 tons; "048," which represents 4 tons; or “060,” which represents 5 tons.

The following design guidelines will increase the chances of the system passing the airflow and fan efficacy testing:

1. Right-size the HVAC system. If a two-ton unit is enough to satisfy the cooling load, do not install a three-ton unit just to be safe. Oversizing equipment can cause comfort problems in addition to excessive energy use.
2. The HVAC designer must coordinate closely with the architect and structural engineer to make sure that the ducts will fit into the dwelling unit as designed.
3. Prepare a detailed mechanical plan that can be followed in the field. If deviations must occur in the field, make sure that they are coordinated with the designer and that the design is adjusted as needed.
4. Follow Manual D for duct sizing:
   - Make sure that the correct duct type is used (vinyl flex, sheet metal, rigid fiberglass, or other).
   - Make sure that all equivalent lengths and pressure drops are correctly accounted for (bends, plenum start collars, t-wyes, filters, grilles, registers, and so forth.
   - Select an air handler that will provide at least 400 CFM/ton at the desired static pressure of 125 to 150 Pa (0.5 to 0.6 inches w.c.).
   - Design the duct system to a static pressure across the fan of no more than 150 Pa (0.6 inches w.c.).
   - Consider upsizing the evaporator coil relative to the condenser to reduce the static pressure drop. This upsizing results in better airflow and slightly better capacity and efficiency. Manufacturers commonly provide performance data for such condenser coil combinations.
   - Consider specifying an air handler with a high efficiency (brushless permanent magnet) fan motor.
5. Install a large grill area and use a proper filter for the system.
6. Locate registers and equipment to make duct runs as short as possible.
7. Make all short-radius 90° bends out of rigid ducting.
8. Install flex duct properly by stretching all flex duct tight and cutting off excess ducting. Ensure the duct is not kinked or compressed and is properly supported every four ft. or less using one inch strapping. Flex duct should have less than two inches of sag between supports.
9. Consider using better quality supply and filter grilles. Bar-type registers have considerably better airflow performance than standard stamped-face registers. Refer to the manufacturer’s specifications and select accordingly.

«»

iii. **Zonally controlled central forced air systems.** Zonally controlled central forced air cooling systems shall be capable of simultaneously delivering, in every zonal control mode, an airflow from the dwelling, through the air handler fan and delivered to the dwelling, of greater than or equal to 350 cfm per ton of nominal cooling capacity, and operating at an air-handling unit fan efficacy of less than or equal to the maximum W/cfm specified in Subsection a or b below. The airflow rate and fan efficacy requirements in this section shall be confirmed by field verification and diagnostic testing in accordance with the applicable procedures specified in Reference Residential Appendix RA3.3.

a. 0.45 W/cfm for gas furnace air-handling units.

b. 0.58 W/cfm for air-handling units that are not gas furnaces.

Exception 1 to Section 160.3(b)5Liii: Multispeed or variable speed compressor systems, with controls that vary fan speed subject to the number of zones, as certified by the installer may demonstrate compliance with the airflow (cfm/ton) and fan efficacy (watt/cfm) requirements of Section 160.3(b)5Liii by operating the system at maximum compressor capacity and system fan speed with all zones calling for conditioning.

Exception 2 to Section 160.3(b)5Liii: Gas furnace air-handling units manufactured prior to July 3, 2019 shall comply with a fan efficacy value less than or equal to 0.58 w/cfm as confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.

«» Commentary for Section 160.3(b)5Liii:

The primary purpose of zoning ducted air conditioners, heat pumps, and furnaces is to improve comfort and reduce energy usage. Increased comfort is attained by having the capacity of the HVAC system (cooling or heating delivered) follow the shift in load as it changes across the dwelling unit.

Since the most common dwelling unit is single-zoned and has only one thermostat placed near the center of the unit, temperatures in the rooms distant from that thermostat will vary, sometimes significantly. If zoning is added, the more distant rooms may be conditioned to a more comfortable temperature. This increased conditioning requires more energy. When designed correctly, zoning allows only the zones that need conditioning to be conditioned, thus potentially saving energy.

It is common for single-speed zonally controlled central forced-air cooling systems to produce lower total system airflow through the returns when fewer than all zones are calling for conditioning. The reduced airflow lowers the sensible efficiency of single-stage heating or cooling equipment. Two primary causes of lower airflow in multiple zone dampered systems are:

1. Restriction of some system supply ducts by closing zoning dampers in zones that do not need additional cooling, while other zones do need cooling.
2. Recirculation of already-cooled air from the supply plenum directly back to the return plenum without first delivering the cooled air to the conditioned space by use of a bypass duct.

To prevent the lower efficiency that results from reduced system airflow or from recirculated bypass duct airflow, single-speed compressor zonally controlled central cooling systems must demonstrate they simultaneously meet mandatory fan efficacy and airflow requirements in all zonal control modes, which is possible with a duct system design that does not restrict the system total airflow when fewer than all zones are calling for conditioning and does not use a bypass duct. Section 170.2(c)3v prohibits use of bypass ducts prescriptively, but bypass ducts may be used if the efficiency penalty due to the reduced airflow through the return grille is modeled as described later in this section.

Zonally controlled cooling systems with or without bypass dampers (multiple zones served by a single air handler with motorized zone dampers) usually do not meet the airflow and fan efficacy requirements when fewer than all zones are calling. The energy penalty that results from this is greater than the benefit of having zonal control; therefore, zonal control is not always a better-than-minimum condition.

Zonal control accomplished by using multiple single-zone systems is not subject to the requirements specified in Section 160.3(b)5Liii. «»

iv. **Small duct high velocity forced air systems.** Demonstrate, in every control mode, airflow greater than or equal to 250 cfm per ton of nominal cooling capacity through the return grilles, and an air-handling unit fan efficacy less than or equal to 0.62 W/cfm as confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.

Exception 1 to Section 160.3(b)5Liv: Standard ducted systems without zoning dampers may comply by meeting the applicable requirements in Table 160.3-A or 160.3-B as confirmed by field verification and diagnostic testing in accordance with the procedures in Reference Residential Appendix Sections RA3.1.4.4 and RA3.1.4.5. The design clean-filter pressure drop requirements specified by Section 160.2(b)1Div for the system air filter(s) shall conform to the requirements given in Table 160.3-A or 160.3-B.

Exception 2 to Section 160.3(b)5Liv: Multispeed compressor systems or variable speed compressor systems shall verify airflow (cfm/ton) and fan efficacy (watt/cfm) for system operation at the maximum compressor speed and the maximum air handler fan speed.

Exception 1 to Section 160.3(b)5L: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four habitable stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

Exception 2 to Section 160.3(b)5L: Multifamily dwelling units in buildings four habitable stories and greater in Climate Zone 1.

«» Commentary for Section 160.3(b)5L:

Table 4-5: Central Forced-Air Cooling Systems Airflow & Fan Efficacy Requirements

Compressor & Zone Type	Mandatory Requirements for Airflow[1]	Mandatory Requirements for Fan Efficacy[1]
Single Zone Single-Speed or Multispeed (tested on highest speed only)	≥ 350 CFM/ton ≥ 250 CFM/ton if a small duct high velocity (SDHV) type	≤ 0.45 W/CFM for gas furnaces (GF) ≤ 0.58 W/CFM for all other air handlers ≤ 0.62 W/CFM for SDHV type
Zonally Controlled Single Speed (tested	≥ 350 CFM/ton	≤ 0.45 W/CFM for gas furnaces (GF)

Compressor & Zone Type	Mandatory Requirements for Airflow[1]	Mandatory Requirements for Fan Efficacy[1]
at all zonal control modes)[2]	≥ 250 CFM/ton if a small duct high velocity (SDHV) type	≤ 0.58 W/CFM for all other air handlers ≤ 0.62 W/CFM for SDHV type
Zonally Controlled Multispeed (tested at all zonal control modes)	≥ 350 CFM/ton ≥ 250 CFM/ton if a small duct high velocity (SDHV) type	≤ 0.45 W/CFM for gas furnaces (GF) ≤ 0.58 W/CFM for all other air handlers ≤ 0.62 W/CFM for SDHV type

[1]Exception: Airflow and fan efficacy testing not required if return system meets Tables 160.3-A or B. However, verification that return duct installation meets Tables 160.3-A or B is required

[2]For the prescriptive approach, use of a bypass duct is not allowed. For the performance approach, use of a bypass duct may be specified in the compliance software input for the zoned system type.

Source: California Energy Commission

«»

6. Piping for space-conditioning systems, solar water-heating system collector loop, and distribution piping for steam and hydronic heating system shall meet the requirements of Section 160.3(c)1.

7. **Defrost**.

   A. If a heat pump is equipped with a defrost delay timer, the delay timer must be set to greater than or equal to 90 minutes.

   B. The installer shall certify on the Certificate of Installation that the control configuration has been tested in accordance with the testing procedure found in the Certificate of Installation.

   Exception to 160.3(b)7. Dwelling units in Climate Zones 1, 6 through 10, 15, and 16 shall not be required to comply with the 90 minute delay timer requirements.

8. **Capacity variation with third-party thermostats. Variable or multi-speed systems shall comply with the following requirements:**

   A. The space conditioning system and thermostat together shall be capable of responding to heating and cooling loads by modulating system compressor speed.

   B. The installer shall certify on the Certificate of Installation that the control configuration has been tested in accordance with the testing procedure found in the Certificate of Installation.

«» Commentary for Section 160.3(b)8:

The requirement ensures that the installer selects an appropriate thermostat for the space conditioning system being installed. Manufacturers are not expected to make their systems compatible with all thermostats. «»

(c) Fluid distribution systems; common area space-conditioning systems. Multifamily buildings shall comply with the applicable requirements of Section 160.3(a)1. Multifamily common areas shall comply with the applicable requirements of Sections 160.3(a)2A through 160.3(a)2J.

1. **Pipe insulation**. Multifamily buildings shall comply with the applicable requirements of Sections 160.3(c)1A through 160.3(c)1D.

   A. **General requirements.** The piping conditions listed below for space-conditioning systems with fluid normal operating temperatures listed in Table 160.3-D shall have at least the amount of insulation specified in Section 160.3(c)1D:

      i. **Space cooling systems.** All refrigerant suction, chilled water and brine fluid distribution systems.

      ii. **Space heating systems.** All refrigerant suction, steam, steam condensate and hot water fluid distribution systems.

      Exception to Section 160.3(c)1Aii: Heat pumps refrigerant vapor line shall be installed with a minimum of 0.75 inch thick or R-6.0 insulation. No insulation is required on the refrigerant liquid line.

   B. Insulation conductivity shall be determined in accordance with ASTM C335 at the mean temperature listed in Table 160.3-D, and shall be rounded to the nearest 1/100 Btu-inch per hour per square foot per °F. Fluid distribution systems include all elements that are in series with the fluid flow, such as pipes, pumps, valves, strainers, coil u-bends and air separators, but not including elements that are not in series with the fluid flow, such as expansion tanks, fill lines, chemical feeders and drains.

   C. **Insulation protection.** Pipe insulation shall be protected from damage due to sunlight, moisture, equipment maintenance and wind. Protection shall, at minimum, include the following:

      i. Pipe insulation exposed to weather shall be protected by a cover suitable for outdoor service. The cover shall be water retardant and provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall not be used to provide this protection.

      ii. Pipe insulation covering chilled water piping and refrigerant suction piping located outside the conditioned space shall include, or be protected by, a Class I or Class II vapor retarder. All penetrations and joints shall be sealed.

      iii. Pipe insulation buried below grade must be installed in a waterproof and noncrushable casing or sleeve.

   D. **Insulation thickness.**

      i. For insulation with a conductivity in the range shown in Table 160.3-D for the applicable fluid temperature range, the insulation shall have the applicable minimum thickness or R-value shown in Table 160.3-D.

ii. For insulation with a conductivity outside the range shown in Table 160.3-D for the applicable fluid temperature range, the insulation shall have a minimum R-value shown in Table 160.3-D or thickness as calculated with Equation 160.3-A:

$$T = PR\left[\left(1+\frac{t}{PR}\right)^{\frac{K}{k}} - 1\right]$$ (Equation 160.3-A)

WHERE:

T = Minimum insulation thickness for material with conductivity K, inches.

PR = Pipe actual outside radius, inches.

t = Insulation thickness from TABLE 160.3-D, inches.

K = Conductivity of alternate material at the mean rating temperature indicated in TABLE 160.3-D for the applicable fluid temperature range, in Btu-inch per hour per square foot per °F.

k = The lower value of the conductivity range listed in TABLE 160.3-D for the applicable fluid temperature range, Btu-inch per hour per square foot per °F.

Exception 1 to Section 160.3(c)1: Factory-installed piping within space-conditioning equipment certified under Section 110.1 or 110.2.

Exception 2 to Section 160.3(c)1: Piping that conveys fluids with a design operating temperature range between 60°F and 105°F.

Exception 3 to Section 160.3(c)1: Where the heat gain or heat loss to or from piping without insulation will not increase building source energy use.

Exception 4 to Section 160.3(c)1: Piping that penetrates framing members shall not be required to have pipe insulation for the distance of the framing penetration. Metal piping that penetrates metal framing shall use grommets, plugs, wrapping or other insulating material to ensure that no contact is made with the metal framing.

«» Commentary for Section 160.3(c)1:

For air conditioners and heat pumps, two refrigerant lines connect the indoor and outdoor units of split-system air conditioners and heat pumps: the liquid line (the smaller diameter line) and the suction line (the larger diameter line). If the liquid line is at an elevated temperature relative to outdoor and indoor temperatures, it should not be insulated. In those areas, heat escaping from it is helpful.

The suction line carries refrigerant vapor that is cooler than ambient in the summer and (with heat pumps) warmer than ambient in the winter. This line must be insulated to the required thickness (in inches).

Insulation used for refrigerant suction lines located outside of conditioned space must include a Class I or Class II vapor retarder. The vapor retarder and insulation must be protected from physical damage, UV deterioration, and moisture with a covering that can be removed for equipment maintenance without destroying the insulation. Insulation is typically protected by aluminum, sheet metal jacket, painted canvas, or plastic cover. Adhesive tape should not be used as insulation protection because removal of the tape will damage the integrity of the original insulation during preventive maintenance. See Figure 4-16: Refrigerant Line Insulation for example of refrigerant line insulation.

Figure 4-16: Refrigerant Line Insulation

Source: Airex Manufacturing Inc.

Most piping conveying mechanically heated or chilled fluids for space conditioning or service water heating must be insulated. The required thickness of piping insulation depends on the temperature of the fluid passing through the pipe, the pipe diameter, the function of the pipe within the system, and the insulation’s thermal conductivity. «»

2. **Requirements for air distribution system, ducts and plenum.** Multifamily common areas shall comply with the applicable requirements of Sections 160.3(c)2A through 160.3(c)2F.

   A**. CMC compliance.** All air distribution system ducts and plenums, including, but not limited to, building cavities, mechanical closets, air-handler boxes and support platforms used as ducts or plenums shall meet the requirements of CMC Sections 601.0, 602.0, 603.0, 604.0 and 605.0, and ANSI/SMACNA-006-2006 HVAC Duct Construction Standards Metal and Flexible 3rd Edition, incorporated herein by reference. Connections of metal ducts and the inner core of flexible ducts shall be mechanically fastened. Openings shall be sealed with mastic, tape, aerosol sealant or other duct-closure system that meets the applicable requirements of UL 181, UL 181A or UL 181B. If mastic or tape is used to seal openings greater than 1/4 inch, the combination of mastic and either mesh or tape shall be used.

«» Commentary for Section 160.3(c)2A:

Poorly sealed or poorly insulated duct work can cause substantial losses of air volume and energy. All air distribution system ducts and plenums, including building cavities, mechanical closets, air handler boxes and support platforms used as ducts or plenums, are required to be in accordance with the California Mechanical Code Sections 601, 602, 603, 604, 605 and ANSI/SMACNA-006-2006 HVAC Duct Construction Standards - Metal and Flexible, 3rd Edition. «»

B. Portions of supply-air and return-air ducts conveying heated or cooled air located in one or more of the following spaces shall be insulated to a minimum installed level of R-8:

   i. Outdoors; or

   ii. In a space between the roof and an insulated ceiling; or

   iii. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces; or

   iv. In an unconditioned crawl space; or

   v. In other unconditioned spaces.

   Portions of supply-air ducts that are not in one of these spaces, including ducts buried in concrete slab, shall be insulated to a minimum installed level of R-4.2 or be enclosed in directly conditioned space.

C**. Duct and plenum materials.**

   i. **Factory-fabricated duct systems.**

      a. All factory-fabricated duct systems shall comply with UL 181 for ducts and closure systems, including collars, connections and splices, and be labeled as complying with UL 181. UL 181 testing may be performed by UL laboratories or a laboratory approved by the Executive Director.

«» Commentary for Section 160.3(c)2B-C:

The CEC has approved three cloth-backed duct tapes with special butyl synthetic adhesives rather than rubber adhesive to seal flex duct to fittings. These tapes are:

1. Polyken 558CA, manufactured by Berry Plastics Tapes and Coatings Division.
2. Nashua 558CA, manufactured by Berry Plastics Tapes and Coatings Division.
3. Shurtape PC 858CA, manufactured by Shurtape Technologies, Inc.

These tapes passed Lawrence Berkeley Laboratory tests comparable to those that cloth-backed, rubber-adhesive duct tapes failed. (The LBNL test procedure has been adopted by the American Society of Testing and Materials as ASTM E2342.) These tapes are allowed to be used to seal flex duct to fittings without being in combination with mastic. These tapes cannot be used to seal other duct system joints, such as the attachment of fittings to plenums and junction boxes. These tapes have on the backing a drawing of a fitting to plenum joint in a red circle with a slash through it (the international symbol of prohibition) to illustrate where they are not allowed to be used, installation instructions in the packing boxes that explain how to install them on duct core to fittings, and a statement that the tapes cannot be used to seal fitting to plenum and junction box joints. «»

b. All pressure-sensitive tapes, heat-activated tapes and mastics used in the manufacture of rigid fiberglass ducts shall comply with UL 181 and UL 181A.

c. All pressure-sensitive tapes and mastics used with flexible ducts shall comply with UL 181 and UL 181B.

d. Ductwork and plenums with pressure class ratings shall be constructed to Seal Class A. Joints and seams of duct systems and their components shall not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.

Exception to Section 160.3(c)2Cid: Ductwork located in occupied space and exposed to view.

«» Commentary for Section 160.3(c)2C:

The Energy Code requires all ductwork to be sealed to meet Seal Class A. Sealing means the use of adhesives, gaskets, and/or tape systems to close openings in the surface of ductwork and field erected plenums and casings through which air leakage would occur, or the use of continuous welds. Seal Class A means sealing all ductwork connections and applicable duct wall penetrations. Penetrations include pipe, tubing, rods, and wire. Rods that penetrate the duct wall must be allowed to move to function properly (such as a control rod for a volume damper) and should not be sealed in a way that prevents operation. Penetrations do not include screws and other fasteners. «»

ii. **Field-fabricated duct systems.**

a. Factory-made rigid fiberglass and flexible ducts for field-fabricated duct systems shall comply with UL 181. All pressure-sensitive tapes, mastics, aerosol sealants or other closure systems used for installing field-fabricated duct systems shall meet the applicable requirements of UL 181, UL 181A and UL 181B.

b. Mastic sealants and mesh.

I. Sealants shall comply with the applicable requirements of UL 181, UL 181A and UL 181B, and be nontoxic and water resistant.

II. Sealants for interior applications shall pass ASTM C731 (extrudability after aging) and D2202 (slump test on vertical surfaces), incorporated herein by reference.

III. Sealants for exterior applications shall pass ASTM C731, C732 (artificial weathering test) and D2202, incorporated herein by reference.

IV. Sealants and meshes shall be rated for exterior use.

c. Pressure-sensitive tape. Pressure-sensitive tapes shall comply with the applicable requirements of UL 181, UL 181A and UL 181B.

d. Ductwork and plenums with pressure class ratings shall be constructed to Seal Class A. Joints and seams of duct systems and their components shall not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.

«» Commentary for Section 160.3(c)2C:

The Energy Code requires all ductwork to be sealed to meet Seal Class A. Sealing means the use of adhesives, gaskets, and/or tape systems to close openings in the surface of ductwork and field erected plenums and casings through which air leakage would occur, or the use of continuous welds. Seal Class A means sealing all ductwork connections and applicable duct wall penetrations. Penetrations include pipe, tubing, rods, and wire. Rods that penetrate the duct wall must be allowed to move to function properly (such as a control rod for a volume damper) and should not be sealed in a way that prevents operation. Penetrations do not include screws and other fasteners. **«»**

e. Drawbands used with flexible duct.

I. Drawbands shall be either stainless-steel worm-drive hose clamps or UV-resistant nylon duct ties.

II. Drawbands shall have a minimum tensile strength rating of 150 pounds.

III. Drawbands shall be tightened as recommended by the manufacturer with an adjustable tensioning tool.

f. Aerosol-sealant closures.

I. Aerosol sealants shall meet the requirements of UL 723 and be applied according to manufacturer specifications.

II. Tapes or mastics used in combination with aerosol sealing shall meet the requirements of this section.

D. All duct insulation product R-values shall be based on insulation only (excluding air films, vapor retarders or other duct components) and tested C-values at 75°F mean temperature at the installed thickness, in accordance with ASTM C518 or ASTM C177, incorporated herein by reference, and certified pursuant to Section 110.8.

E. The installed thickness of duct insulation used to determine its R-value shall be determined as follows:

i. For duct board, duct liner and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.

ii. For duct wrap, installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.

iii. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.

F. Insulated flexible duct products installed to meet this requirement must include labels, in maximum intervals of 3 feet, showing the thermal performance R-value for the duct insulation itself (excluding air films, vapor retarder or other duct components), based on the tests in Section 160.3(c)2D and the installed thickness determined by Section 160.3(c)2Eiii.

G. Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance and wind but not limited to the following: Insulation exposed to weather shall be suitable for outdoor service; e.g., protected by aluminum, sheet metal, painted canvas or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.

H. Duct systems shall be tested in accordance with i or ii below:

i. New duct systems that meet the criteria in Subsections a, b and c below or ductwork that is part of a system that meets the criteria of Section 180.2(b)2B shall be sealed to a leakage rate not to exceed 6 percent of the nominal air handler airflow rate as confirmed through acceptance testing, in accordance with Reference Nonresidential Appendix NA7.5.3.

a. The duct system provides conditioned air to an occupiable space for a constant volume, single zone, space-conditioning system; and

b. The space-conditioning system serves less than 5,000 square feet of conditioned floor area; and

c. The combined surface area of the ducts located in the following spaces is more than 25 percent of the total surface area of the entire duct system:

I. Outdoors; or

II. In a space directly under a roof that has a U-factor greater than the U-factor of the ceiling, or if the roof does not meet the requirements of Section 170.2(a)1; or

III. In a space directly under a roof that has fixed vents or openings to the outside or unconditioned spaces; or

IV. In an unconditioned crawl space; or

V. In other unconditioned spaces.

ii. All duct systems that do not meet the criteria in Section 160.3(c)2H shall meet the duct leakage testing requirements of CMC Section 603.9.2.

«» Commentary for Section 160.3(c)2H:

The 2019 California Mechanical Code (CMC) introduced mandatory requirements to seal and test all nonresidential air distribution systems and all systems that do not meet the criteria for testing according to the Energy Code may be required to meet the requirements in the CMC.

The outside air ducts for CFI ventilation systems are not allowed to be sealed/taped off during duct leakage testing. However, CFI outdoor air ductwork that uses controlled motorized dampers that open only when outdoor air ventilation is required and close when outdoor air ventilation is not required may be closed during duct leakage testing. **«»**

(d) **Mechanical acceptance testing.**

1. Common areas. Before an occupancy permit is granted, the following systems and equipment serving multifamily common areas shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified by Reference Nonresidential Appendix NA7. These systems and equipment shall also comply with the applicable requirements of Section 160.3(d)3. A Certificate of Acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the acceptance requirements:

   A. Outdoor air ventilation systems shall be tested in accordance with NA7.5.1.

«» Commentary for Section 160.3(d)1A:

This test (NA7.5.1) ensures the constant volume air handling unit provides adequate outdoor air ventilation to the spaces served under all operating conditions. Systems requiring demand ventilation controls per Section 160.2(c)5C must conform to Section 160.2(c)5D regarding the minimum ventilation rate when the system is in occupied mode. Related acceptance tests for these systems include the following:

1. NA7.5.2 Constant-Volume, Single-Zone, Unitary Air Conditioners and Heat Pump Systems Acceptance
2. NA7.5.4 Air Economizer Controls Acceptance (if applicable)
3. NA7.5.5 Demand-Controlled Ventilation Systems Acceptance (if applicable)Text

This test (NA7.5.1) is restricted to certified Mechanical ATTs only, using Certificate of Acceptance NRCA-MCH-02-A. **«»**

B. Constant volume, single zone air conditioning and heat pump unit controls shall be tested in accordance with NA7.5.2.

«» Commentary for Section 160.3(d)1B:

This acceptance test (NA7.5.2) is meant for constant volume, single zone, unitary (packaged and split) air conditioner and heat pump systems. This test verifies the components of a constant volume, single-zone, unitary air conditioner and heat pump system function correctly, including: thermostat installation and programming, supply fan, heating, cooling, and damper operation. Testing of the economizer, outdoor air ventilation, and demand-controlled ventilation are located in the following sections of the Reference Appendices:

1. NA7.5.1.2 Constant Volume System Outdoor Air Acceptance
2. NA7.5.4 Air Economizer Controls (if applicable)
3. NA7.5.5 Demand Control Ventilation (DCV) Systems (if applicable)

This test (NA7.5.2) is restricted to certified Mechanical ATTs only, using Certificate of Acceptance NRCA-MCH-03-A. **«»**

C. Duct systems shall be tested in accordance with NA7.5.3 where either:

a. They are new duct systems; or

b. They are part of an altered system.

«» Commentary for Section 160.3(d)1C:

This test (NA7.5.3) verifies all duct work associated with all nonexempt constant volume, single-zone HVAC units (in other words, air conditioners, heat pumps, and furnaces) meet the material, installation, and insulation R-values per Section 160.3(c)2A through G and leakage requirements outlined either in Section 160.3(c)2H for new duct systems or Section 180.2(b)2Bii for existing duct systems.

This test may either be verified by a ECC-Rater (sampling permitted) with the technician testing each installation and using LMCV-MCH-20-H (less than or equal to 3 stories) or NRCV-MCH-04-H (greater than or equal to 4 stories) to record the results or performed by a certified Mechanical ATT (no sampling permitted) using NRCA-MCH-04-A and recording it with an Acceptance Test Technician Certification Provider (ATTCP). **«»**

D. Air economizers, DOAS, HRV or ERV systems shall be tested in accordance with NA7.5.4.

Exception to Section 160.3(d)1D: Air economizers installed by the HVAC system manufacturer and certified to the Commission as being factory calibrated and tested are not required to comply with the Functional Testing section of the Air Economizer Controls acceptance test as described in NA7.5.4.2.

«» Commentary for Section 160.3(d)1D:

This test (NA7.5.4) is restricted to certified Mechanical ATTs and is intended to verify Energy Code compliance for multifamily common use areas with newly installed economizers, dedicated outdoor air system (DOAS), HRV system, and ERV system. Economizers must be certified to the Energy Commission in compliance with JA6.3

Submit one Certificate of Acceptance (NRCA-MCH-05-A) for each economizer, DOAS, HRV system, or ERV system that must demonstrate compliance with the Energy Code. For direct Energy Code reference see JA6.3, NA7.5.4, and Section 160.3(d)1D.

Functionally testing an air economizer cycle verifies that an HVAC system uses outdoor air to satisfy space-cooling loads. There are two types of economizer controls: stand-alone packages and DDC controls. The stand-alone packages are commonly associated with small unitary rooftop HVAC equipment. DDC controls are typically associated with built-up or large packaged air handling systems.

Cooling fan systems greater than 33,000 Btu/hr may use an economizer to comply with prescriptive requirements. Air economizers must be able to provide 100 percent of the design supply air with outside air; water economizers must be able to provide 100 percent of the design cooling load at 50°F dry-bulb and 45°F wet-bulb. «»

E. Demand control ventilation systems required by Section 160.2(c)3 shall be tested in accordance with NA7.5.5.

«» Commentary for Section 160.3(d)1E:

The purpose of the test (NA7.5.5) is to verify that systems required to employ demand controlled ventilation (refer to Section 160.2(c)5C) can vary outside ventilation flow rates based on maintaining interior carbon dioxide (CO2) concentration setpoints. DCV refers to an HVAC system's ability to reduce outdoor air ventilation flow below design values when the space served is at less than design occupancy. CO_2 is a good indicator of occupancy load and is the basis used for modulating ventilation flow rates.

DCV complying with Section 160.2(c)5D are required for a space with a design occupant density, or a maximum occupant load factor for egress purposes in the CBC, greater than or equal to 25 people per 1000 square feet (40 square feet or less per person) if the ventilation system serving the space has one or more of the following:

1. an air economizer, modulating outside air control, or
2. design outdoor airflow rate > 3,000 cfm (Section 160.2(c)3).

This acceptance test is limited to certified Mechanical ATTs using NRCA-MCH-06-A to verify that a system required to employ DCV can vary outside air ventilation flow rates based on maintaining interior carbon dioxide (CO2) concentration setpoints in compliance with Section 160.2(c)5D. NRCA-MCH-02-A must be completed either prior to or concurrently with this acceptance test for the space in which the CO2 monitor is located. One NRCA-MCH-06-A must be completed for each CO2 sensor in the system that must demonstrate compliance. For direct Energy Code reference see Section 160.2(c)5C, Section 160.2(c)5D, Section 160.3(d)1E, NA7.5.1, and NA7.5.5. **«»**

F. Supply fan variable flow controls shall be tested in accordance with NA7.5.6.

«» Commentary for Section 160.3(d)1F:

The purpose of the test (NA7.5.6) is to ensure that the supply fan in a variable air volume application modulates to meet system airflow demand. In most applications, the individual VAV boxes serving each space will modulate the amount of air delivered to the space based on heating and cooling requirements. As a result, the total supply airflow provided by the central air handling unit must also vary to maintain sufficient airflow through each VAV box. Airflow is typically controlled using a variable frequency drive (VFD) to modulate supply fan speed and vary system airflow. The most common strategy for controlling the VFD is to measure and maintain static pressure within the duct.

This test is restricted to a certified Mechanical ATT using NRCA-MCH-07-A to verify that the supply fan speed in a variable air volume system modulates to meet system airflow demand. NRCA-MCH-07-A can be performed in conjunction with NRCA-MCH-02-A Outdoor Air Acceptance since testing activities overlap. **«»**

G. Hydronic system variable flow controls shall be tested in accordance with NA7.5.7 and NA7.5.9.

«» Commentary for Section 160.3(d)1G:

This test (NA7.5.7) ensures that control valves serving variable flow systems are designed to withstand the pump pressure over the full range of operation. Valves with insufficient actuators will lift under certain conditions causing water to leak and loss of flow control. This test applies to the variable flow systems covered by Section 170.2(c)4Ii chilled and hot-water variable flow systems, Section 170.2(c)4Iii chiller isolation valves, Section 170.2(c)4Iiii boiler isolation valves, and Section 170.2(c)4Iv water-cooled air conditioner and hydronic heat pump systems.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-08-A to ensure that control valves serving variable flow systems can withstand the pump pressure over the full range of operation. Related acceptance tests for these systems include NA7.5.9 Hydronic System Variable Flow Controls Acceptance Testing time will be greatly reduced if these acceptance tests are done simultaneously.

This test (NA7.5.9) is for all hydronic variable flow chilled water and water-loop heat pump systems with total circulating pump power larger than 5 hp shall vary system flow rate by modulating pump speed using either a variable frequency drive (VFD) or equivalent according to Section 170.2(c)4Ivi. Pump speed and flow must be controlled as a function of differential pressure, and pump motor demand must be no more than 30 percent design wattage at 50 percent design flow.

As the loads within the building fluctuate, control valves should modulate the amount of water passing through each coil and add or remove the desired amount of energy from the air stream to satisfy the load. In the case of water-loop heat pumps, each two-way control valve associated with a heat pump closes when not operating. The purpose of the test is to ensure that, as each control valve modulates, the pump variable frequency drive (VFD) responds accordingly to meet system water flow requirements.

This test is restricted to certified mechanical ATTs using NRCA-MCH-10-A to ensure that hydronic pump speed varies with building heating and cooling loads. The related acceptance tests for this system is NA7.5.7 Valve Leakage Test – NRCA-MCH-08-A (if applicable). **«»**

H. Boilers or chillers that require isolation controls as specified by Section 170.2(c)4Iii or 170.2(c)4Iiii shall be tested in accordance with NA7.5.7.

«» Commentary for Section 160.3(d)1H:

This test (NA7.5.7) ensures that control valves serving variable flow systems are designed to withstand the pump pressure over the full range of operation. Valves with insufficient actuators will lift under certain conditions causing water to leak and loss of flow control. This test applies to the variable flow systems covered by Section 170.2(c)4Ii chilled and hot-water variable flow systems, Section 170.2(c)4Iii chiller isolation valves, Section 170.2(c)4Iiii boiler isolation valves, and Section 170.2(c)4Iv water-cooled air conditioner and hydronic heat pump systems.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-08-A to ensure that control valves serving variable flow systems can withstand the pump pressure over the full range of operation. Related acceptance tests for these systems include NA7.5.9 Hydronic System Variable Flow Controls Acceptance Testing time will be greatly reduced if these acceptance tests are done simultaneously. **«»**

I. Hydronic systems with supply water temperature reset controls shall be tested in accordance with NA7.5.8.

«» Commentary for Section 160.3(d)1I:

This test (NA7.5.8) ensures that both the chilled water and hot water supply temperatures are automatically reset based on either building loads or outdoor air temperature, as indicated in the control sequences. Many HVAC systems are served by central chilled and heating hot water plants. The supply water operating temperatures must meet peak loads when the system is operating at design conditions. As the loads vary, the supply water temperatures can be adjusted to satisfy the new operating conditions. Typically the chilled water supply temperature can be raised as the cooling load decreases, and heating hot water supply temperature can be lowered as the heating load decreases.

This requirement only applies to chilled and hot water systems that are not designed for variable flow and that have a design capacity greater than or equal to 500 kBtuh (thousand BTU's per hour), according to Section 170.2(c)4Iiv.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-09-A to ensure that both the chilled water and hot water supply temperatures are automatically reset based on either building loads or outdoor air temperature, as indicated in the control sequences. (Section 170.2(c)4Iiv).

Note the following exception: Hydronic systems that use variable flow to reduce pumping energy. (Section 170.2(c)4Ii.) **«»**

J. Automatic demand shed controls shall be tested in accordance with NA7.5.10.

«» Commentary for Section 160.3(d)1J:

This test (NA7.5.10) is used if the building has direct digital control (DDC) to the zone level, the HVAC control system must be capable receiving a Demand Response Signal and automatically initiating a control strategy once the signal is received. This acceptance test confirms that the HVAC control system is programmed so that it is capable of initiating the control strategy specified in Section 110.12(b). That is, modify the temperature setpoints in non-critical zones up by 4ºF if the system is cooling the space or down by 4ºF if the system is heating the space. The building owner or occupant has the option of selecting another control strategy than the one tested here if they choose to enroll in a demand response program.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-11-A to ensure that the central demand shed sequences have been properly programmed into the DDC system. **«»**

K. Fault detection and diagnostics (FDD) for packaged direct expansion units shall be tested in accordance with NA7.5.11.

«» Commentary for Section 160.3(d)1K:

The purpose of this test (NA7.5.11) is to verify proper fault detection and diagnostic (FDD) reporting for automated fault detection and diagnostics systems for packaged DX units. Automated FDD systems ensure proper equipment operation by identifying and diagnosing common equipment problems such as temperature sensor faults, low airflow or faulty economizer operation. FDD systems help to maintain equipment efficiency closer to rated conditions over the life of the equipment.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-12-A and is recommended to be performed simultaneity with NRCA-MCH-02-A (Outside Air) and NRCA-MCH-05-A (Air Economizer Controls). **«»**

L. Automatic fault detection and diagnostics (FDD) for air handling units and zone terminal units shall be tested in accordance with NA7.5.12.

«» Commentary for Section 160.3(d)1L:

The purpose of this test (NA7.5.12) is to verify proper FDD reporting for air handling unit (AHU) and zone terminal unit (ZTU) systems. Fault detection and diagnostics can also be used to detect common faults with air handling units and zone terminal units. Many FDD tools are standalone software products that process trend data offline. Maintenance problems with built-up air handlers and variable air volume boxes are often not detected by energy management systems because the required data and analytical tools are not available. Performing the FDD analysis within the distributed unit controllers is more practical because of the large volume of data.

The acceptance tests are designed to verify that the system detects common faults in air handling units and terminal units. FDD systems for air handling units and zone terminal units require DDC controls to the zone level. Successful completion of this test provides a compliance credit when using the performance approach. An FDD system that does not pass this test may still be installed, but no compliance credit will be given.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-13-A to verify that the system detects common faults in air handling units and zone terminal units. «»

M. Distributed energy storage DX AC systems shall be tested in accordance with NA7.5.13.

«» Commentary for Section 160.3(d)1M:

This test (NA7.5.13) verifies proper operation of distributed energy storage DX systems. Distributed energy systems reduce peak demand by operating during off peak hours and storing cooling, usually in the form of ice. During peak cooling hours the ice is melted to avoid compressor operation.

This acceptance test applies to direct expansion (DX) system with distributed energy storage (DES/DXAC). These acceptance requirements are in addition to those for those other systems or equipment such as economizers or packaged equipment. This acceptance test was developed by AEC for Distributed Energy Storage for Direct-Expansion Air Conditioners, January 27, 2005, and is directly referenced by the Energy Code.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-14-A to verify that the system conforms with the Energy Code requirements. «»

N. Thermal energy storage (TES) systems shall be tested in accordance with NA7.5.14.

«» Commentary for Section 160.3(d)1N:

This test (NA7.5.14) verifies proper operation of thermal energy storage (TES) systems. TES systems reduce energy consumption during peak demand periods by shifting energy consumption to nighttime. Operation of the thermal energy storage compressor during the night produces cooling energy, which is stored in the form of cooled fluid or ice in tanks. During peak cooling hours the thermal storage is used for cooling to prevent the need for chiller operation.

The test will ensure that the TES system is able to charge the storage tank during off-peak hours and conversely discharge the storage tank during on peak hours. Since the chiller may operate more efficiently at night when ambient temperatures are lower, the system may save cooling energy in some climate zones. This acceptance test is intended for TES systems that are used in conjunction with chilled water air conditioning systems.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-15-A to verify that the system conforms with the Energy Code requirements. «»

O. Supply air temperature reset controls shall be tested in accordance with NA7.5.15.

«» Commentary for Section 160.3(d)1O:

The purpose of the test (NA7.5.15) is to ensure that the supply air temperature in a constant or variable air volume application serving multiple zones, according to Section 170.2(c)4D, modulates to meet system heating and cooling loads. Space conditioning systems must have zone level controls to avoid reheat, re-cool, and simultaneous cooling and heating (Section 170.2(c)4B); or must have controls to reset supply air temperature (SAT) by at least 25 percent of the difference between the design supply-air temperature and the design room air temperature (Section 170.2(c)4Dii). Air distribution systems serving zones with constant loads must be designed for the air flows resulting from the fully reset (e.g. lowest/highest) supply air temperature. The requirements for SAT reset apply to both CAV and VAV systems. Exceptions include:170.2(c)4B; or must have controls to reset SAT by at least 25 percent of the difference between the design supply-air temperature and the design room air temperature (Section 170.2(c)4Dii). Air distribution systems serving zones with constant loads must be designed for the air flows resulting from the fully reset (e.g. lowest/highest) supply air temperature. The requirements for SAT reset apply to both CAV and VAV systems. Exceptions include:

1. Systems with specific humidity needs for exempt process loads (computer rooms or spaces serving only IT equipment are not exempt).
2. Zones served by space conditioning systems in which at least 75 percent of the energy for reheating, or providing warm air in mixing systems, is provided from a site-recovered or site-solar energy source.
3. Systems in which supply air temperature reset would increase overall building energy use.
4. Systems with controls to prevent reheat, re-cool, and/or simultaneous cooling and heating.

Supply air temperature may be reset in response to building loads, zone temperature, outside air temperature, or any other appropriate variable.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-16-A to verify that the supply air temperature modulates to meet system temperature setpoint(s). «»

P. Water-cooled chillers served by cooling towers with condenser water reset controls shall be tested in accordance with NA7.5.16.

«» Commentary for Section 160.3(d)1P:

The intent of the test (NA7.5.16) is to verify that the condenser water supply (entering condenser water) temperature is automatically reset as indicated in the control sequences; based upon building loads, outdoor air wet-bulb temperature, or another appropriate control variable. All cooling tower system components (e.g. fans, spray pumps) should operate per the control sequences to maintain the proper condenser water temperature and pressure set points.

Chilled water plants serve many buildings, responding to the varying cooling loads throughout the year. As the loads vary, the chilled water supply temperatures adjust to satisfy the new operating conditions. Often, water-cooled chilled water plants can decrease the condenser water temperature in times of low cooling load. This occurrence can be demonstrated by running the cooling tower fans at a higher speed, staging on additional fans, or varying water distribution across the tower fill by closing and opening bypass valves. As a result, the cooling tower produces an energy penalty, however the chiller efficiency and the overall plant efficiency improves.

The purpose of this test is not to evaluate whether a particular control sequence is the most appropriate for the facility, but whether the system follows the intended control sequence. This test is restricted to certified Mechanical ATTs using NRCA-MCH-17-A to ensure that the condenser water supply temperature is automatically reset as indicated in the control sequence(s). **«»**

Q. When an energy management control system is installed, it shall functionally meet all of the applicable requirements of Part 6.

«» Commentary for Section 160.3(d)1Q:

The purpose of this acceptance test is to ensure that when an Energy Management Control System (EMCS) is installed for the purpose of compliance with the Energy Code, it is properly installed, operational, and is in compliance with each relevant requirement in the Energy Code.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-18-A to ensure that when an EMCS is installed for the purpose of compliance with the Energy Code, it is properly installed, operational, and is in compliance with each relevant requirement in the Energy Code. **«»**

R. Occupant sensing zone controls shall be tested in accordance with NA7.5.17.

«» Commentary for Section 160.3(d)1R:

This test (NA7.5.17) verifies that an installed occupancy sensor is functional and in compliance with the approved project designs and Energy Code. The technician must submit one Certificate of Acceptance for each occupancy sensor installed.

This test is restricted to certified mechanical ATTs using NRCA-MCH-19-A to ensure that the occupancy sensor is functional and in compliance with the design and with the Energy Code. **«»**

2. Multifamily dwelling units. Before an occupancy permit is granted, the following systems and equipment serving multifamily dwelling units shall be certified as meeting the acceptance requirements for code compliance, as specified by the Reference Nonresidential Appendix NA7. These systems and equipment shall also comply with the applicable requirements of Section 160.3(d)3. A Certificate of Acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the acceptance requirements:

«» Commentary for Section 160.3(d)2:

This test (NA7.18.1) can be performed by a certified Mechanical ATT or uncertified technician and ECC-Rater to verify that the continuous ventilation airflow (supply, exhaust, or balanced) system, the kitchen exhaust fan, and/or the HRV system or ERV system conforms to the requirements of the Energy Code and ANSI/ASHRAE Standards 62.2-2016. If using supply-only or exhaust-only ventilation, Certificate of Acceptance NRCA-MCH-21-H must be completed prior to beginning this acceptance test.

This test is not restricted to certified Mechanical ATTs if a ECC-Rater is used as a verification for an uncertified technician to perform the same test and the verification is registered with a ECC-Provider. Alternatively, these same forms can be used by a mechanical ATT without need of a ECC-Rater.

NRCA-MCH-20a-H must be completed (once) for all of the subsequent forms for dwelling ventilation requirements. NRCA-MCH-20b-H is used to verify the kitchen range hood complies with the Energy Code requirements. NRCA-MCH-20c-H is used to verify the indoor air quality ventilation systems complies with the Energy Code requirements. NRCA-MCH-20d-H is used to verify HRV or ERV (if installed) systems comply with the Energy Code requirements.

This acceptance test is intended for multifamily dwelling units where CONTINUOUS ventilation is used. Ventilation airflow of systems with multiple operating modes shall be tested in all modes designed to comply with the required ventilation airflows. Approved systems, devices, or controls, and field verification and diagnostic test protocols for intermittent mechanical ventilation systems will be listed in directories published by the Energy Commission.

This acceptance test (NA7.18.2) is used to verify that the envelope leakage rate for multifamily dwelling units conforms to the requirements of the Energy Code.

This test is not restricted to certified Mechanical ATTs if an ECC-Rater is used as a verification for an uncertified technician to perform the same test and the verification is registered with a ECC-Provider. Alternatively, this same form can be used by a mechanical ATT without need of an ECC-Rater.

NRCA-MCH-21-H must be completed for each dwelling unit using a supply-only or exhaust-only ventilation system to verify that the envelope leakage conforms to the requirements of the Energy Code Section 160.2(b)2 and Nonresidential Reference Appendices NA7.18.2, NA2.3, ANSI/RESNET/ICC 380-2016, and ASTM E779-10 (2010). The certified mechanical ATT or technician and ECC-Rater is required to complete this compliance certificate prior to completing NRCA-MCH-20-H. **«»**

A. Multifamily building central ventilation ducts subject to Section 160.2(b)2C shall be leak tested in accordance with NA7.18.3.

«» Commentary for Section 160.3(d)2A:

The objective of this procedure (NA7.18.3) is to verify the leakage of a new central ventilation duct system(s) (Section 160.2(b)2Ci) that serve multiple dwelling units and provides continuous airflows or are part of a balanced ventilation system to meet the requirements specified in Sections 160.2(b)2Aiv or 160.2(b)2Av. This compliance document (NRCA-MCH-22-A) is used to record the results of one system duct leakage test performed. These test procedures are based on ATSM 1554 Method D – Total duct leakage test. This test may only be performed by a certified Mechanical ATT. «»

B. Multifamily building central ventilation system heat recovery or energy recovery systems in multifamily buildings with four or more habitable stories shall be tested in accordance with NA7.18.4.

«» Commentary for Section 160.3(d)2B:

The objective of this acceptance test is to verify the HRV or ERV system requirement in multifamily buildings for compliance with Section 170.2(c)3Bivb, a central ERV/HRV systems serving multiple dwelling units. This test may only be performed by a certified Mechanical ATT. «»

3. When certification is required by Title 24, Part 1, Section 10-103.2, the acceptance testing specified by Section 160.3(d)1 and 2 shall be performed by a Certified Mechanical Acceptance Test Technician (CMATT). If the CMATT is operating as an employee, the CMATT shall be employed by a Certified Mechanical Acceptance Test Employer. The CMATT shall disclose on the Certificate of Acceptance a valid CMATT certification identification number issued by an approved Acceptance Test Technician Certification Provider. The CMATT shall complete all Certificate of Acceptance documentation in accordance with the applicable requirements in Section 10-103(a)4.

«» Commentary for Section 160.3(d)3:

Detailed instructions on how to conduct acceptance tests are located at the Energy Commission website, https://www.energy.ca.gov/programs-and-topics/programs/acceptance-test-technician-certification-provider-program. «»

TABLE 160.3-A: Return Duct Sizing for Single Return Duct Systems

Return duct length shall not exceed 30 feet and shall contain no more than 180 degrees of bend. If the total bending exceeds 90 degrees, one bend shall be a metal elbow.

Return grille devices shall be labeled in accordance with the requirements in Section 160.2(b)1Biv to disclose the grille's design airflow rate and a maximum allowable clean-filter pressure drop of 25 Pa (0.1 inches water) for the air filter when tested using

ASHRAE Standard 52.2, or as rated in accordance with AHRI Standard 680 for the design airflow rate for the return grille.

System Nominal Cooling Capacity (Ton)*	Return Duct Minimum Nominal Diameter (inch)	Minimum Total Return Filter Grille Nominal Area (inch^2)
1.5	16	500
2.0	18	600
2.5	20	800

*Not applicable to systems with nominal cooling capacity greater than 2.5 tons or less than 1.5 ton

TABLE 160.3-B: Return Duct Sizing for Multiple Return Duct Systems

Each return duct length shall not exceed 30 feet and shall contain no more than 180 degrees of bend. If the total bending exceeds 90 degrees, one bend shall be a metal elbow.

Return grille devices shall be labeled in accordance with the requirements in Section 160.2(b)1Biv to disclose the grille's design airflow rate and a maximum allowable clean-filter pressure drop of 25 Pa (0.1 inches water) for the air filter when tested using ASHRAE Standard 52.2, or as rated in accordance with AHRI Standard 680 for the design airflow rate for the return grille.

System Nominal Cooling Capacity (Ton)*	Return Duct 1 Minimum Nominal Diameter (inch)	Return Duct 2 Minimum Nominal Diameter (inch)	Minimum Total Return Filter Grille Nominal Area (inch^2)
1.5	12	10	500
2.0	14	12	600
2.5	14	14	800
3.0	16	14	900
3.5	16	16	1000
4.0	18	18	1200
5.0	20	20	1500

*Not applicable to systems with nominal cooling capacity greater than 5.0 tons or less than 1.5 tons.

TABLE 160.3-C DDC Applications and Qualifications

Building Status	Applications	Qualifications
Newly Constructed Buildings	Air handling system and all zones served by the system	Individual systems supplying more than three zones and with design heating or cooling capacity of 300 kBtu/h and larger
Newly Constructed Buildings	Chilled water plant and all coils and terminal units served by the system	Individual plants supplying more than three zones and with design cooling capacity of 300 kBtu/h (87.9 kW) and larger

Newly Constructed Buildings	Hot water plant and all coils and terminal units served by the system	Individual plants supplying more than three zones and with design heating capacity of 300 kBtu/h (87.9 kW) and larger
Additions or Alterations	Zone terminal unit such as VAV box	Where existing zones served by the same air handling, chilled water, or hot water systems that have DDC
Additions or Alterations	Air handling system or fan coil	Where existing air handling system(s) and fan coil(s) served by the same chilled or hot water plant have DDC
Additions or Alterations	New air handling system and all new zones served by the system	Individual systems with design heating or cooling capacity of 300 kBtu/h and larger and supplying more than three zones and more than 75 percent of zones are new
Additions or Alterations	New or upgraded chilled water plant	Where all chillers are new and plant design cooling capacity is 300 kBtu/h (87.9 kW) and larger
Additions or Alterations	New or upgraded hot water plant	Where all boilers are new and plant design heating capacity is 300 kBtu/h (87.9 kW) and larger

TABLE 160.3-D PIPE INSULATION THICKNESS

Space heating (Steam, Steam Condensate, Refrigerant, Space Heating)

Fluid Operating Temperature Range (°F)	**Insulation Conductivity (Btu·in/h·ft^2 °F)**	**Insulation Conductivity Mean Rating Temp. (°F)**	**Nominal Pipe Diameter (in inches) < 1**	**Nominal Pipe Diameter (in inches) 1 to <1.5**	**Nominal Pipe Diameter (in inches) 1.5 to < 4**	**Nominal Pipe Diameter (in inches) 4 to < 8**	**Nominal Pipe Diameter (in inches) 8 and larger**
Above 350	0.32-0.34	250	4.5 (R 37)	5.0 (R 41)	5.0 (R 37)	5.0 (R 27)	5.0 (R 23)
251-350	0.29-0.32	200	3.0 (R 24)	4.0 (R 34)	4.5 (R 35)	4.5 (R 26)	4.5 (R 22)
201-250	0.27-0.30	150	2.5 (R 21)	2.5 (R 20)	2.5 (R 17.5)	3.0 (R 17)	3.0 (R 14.5)
141-200	0.25-0.29	125	1.5 (R 11.5)	1.5 (R 11)	2.0 (R 14)	2.0 (R 11)	2.0 (R 10)
105-140	0.22-0.28	100	1.0 (R 7.7)	1.5 (R 12.5)	1.5 (R 11)	1.5 (R 9)	1.5 (R 8)

CONTINUED: TABLE 160.3-D PIPE INSULATION THICKNESS REQUIRED (thickness in inches or R-Value)

Space cooling systems (chilled water, refrigerant and brine)

Fluid Operating Temperature Range (°F)	Insulation Conductivity (Btu·in/h·ft² °F)	Insulation Conductivity Mean Rating Temp. (°F)	Nominal Pipe Diameter (in inches) < 1	Nominal Pipe Diameter (in inches) 1 to <1.5	Nominal Pipe Diameter (in inches) 1.5 to < 4	Nominal Pipe Diameter (in inches) 4 to < 8	Nominal Pipe Diameter (in inches) 8 and larger
40-60	0.21-0.27	75	0.75 (R 6)	0.75 (R 5)	1.0 (R 7)	1.0 (R 6)	1.0 (R 5)
Below 40	0.20-0.26	50	1.0 (R 8.5)	1.5 (R 14)	1.5 (R 12)	1.5 (R 10)	1.5 (R 9)

Footnote to TABLE 160.3-D:

1. These thicknesses are based on energy efficiency considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 160.9 – MANDATORY REQUIREMENTS FOR ELECTRIC READY BUILDINGS

(a) General Requirements. Multifamily buildings shall comply with the applicable requirements of subsection 160.9. The building electrical system shall be sized to meet the future electric requirements of the electric ready equipment specified in sections 160.9(b) through (f). The building main service conduit, the electrical system to the point specified in each subsection, and any on-site distribution transformers shall have sufficient capacity to supply full rated amperage at each electric ready appliance in accordance with the California Electrical Code.

(b) Heat Pump Space Heater Ready. Systems using gas or propane furnaces to serve individual dwelling units shall include the following:

1. A dedicated 240 volt branch circuit wiring shall be installed within 3 feet from the furnace and accessible to the furnace with no obstructions. The branch circuit conductors shall be rated at 30 amps minimum. The blank cover shall be identified as "240V ready." All electrical components shall be installed in accordance with the California Electrical Code.
2. The main electrical service panel shall have a reserved space to allow for the installation of a double pole circuit breaker for a future heat pump space heater installation. The reserved space shall be permanently marked as "For Future 240V use."

«» Commentary for Section 160.9(b):

Installation of branch circuits per 160.9(b)1 are dedicated to future electric replacement equipment and cannot be used for other appliances. Other electrical components must be installed in accordance with the California Electrical Code.

Dedicated space is required for double breakers in the main service panel that will serve the future in-unit space heating. The Energy Code does not require the installation of breakers at time of construction.

Dedicated space in the panel next to the location of the water heater breaker to accommodate converting it to 240V in the future, per Section 160.4. The dedicated space in the panels must be identified as "Future 240V Use." The code does not require the installation of breakers at time of construction.

There are no electric ready requirements for additions or alterations. There are no performance or prescriptive electric ready requirements for multifamily buildings.

The unused circuits must have a blank cover identified as "240V ready." Receptacles are required for dwelling unit water heating, and must be connected to the panel with a 120/240V, 3-conductor circuit rated at 30 amps minimum with both ends of the unused conductor labeled as "spare" and be electrically isolated.

Electric Ready requirements for other building systems and appliances, as specified in Section 160.9(c)-(f), are described in Chapter 6 – Electrical and Lighting Systems. «»

SECTION 170.1 – PERFORMANCE APPROACH

A building complies with the performance approach if the energy consumption calculated for the proposed design building is no greater than the energy budget calculated for the standard design building using Commission-certified compliance software as specified by Sections 10-109, 10-116 and the Alternative Calculation Method Reference Manual.

(a) Energy budget. The Energy budget is expressed in terms of Long-Term System Cost (LSC) and Source Energy:

1. **Long-term System Cost (LSC).** The LSC energy budget is determined by applying the mandatory and prescriptive requirements of the standard design to the proposed design building and has two components, the Efficiency LSC and the Total LSC.
   A. The Efficiency LSC energy is the sum of the LSC energy for space-conditioning, water heating, mechanical ventilation, lighting and the self-utilization credit.
   B. The Total LSC energy is the sum of the Efficiency LSC energy and LSC energy from the photovoltaic system, battery energy storage systems (BESS), and demand flexibility.
2. **Source Energy.** The source energy budget is determined by applying the mandatory and prescriptive requirements of the standard design, except with a consumer gas or propane water heater, to the proposed design building.

Exception to Section 170.1(a): A community shared solar electric generation system, or other renewable electric generation system, and/or community shared BESS, that provides dedicated power, utility energy reduction credits or payments for energy bill reductions to the permitted building and is approved by the Energy Commission as specified in Title 24, Part 1, Section 10-115, may offset part or all of the solar electric generation system or BESS LSC energy required to comply with the standards, as calculated according to methods established by the Commission in the Nonresidential ACM Reference Manual.

«» Commentary for Section 170.1(a):

HVAC Performance Approach

Under the performance approach, the energy use of the building is modeled using a compliance software program approved by the Energy Commission. Program users and those checking for enforcement should consult the most current version of the user's manuals and associated compliance supplements for specific instructions on the operation of the program. All compliance software programs, however, are required to have the same basic modeling capabilities.

The compliance rules used by the computer methods in generating the energy budget and compliance credits are based on features required for prescriptive compliance. Detailed information can be found in the 2025 Nonresidential and Multifamily Alternative Calculation Method (ACM) Reference Manual.

There are minimum modeling capabilities required for programs that are used for the performance approach. All certified programs are tested for conformance with the requirements of the 2025 Nonresidential and Multifamily ACM Reference Manual. The designer has to use an approved program to show compliance.

Compliance is shown by running two models: a base case budget building that nominally meets the mandatory and prescriptive requirements and a proposed building that represents the actual proposed envelope, lighting, and mechanical systems of the building. To create a level playing field the base case and proposed designs are compared using the same assumptions of occupancy, proscribed climatic conditions and operating schedules. The results are compared using standardized time of use rates, or long-term system cost (LSC) of energy cost.

The proposed building complies if its annual source Energy and LSC energy is less than or equal to that of the budget building. Reference Appendix JA3 describes the derivation of the LSC energy multipliers.

Compliance in the Performance Approach is across all building systems. The design team can use more glass than with the prescriptive approach and comply by making a more efficient HVAC system. Energy can be traded off between prescriptive requirements in the envelope, HVAC system, water heating, indoor lighting, photovoltaics, battery energy storage system and covered processes.

The alternative calculation method defines the modeling rules for developing the base-case model of the building and mechanical systems. The base-case HVAC system(s) is modeled on a system(s) according to occupancy type, floor area of building, number of floors, and zoning.

The following are some examples of how to get credit in the Performance Approach from HVAC systems:

1. Use of high efficiency equipment that exceeds the minimum requirements of Section 110.1 and Section 110.2
2. Application of economizers where they are not required
3. Oversizing ducts and pipes to reduce fan and pump energy
4. Use of heat recovery for space or water heating
5. Use of thermal energy storage systems or building mass to move cooling off peak
6. Reduce reheating and recooling
7. Use of thermally driven cooling equipment, such as absorption chillers.

HVAC Issues

When a building has no cooling system, the software simulates a hypothetical system with the characteristics required by Table 170.2-K as if a cooling system were installed. The result is neither a penalty nor a credit.

Alternative Calculation Methods (Compliance Software)

Compliance software must be approved by the Energy Commission. Approval involves the demonstration of minimum modeling capabilities, required input and output, and adequate user documentation. The compliance software must be able to:

1. Automatically calculate the energy budget of the standard design.
2. Calculate the energy budget of the proposed design in accordance with specific fixed and restricted inputs.
3. Print the appropriate standardized compliance documents with the required information and format when a proposed building complies. Other reports that do not resemble compliance documents may be printed for buildings that do not comply.

Input and Output Requirements

Input and output requirements and modeling capabilities are tested by using the compliance software to calculate the energy use of certain prototype buildings under specific conditions. These results are compared with the results from the reference public domain compliance software, CBECC, which uses EnergyPlus as the simulation engine. This is explained in detail in the Nonresidential and Multifamily ACM Reference Manual.

Long-Term System Cost (LSC)

Under the performance approach, energy use of the building is modeled by compliance software approved by the Energy Commission. The compliance software simulates the Long-Term System Cost (LSC) energy budget of the proposed building, including a detailed accounting of envelope heat transfers using the assemblies and fenestration input, and the precise geometry of any exterior overhangs or side fins. The most accurate tradeoffs between different envelope components – and among the envelope, the space-conditioning system, and the installed common area lighting – are accounted for and compared with the standard design version of the building. The proposed design must have LSC energy less than or equal to the standard design. **«»**

(b) Compliance demonstration requirements for performance standards.

1. Certificate of Compliance and Application for a Building Permit. The application for a building permit shall include documentation pursuant to Sections 10-103(a)1 and 10-103(a)2 that demonstrates, using an approved calculation method, that the building has been designed so that its source energy and LSC energy consumption do not exceed the standard design energy budgets for the applicable climate zone.

2. Field verification of individual dwelling unit systems. When performance of installed features, materials, components, manufactured devices or systems above the minimum specified in Section 170.2 is necessary for the building to comply with Section 170.1, or is necessary to achieve a more stringent local ordinance, field verification shall be performed in accordance with the applicable requirements in the following subsections, and the results of the verification(s) shall be documented on applicable Certificates of

Installation pursuant to Section 10-103(a)3 and applicable Certificates of Verification pursuant to Section 10-103(a)5.

A. EER2/SEER2/CEER/HSPF2 Rating. When performance compliance requires installation of a space-conditioning system with a rating that is greater than the minimum rating required by Table 170.2-K or specified for the standard design, the installed system shall be field verified in accordance with the procedures specified in the applicable sections of Reference Residential Appendix RA3.

«» Commentary for Section 170.1(b)2A:

For individual dwelling units, the minimum efficiency is required to be met for prescriptive compliance or performance compliance. When the performance compliance approach is used, additional compliance credit may be available from higher efficiency heating equipment which can be used to offset less efficient building features.

When a heat pump is providing space heating, if the efficiency used for compliance is higher than the minimum required HSPF2, the system efficiency must be verified by an ECC-Rater. Moreover, because the capacity of the heat pump affects the amount of back-up electric resistance heating required to attain and maintain comfort conditions, if the capacity proposed for compliance is different than the default capacity used in the performance compliance software, the Air Conditioning, Heating, and Refrigeration Institute (AHRI) ratings for heating capacity of the installed heat pump must be verified by an ECC-Rater to confirm the heating capacities at 47 °F and 17 °F are equal or greater than the heating capacities given on the certificate of compliance. See RA3.4 for more information about this ECC verification.

Air conditioner efficiencies are determined according to federal test procedures. The efficiencies are reported in terms of seasonal energy efficiency ratio (SEER2) and energy efficiency ratio (EER2). Savings can be achieved by choosing an air conditioner that exceeds the minimum efficiency requirements.

The EER2 is the efficiency at specific operating conditions. It is possible that two units with the same SEER2 can have different EER2s. In cooling climate zones of California, for two units with a given SEER2, the unit with the higher EER2 is more effective in saving energy. Using the performance compliance method, credit is available for specifying an air conditioner with an EER2 greater than the minimum. When credit is taken for a high EER2 and/or SEER2 in multifamily buildings with three or fewer habitable stories, field verification by an ECC-Rater is required. (See RA3.4.4). «»

B. Variable capacity heat pump (VCHP) compliance option. When performance compliance requires installation of a heat pump system that meets all the requirements of the VCHP compliance option specified in the ACM Reference Manual, the system shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.4.4.3.

«» Commentary for Section 170.1(b)2B:

Several manufacturers offer variable capacity mini-split or multi-split heat pump equipment that may or may not use air distribution ducts to heat or cool spaces. These systems provide advanced controls and multispeed compressors for optimizing performance through a wide range of conditioning loads.

These systems are required to be modeled as minimally efficient systems unless the variable capacity heat pump (VCHP) compliance credit is taken. This option is available to provide credit for systems meeting the eligibility requirements published in the Residential Appendices RA3.4.4.3. The credit can be applied through a CEC-approved modeling software by selecting the VCHP compliance option for the HVAC system type. The Certificate of Compliance will indicate when a space conditioning system requires verification of the VCHP compliance option eligibility requirements. A system that does not meet the eligibility requirements upon verification will not be eligible to claim the VCHP performance compliance credit for the specified space conditioning system.

Compliance with the mandatory duct system sealing and leakage (Section 160.3(b)5K) and fan airflow rate and fan efficacy testing (Section 160.3(b)5L) are not required for systems that use this VCHP performance compliance option. However, there are requirements to verify that VCHP system indoor unit ducts are located entirely in conditioned space that are specified as eligibility requirements for this compliance option. There are also requirements for verification of minimum airflow rates for VCHP system indoor units that are specified as eligibility requirements for this compliance option.

Additional verification requirements apply depending on the system type and credit taken, see below.

1. Low-Static Certification for Ducted Systems
2. Non-Continuous Indoor Unit Fan Operation
3. Refrigerant Charge Verification
4. Ducts Located Entirely in Conditioned Space
5. Indoor Units Located Entirely in Conditioned Space
6. Supply to All Habitable Spaces
7. Wall-Mounted Thermostat
8. Space-Conditioning System Airflow
9. Air Filter Sizing
10. Air Filter Pressure Drop Rating

Default indoor unit fan configuration settings may require modification in order for the installed fan airflow to meet the required rate. The manufacturer’s product documentation should provide direction for configuring the indoor unit fan for operation at airflow rates equal to or greater than the minimum rates required for compliance. The list of low-static ducted VCHP systems certified to the Energy Commission including the manufacturer’s product documentation can be found at: https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment-2. «»

C. Low leakage air handler. When performance compliance requires installation of a low leakage air-handling unit, the installed air handling unit shall be field verified in accordance with the procedures specified in Reference Residential Appendix RA3.1.4.3.9.

D. Thermal Balancing Valve. When performance compliance requires installation of thermal balancing valves with variable speed circulation pump(s), the installation shall meet the procedures specified in Reference Residential Appendix RA4.4.3.

E. Heat pump—rated heating capacity. When performance compliance requires installation of a heat pump system, the heating capacity values at 47°F and 17°F shall be field verified in accordance with the procedures specified in Reference Residential Appendix RA3.4.4.2.

F. Dwelling unit enclosure air leakage. When performance compliance requires a building enclosure leakage rate that is lower than the standard design, the building enclosure shall be field verified in accordance with the procedures specified in Reference Residential Appendix RA3.8.

«» Commentary for Section 170.1(b)2F

As a compliance option, additional energy savings is available for achieving a tighter level of compartmentalization (reduce envelope leakage) than is required. See the ACM Manual for more details. «»

G. Quality insulation installation (QII). When performance compliance requires field verification of QII, the building insulation system shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.5.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 170.2 – PRESCRIPTIVE APPROACH

Multifamily buildings, including both dwelling units and common use areas, that comply with the prescriptive standards shall be designed, constructed and equipped to meet all of the requirements for the appropriate climate zone shown in Table 170.2-A. In Table 170.2-A, NA (not allowed) means that feature is not permitted in a particular climate zone and NR (no requirement) means that there is no prescriptive requirement for that feature in a particular climate zone. Installed components shall meet the following requirements:

(c) **Space-conditioning systems.** All space heating, space cooling and ventilation equipment shall comply with minimum Appliance Efficiency Regulations as specified in Sections 110.0 through 110.2 and the applicable requirements of Subsections 1 through 4.

1. Sizing and equipment selection—common use areas. Mechanical heating and mechanical cooling equipment serving common use areas of multifamily buildings shall be the smallest size, within the available options of the desired equipment line, necessary to meet the design heating and cooling loads of the building, as calculated according to Subsection 2 below.

   Exception 1 to Section 170.2(c)1: Where it can be demonstrated to the satisfaction of the enforcing agency that oversizing will not increase building LSC energy use.

   Exception 2 to Section 170.2(c)1: Standby equipment with controls that allow the standby equipment to operate only when the primary equipment is not operating.

   Exception 3 to Section 170.2(c)1: Multiple units of the same equipment type, such as multiple chillers and boilers, having combined capacities exceeding the design load, if they have controls that sequence or otherwise optimally control the operation of each unit based on load.

«» Commentary for Section 170.2(c)1:

The Energy Code requires mechanical heating and cooling equipment (including electric heaters and boilers) serving common use areas in multifamily buildings to be the smallest size available, while still meeting the design heating and cooling loads of the building or spaces being served. Depending on the equipment, oversizing can be either a penalty or benefit to energy usage. For vapor compression equipment, gross oversizing can drastically increase the energy usage and in some cases cause premature failure from short cycling of compressors. Boilers and water-heaters generally suffer lower efficiencies and higher standby losses if they are oversized. On the other hand, cooling towers, cooling coils, and variable speed driven cooling tower fans can actually improve in efficiency if oversized. Oversized distribution ductwork and piping can reduce system pressure losses and reduce fan and pump energy.

When equipment is offered in size increments, such that one size is too small and the next is too large, the larger size may be selected.

Packaged HVAC equipment may serve a space with substantially different heating and cooling loads. The unit size should be selected on the larger of the loads, based on either capacity or airflow. The capacity for the other load should be selected as required to meet the load, or if very small, should be the smallest capacity available in the selected unit. For example, packaged air-conditioning units with gas heat are usually sized on the basis of cooling loads. The furnace is sized on the basis of airflow and is almost always larger than the design heating load.

Equipment may be oversized provided one or more of the following conditions are met:

1. It can be demonstrated (to the satisfaction of the enforcing agency) that oversizing will not increase building LSC use
2. Oversizing is the result of standby equipment that will operate only when the primary equipment is not operating. Controls must be provided that prevent the standby equipment from operating simultaneously with the primary equipment
3. Multiple units of the same equipment type are used, each having a capacity less than the design load. In combination, however, the units have a capacity greater than the design load. Controls must be provided to sequence or otherwise optimally control the operation of each unit based on load.

«»

2. **Calculations**—common use areas**.** In making equipment sizing calculations under Subsection (c)1, all of the following rules shall apply:

   A. **Heating and cooling loads.** Heating and cooling system design loads shall be determined in accordance with the method in the 2017 ASHRAE Handbook, Fundamentals Volume, or as specified in a method approved by the Commission.

   B. **Indoor design conditions.** Indoor design temperature and humidity conditions for comfort applications shall be determined using ASHRAE Standard 55 or the 2021 ASHRAE Handbook, Fundamentals Volume, except that winter humidification and summer dehumidification shall not be required.

   C. **Outdoor design conditions.** Outdoor design conditions shall be selected from Reference Joint Appendix JA2, which is based on data from the ASHRAE Climatic Data for Region X or the ASHRAE Handbook Fundamentals Volume. Heating design temperatures shall be no lower than the 99.0 percent Heating Dry Bulb or the Heating Winter Median of Extremes values. Cooling design temperatures shall be no greater than the 0.5 percent Cooling Dry Bulb and Mean Coincident Wet Bulb values.

   Exception to Section 170.2(c)2C: Cooling design temperatures for cooling towers shall be no greater than the 0.5 percent Cooling Design Wet Bulb values.

   D**. Ventilation.** Outdoor air ventilation loads shall be calculated using the ventilation rates required in Section 160.2(c)3.

   E**. Envelope**. Envelope heating and cooling loads shall be calculated using envelope characteristics, including square footage, thermal conductance, solar heat gain coefficient or shading coefficient, and air leakage, consistent with the proposed design.

F. **Lighting.** Lighting heating and cooling loads shall be based on actual design lighting levels or power densities as specified in Section 170.2(e)1.

G. **People.** Occupant density shall be based on the expected occupancy of the building and shall be the same as determined under Section 160.2(c)3A, if used. Sensible and latent heat gains shall be as listed in the 2017 ASHRAE Handbook—Fundamentals, Chapter 18.

H. **Process loads.** Loads caused by a process shall be based upon actual information on the intended use of the building.

I. **Miscellaneous equipment.** Equipment loads other than process loads shall be calculated using design data compiled from one or more of the following sources:

  i. Actual information based on the intended use of the building; or

  ii. Published data from manufacturers' technical publications or from technical societies, such as the ASHRAE Handbook, Applications Volume; or

  iii. Other data based on the designer's experience of expected loads and occupancy patterns.

J. **Internal heat gains.** Internal heat gains may be ignored for heating load calculations.

K**. Safety factor.** Calculated design loads based on Sections 170.2(c)2A through K may be increased by up to 10 percent to account for unexpected loads or changes in space usage.

L. **Other loads.** Loads such as warm-up or cool-down shall be calculated from principles based on the thermal capacity of the building and its contents, the degree of setback, and desired recovery time; or may be assumed to be no more than 30 percent for heating and 10 percent for cooling of the steady-state design loads. In addition, the steady-state load may include a safety factor in accordance with Section 170.2(c)2K.

«» Commentary for Section 170.2(c)2L:

For the purposes of sizing HVAC equipment, the designer shall use all of the following criteria for load calculations:

1. The heating and cooling system design loads must be calculated in accordance with the procedures described in the ASHRAE Handbook, Fundamentals Volume, Chapter 30, Table 1. Other load calculation methods (e.g., ACCA, SMACNA) are acceptable provided that the method is ASHRAE-based. If the designer is unclear as to whether or not the calculation method is ASHRAE-based, the vendor or organization providing the calculation method should be contacted to verify that the method is derived from ASHRAE.
2. Indoor design conditions of temperature and relative humidity for general comfort applications are not explicitly defined. Designers may use any temperature conditions within the "comfort envelope" defined by ANSI/ASHRAE 55-1992 or the 2022 ASHRAE Handbook, Fundamentals Volume. Winter humidification or summer dehumidification is not required.
3. Outdoor design conditions shall be selected from Reference Joint Appendix JA2., which is based on data from the ASHRAE Climatic Data for Region X, for the following design conditions:
    - Heating design temperatures shall be no lower than the temperature listed in the Heating Winter Median of Extremes value.
    - Cooling design temperatures shall be no greater than the 0.5 percent Cooling Dry Bulb and Mean Coincident Wet Bulb values.
    - Cooling design temperatures for cooling towers shall be no greater than the 0.5 percent cooling design wet bulb values.
4. Outdoor air ventilation loads must be calculated using the ventilation rates required in Section 160.2(c)3.
5. Envelope heating and cooling loads must be calculated using envelope characteristics including square footage, thermal conductance, solar heat gain coefficient or shading coefficient and air leakage, consistent with the proposed design.
6. Lighting, heating, or cooling loads shall be based on actual design lighting levels or power densities consistent with Section 170.2(e)1.
7. People, sensible, and latent gains must be based on the expected occupant density of the building and occupant activities as determined under Section 160.2(c)3A. If ventilation requirements are based on a cfm/person basis, then people loads must be based on the same number of people as ventilation. Sensible and latent gains must be selected for the expected activities as listed in ASHRAE Handbook, Fundamentals Volume, Cooling and Heating Load Calculations chapters.
8. Loads caused by a process shall be based on actual information (not speculative) on the intended use of the building.
9. Miscellaneous equipment loads include such things as duct losses, process loads and infiltration and shall be calculated using design data compiled from one or more of the following sources:
    - Actual information based on the intended use of the building
    - Published data from manufacturer's technical publications or from technical societies (such as the ASHRAE Handbook, HVAC Applications Volume)

- Other data based on the designer's experience of expected loads and occupancy patterns

10. Internal heat gains may be ignored for heating load calculations.
11. A safety factor of up to 10 percent may be applied to design loads to account for unexpected loads or changes in space usage.
12. Other loads such as warm-up or cool-down shall be calculated using one of the following methods:
    - A method using principles based on the heat capacity of the building and its contents, the degree of setback, and desired recovery time
    - The steady state design loads may be increased by no more than 30 percent for heating and 10 percent for cooling. The steady state load may include a safety factor of up to 10 percent as discussed above.
13. The combination of safety factor and other loads allows design cooling loads to be increased by up to 21 percent (1.10 safety x 1.10 other), and heating loads by up to 43 percent (1.10 safety x 1.30 other). **«»**

3. **Dwelling unit space-conditioning systems**.

   A. **Heating** system type**.** Space-conditioning systems serving dwelling units shall meet i or ii. Systems that cannot meet the requirements of i or ii, including multi-zone systems and systems using central boilers or chillers, shall comply with the performance requirements of Section 170.1.

   i. Multifamily buildings three habitable stories or fewer. For Climate Zones 1 through 15, the space-conditioning system shall be a heat pump. For Climate Zone 16, the space-conditioning system shall be an air conditioner with furnace. Additionally, balanced ventilation systems serving these dwelling units shall meet the applicable requirements of Section 170.2(c)3Bivc.

   ii. Multifamily buildings four habitable stories or greater. For Climate Zones 2 through 15, the space-conditioning system shall be a heat pump. For Climate Zones 1 and 16, the space-conditioning system shall be a dual-fuel heat pump.

   Exception to Section 170.2(c)3A: A supplemental heating unit may be installed in a space served directly or indirectly by a primary heating system, provided that the unit thermal capacity does not exceed 2 kW or 7,000 Btu/hr and is controlled by a time-limiting device not exceeding 30 minutes.

«» Commentary for Section 170.2(c)3A:

Prescriptive compliance requires the installation of a heat pump for dwelling units in buildings up to three habitable stories in climate zones 1 – 15. For climate zone 16, the installation of an air conditioner with gas-fired furnace is prescriptively required. For buildings with four or more habitable stories, prescriptive compliance requires installation of a heat pump for climate zones 2 – 15. For climate zone 1 and 16, prescriptive compliance requires the installation of a dual-fuel heat pump that uses gas as supplemental heat.

Dual-fuel Heat Pump System

For Climate Zones 1 and 16, the prescriptive requirement includes the use of a dual-fuel heat pump for buildings four habitable stores or greater. This system pairs an electric heat pump with a gas-fired furnace and alternates between the two fuel sources for heating. Heat pumps face a challenge in colder climates where their capacity for providing heat and the efficiency of the equipment reduces as the outdoor temperature drops. This is especially true for the type of minimal efficiency heat pumps that are the basis for the federal appliance standards for heat pumps. To address these challenges, gas-fired furnaces can be used for space heating when outdoor air temperature is below a certain threshold, normally between 35 – 45°F.

The dual-fuel heat pump system can be controlled similarly to a heat pump with electric resistance required by Section 110.2(b). The control should have the capability to set the cut-on and cut-off temperatures for the heat pump and supplementary gas-fired heating at different levels. For example, if the heat pump begins heating when the inside temperature reaches 68°F, the gas-fired furnace heating may be set to come on if the temperature goes below 65°F, if the heat pump alone could not maintain the set point of 68°F. Also, there should be an OFF mode that automatically shuts off the gas-fired heating when the inside temperature reaches 68°F. The system may also have a control capability that prevents the supplemental gas-fired furnace from operating if the outdoor air temperature is above a pre-set threshold.

Supplemental Heating System

Supplemental heating systems are allowed prescriptively, and the designer may elect to provide supplemental heating to a space such as a bathroom. In this instance, the supplemental heating system must be installed in a space that is served by the primary heating system and must have a thermal capacity of less than 2 kilowatts (kW) or 7,000 Btu/h while being controlled by a time-limiting device not exceeding 30 minutes. Electric resistance and electric radiant heating installation are not allowed as the primary heating system when using the prescriptive compliance method. **«»**

B. **Space-conditioning and ventilation systems**. All space heating and space cooling equipment serving dwelling units shall comply with minimum Appliance Efficiency Regulations as specified in Sections 110.0 through 110.2 and meet all applicable requirements of Sections 160.3(b) and 170.2(c)2.

i. Refrigerant charge—systems serving individual dwelling units. When refrigerant charge verification or fault indicator display is shown as required by Table 170.2-K, the system shall comply with either Section 170.2(c), 170.2(c)3Bia or 170.2(c)3Bib:

a. Air-cooled air conditioners and air-source heat pumps, including but not limited to ducted split systems, ducted packaged systems, small duct high velocity systems and mini-split systems, shall comply with Subsections I, II and III, unless the system is of a type that cannot be verified using the specified procedures:

I. Have measurement access holes (MAH) installed according to the specifications in Reference Residential Appendix Section RA3.2.2.3; and

«» Commentary for Section 170.2(c)3BiaI:

The measurement access hole (MAH) provides a nonintrusive means for refrigerant charge verification by ECC-Raters or ATT and other third-party inspectors. They eliminate the need for raters/inspectors to drill holes into the installed air conditioning equipment enclosures to place the temperature sensors that are required by the refrigerant charge verification test procedures described in the Reference Residential Appendix RA3.2.

Installation of MAH must be performed by the installer of the air conditioner or heat pump equipment according to the specifications given in Reference Residential Appendix RA3.2.

The MAH feature consists of one 5/8-inch (16 millimeters [mm]) diameter hole in the return plenum, upstream from the evaporator coil. (See Figure RA3.2-1 in Reference Residential Appendix RA3.2.) **«»**

II. System airflow rate in accordance with Subsection A or B below shall be confirmed through field verification and diagnostic testing in accordance with all applicable procedures specified in Reference Residential Appendix Section RA3.3 or an approved alternative procedure as specified by RA1; and

A. For small duct high velocity systems, the system airflow rate shall be greater than or equal to 250 cfm per ton; or

B. For all other air-cooled air conditioner or air-source heat pump systems, the system airflow rate shall be greater than or equal to 350 cfm per ton.

«» Commentary for Section 170.2(c)3BiaII:

Ducted forced-air cooling systems must comply with the minimum system airflow rate of greater than or equal to 350 CFM/ton, or 250 CFM/ton for small duct, high velocity systems, when performing the refrigerant charge verification. The airflow is important when performing the refrigerant charge verification to validate the measured values for pressure and temperature. The correct airflow will also improve the performance of the air-conditioning equipment.

The airflow verification procedure is documented in Reference Residential Appendix RA3.3. **«»**

III. The installer shall charge the system according to manufacturer's specifications. Refrigerant charge shall be verified according to one of the following options, as applicable:

A. The installer and rater shall perform the standard charge procedure as specified by Reference Residential Appendix Section RA3.2.2 or an approved alternative procedure as specified by RA1; or

B. The installer shall perform the weigh-in charging procedure as specified by Reference Residential Appendix Section RA3.2.3.1, provided the system is of a type that can be verified using the RA3.2.2 standard charge verification procedure and RA3.3 airflow rate verification procedure or approved alternatives in RA1. The ECC-Rater shall verify the charge using RA3.2.2 and RA3.3 or approved alternatives in RA1.

Exception to Section 170.2(c)3BiaI: Systems that cannot conform to the specifications for hole location in Reference Residential Appendix Figure RA3.2-1 shall not be required to provide holes as described in Figure RA3.2-1.

Exception to Section 170.2(c)3BiaII: Standard ducted systems without zoning dampers may comply with the minimum airflow rate by meeting the applicable requirements in Table 160.3-A and Table 160.3-B as confirmed by field verification and diagnostic testing in accordance with the procedures in Reference Residential Appendix Sections RA3.1.4.4 and RA3.1.4.5. The design clean-filter pressure drop requirements of Section 160.2(b)1D for the system air filter device(s) shall conform to the requirements given in Table 160.3-A and Table 160.3-B.

Exception to Section 170.2(c)3BiaIII: When the outdoor temperature is less than 55 degrees F and the installer utilizes the weigh-in charging procedure in Reference Residential Appendix Section RA3.2.3.1 to verify the refrigerant charge, the installer may elect to utilize the verification procedure in Reference Residential Appendix Section RA3.2.3.2. If the verification procedure in Section RA3.2.3.2 is used for compliance, the system's thermostat shall conform to the specifications in Section 110.12. Ducted systems shall comply with the minimum system airflow rate requirement in Section 170.2(c)3BiaII.

b. For air-cooled air conditioners and air-source heat pumps, including but not limited to ducted split systems, ducted packaged systems, small duct high velocity systems and mini-split systems, which are of a type that cannot comply with the requirements of Section 170.2(c)3Bi:

I. The installer shall confirm the refrigerant charge using the weigh-in charging procedure specified in Reference Residential Appendix Section RA3.2.3.1, as verified by an ECC-Rater according to the procedures specified in Reference Residential Appendix Section RA3.2.3.2; and

II. Systems that utilize forced air ducts shall comply with the minimum system airflow rate requirement in Section 170.2(c)3BiaII, provided the system is of a type that can be verified using the procedures in RA3.3 or an approved alternative procedure in RA1.

Exception 1 to Section 170.2(c)3Bi: Packaged systems for which the manufacturer has verified correct system refrigerant charge prior to shipment from the factory are not required to have refrigerant charge confirmed through field verification and diagnostic testing. The installer of these packaged systems shall certify that the packaged system was precharged at the factory and has not been altered in a way that would affect the charge. Ducted systems shall comply with minimum system airflow rate requirement in Section 170.2(c)3Bib, provided that the system is of a type that can be verified using the procedure specified in RA3.3 or an approved alternative in RA1.

Exception 2 to Section 170.2(c)3Bi: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four habitable stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

«» Commentary for Section 170.2(c)3BiaIII and Section 170.2(c)3Bib:

Refrigerant charge refers to the actual amount of refrigerant present in the system. Excessive refrigerant charge (overcharge) reduces system efficiency and can lead to premature compressor failure. Insufficient refrigerant charge (undercharge) also reduces system efficiency and can cause compressors to overheat. Ensuring correct refrigerant charge can significantly improve the performance of air-conditioning equipment. Refrigerants are the working fluids in air-conditioning and heat-pump systems that absorb heat energy from one area (through the evaporator), transfer, and reject it to another (through the condenser).

Verification of proper refrigerant charge must occur after the HVAC contractor has installed and charged the system in accordance with the manufacturer's specifications. The procedure requires properly calibrated digital refrigerant gauges, thermocouples, and digital thermometers. When multiple systems in the same dwelling unit require testing, test each system.

In a typical cooling system, there are two important performance criteria that are relatively easy to verify that there is neither too much nor too little refrigerant in the system. In systems with a fixed-orifice device in the evaporator coil, the number to check is called the superheat. In a system with a variable-metering device, the number to check is called the subcooling.

Superheat refers to the number of degrees the refrigerant is raised after it evaporates into a gas. This occurs inside the evaporator coil (or indoor coil). The correct superheat for a system will vary depending on certain operating conditions. The target superheat for a system must be obtained from a table provided in the RA3.2 protocols or the manufacturer's superheat table. There is an allowed range of several degrees between the measured superheat and the target superheat for a system to pass.

Subcooling refers to the number of degrees the refrigerant is lowered after it condenses into a liquid. This occurs inside the condenser coil (or outdoor coil). The manufacturer specifies the correct subcooling for a system. It may vary depending on operating conditions. Like superheat, there is an allowed range of several degrees between the measured subcooling and the target subcooling for a system to pass.

The temperature at which a refrigerant condenses or evaporates is called the saturation temperature. Above the saturation temperature, a refrigerant is always a gas. Below the saturation temperature, a refrigerant is always a liquid.

Saturation is when a refrigerant exists as both a liquid and a gas. It always occurs at the same temperature, depending on what the pressure of the refrigerant happens to be. At higher pressures, the saturation temperature goes up and vice versa. This convenient property is what makes refrigeration work.

The saturation temperature can be determined by simply measuring the pressure of a refrigerant and referring to a table, known as a pressure-temperature (PT) table, for that specific refrigerant. Saturation temperatures are well-documented for all common refrigerants.

Because variable refrigerant metering devices are prone to failure and even more so to improper installation, it is important that the operation of these devices be checked. A metering device maintains a relatively constant superheat over a wide range of operating conditions; therefore, checking the superheat, in addition to the other tests performed, will indicate if the metering device is operating correctly.

Unfortunately, checking superheat and subcooling can be done only under certain indoor and outdoor conditions. This verification procedure, called the Standard Charge Verification Method, is very weather-dependent.

There is another way to verify proper refrigerant charge that is not weather–dependent, and that is by weighing the refrigerant. Called the Weigh-in Charge Verification Method, this approach can be performed only by the installer. It can be verified by the ECC-Rater either by simultaneous observation or by using the standard method when conditions permit.

Minimum System Airflow Verification for Refrigerant Charge Verification

To have a valid charge test, the system airflow must be verified to be at least 300 CFM/ton for altered systems and 350 CFM/ton for new systems. 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 (nonpowered) flow hood. The airflow verification procedures for refrigerant charge verification no longer include the temperature split method.

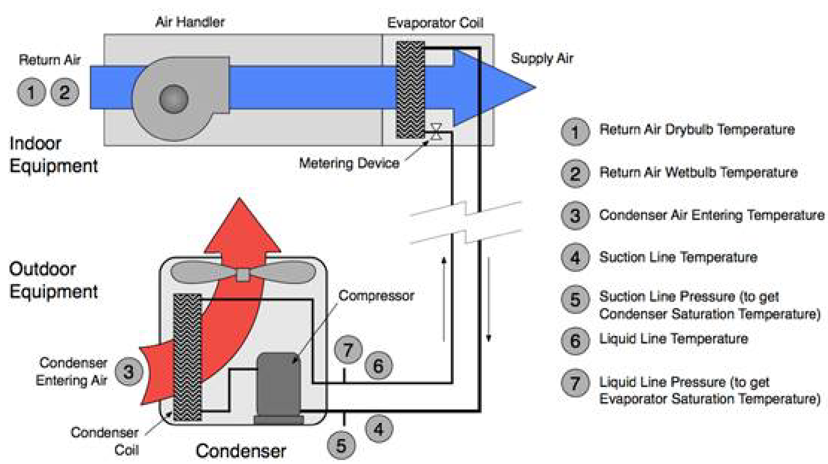
If an altered system does not meet the minimum airflow requirements, remedial steps are required to increase system airflow. More airflow is generally better for systems with air conditioning. Not only does this allow proper refrigerant charge to be verified, but it improves the overall performance of the system. When able to be performed on a system, regardless of the refrigerant charge verification procedure, minimum system airflow must always be verified.

In some alterations, improving airflow may be cost-prohibitive, and there is a process for documenting this (RA3.3.3.1.5). When this option is used, verification by sample groups is not allowed. Minimum airflow is critical to proper air-conditioner operation. Reducing airflow reduces cooling capacity and efficiency. Many systems in California have oversized equipment and undersized ducts. In newly installed duct systems, the minimum airflow requirement is higher because the opportunity exists to design and install a better system. In altered systems, the installer may be required to modify the ducts system to meet the minimum airflow. The minimums of 300 and 350 CFM/ton are lower than the desired airflow for most systems, which is usually 400 CFM/ton and higher.

Standard Charge Verification Procedure (RA3.2.2)

The first step is to turn on the air-conditioning system and let it run for at least 15 minutes to stabilize temperatures and pressures. While the system is stabilizing, the ECC-Rater or the installer may attach the instruments needed to take the measurements.

Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests



Source: California Energy Commission

The following measurements must be taken by the technician or ECC-Rater, when applicable.

1. The return air wet bulb and dry bulb temperatures are measured in the return plenum before the blower at the location labeled "Title 24 – Return Plenum Measurement Access Hole." This hole must be provided by the installer, not the rater (See Points 1 and 2 in Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests). See Figure RA 3.2-1 for more information on the placement of the measurement access hole (MAH).
2. Moreover, the outdoor air dry bulb temperature is measured at the point where the air enters the outdoor condensing coil. (See Point 3 in Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests. It is important that this outdoor temperature sensor be shaded from direct sun during the verification procedure.

In addition to the air temperature measurements, four refrigerant properties need to be measured. Two of these measurements are taken near the suction line service valve before the line enters the outdoor unit and are used to check the superheat.

1. The first measurement is the temperature of the refrigerant in the suction line, which is taken by a clamp-on thermocouple or other suitable device insulated from the outdoor air. (See Point 4 in Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests.)
2. The second measurement determines the saturation temperature of the refrigerant in the evaporator coil. (See Point 5 in Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests.) The saturation temperature can be determined from the low-side (suction line) pressure and a saturation temperature table for the applicable refrigerant.

To check the subcooling, two more refrigerant properties are required and may be measured near the liquid line service valve at the point where the line exits the outdoor unit.

1. The liquid refrigerant temperature in the liquid line is measured by a clamp-on thermocouple insulated from the outdoor air. (See Point 6 in Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests.)
2. The condenser saturation temperature can be determined from the liquid line pressure and a saturation temperature table for the applicable refrigerant. (See Point 7 in Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests)

Determination of the condenser saturation temperature and the liquid line temperature is used only for the subcooling verification method on systems with thermostatic expansion valve (TXV) or electronic expansion valve (EXV) metering devices.

Superheat Charge Verification Method (RA3.2.2.6.1)

The Superheat Charge Verification Method is used on units with a fixed-orifice refrigerant metering device (not a TXV or EXV).

Airflow verification must be confirmed before starting the Superheat Verification Method.

The Superheat Verification Method compares the actual (measured) superheat temperature to a target value from a table. The actual superheat temperature is the measured suction line temperature ($T_{Suction,\ db}$) minus the evaporator saturation temperature ($T_{Evaporator,\ Saturation}$). The target superheat value is read from a table (Table RA3.2-2 or the manufacturer's superheat table).

Only an EPA-certified technician may add or remove refrigerant. Under no circumstances may ECC-Raters add or remove refrigerant on systems that they are verifying.

Subcooling Verification Method (RA3.2.2.6.2)

The Subcooling Verification Method is used on units with a variable refrigerant metering device (a TXV or EXV).

Airflow verification must be confirmed before starting the Subcooling Verification Method.

The Subcooling Verification Method compares the actual subcooling temperature to the target value supplied by the manufacturer. The actual subcooling is the condenser saturation temperature ($T_{Condenser, Saturation}$) minus the liquid line temperature (T_{Liquid}).

Weigh-In Charging Procedure (RA3.2.3)

The weigh-in charging procedure charges the system by determining the appropriate weight of refrigerant based on the size of the equipment and refrigerant lines rather than by measuring steady-state performance of the system. Systems using the weigh-in procedure to meet the refrigerant charge verification requirement may not use group sampling procedures for ECC-verification compliance.

The weigh-in procedure does not relieve the installer of the responsibility to comply with the required minimum system airflow.

There are two installer options for completing the weigh-in procedure. One involves adjusting the amount of refrigerant supplied by the manufacturer in a new system, 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 be used only when a new factory-charged outdoor unit 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. Only the installer/technician may perform any kind of weigh-in procedure.

Equipment Limitations

The Energy Code specifically requires verification of refrigerant charge only for air-cooled air conditioners and air-source heat pumps. All other types of systems are not expressly exempt from the refrigerant charge requirements. Certain portions of the requirements may still apply, such as the minimum system airflow requirement. The installer would have to confirm with the manufacturer and the CEC. The installer must adhere strictly to the manufacturer's specifications.

Variable refrigerant flow systems and systems such as some mini-split systems that cannot be verified using the standard charge verification procedure in RA3.2.2 must demonstrate compliance using the weigh-in method. Verification by the ECC-Rater can be accomplished only by simultaneous observation of the installer's weigh-in as specified by RA3.2.3.2, and only if use of ECC-Rater observation procedure is specified by the Energy Code. **«»**

ii. Space-conditioning distribution systems. All space-conditioning systems shall meet all applicable requirements of a or b below:

a. High performance attics. Air handlers or ducts are allowed to be in ventilated attic spaces when the roof and ceiling insulation level meet Option B in Table 170.2-A.

b. Duct and air handlers located in conditioned space. Duct systems and air handlers of HVAC systems shall be located in conditioned space, and confirmed by field verification and diagnostic testing to meet the criterion of Reference Residential Appendix RA3.1.4.3.8.

Note: Gas heating appliances installed in conditioned spaces must meet the combustion air requirements of California Mechanical Code Chapter 7, as applicable.

«» Commentary for Section 170.2(c)3Bii:

Duct Location

Standard multifamily construction practice in California is to place ducts and associated air handling equipment in conditioned space. Ducts are typically in a dropped soffit or in-between floors, and equipment may also be in the ceiling or an interior mechanical closet. When meeting the prescriptive requirements for the Energy Code, there are two options for where ducts and equipment can be located:

1. Ducts in conditioned space (DCS) with the duct system and air handler(s) within the thermal envelope and air barrier of the building. This DCS option requires field verification to meet the prescriptive requirement. This option applies to both attic roofs and non-attic roofs.
2. For buildings with attic roofs, ducts may be installed in a vented attic if Option B in Table 170.2-A is met. Option B requires a high-performance attic (HPA) design in climate zones 4 and 8 – 16. A HPA implements requirements that minimize temperature differences between the attic space and the conditioned air being transported through ductwork in the attic. The package consists of insulation below the roof in addition to insulation at the ceiling. These requirements and approaches to meet the requirements are explained in Chapter 3 Building Envelope.

For the DCS prescriptive approach, additional requirements apply:

1. Air handlers containing a combustion component should be direct-vent (sealed combustion chambers) and must not use air from any conditioned or unconditioned space as combustion air. Other types of combustion heating systems are possible if the system installer adheres to the combustion air requirements found in Chapter 7 of the California Mechanical Code.
2. Duct location needs to be verified through a visual inspection per Reference Residential Appendix RA3.1.4.1.3. This must be conducted by a ECC-Rater for multifamily buildings up to three habitable stories. Otherwise, the installing contractor can certify the results.
3. Duct leakage to outside needs to be confirmed by field verification and diagnostic testing in accordance with Reference Residential Appendix RA3.1.4.3.8. This must be conducted by a ECC-Rater for multifamily buildings up to three habitable stories. Otherwise, the installing contractor can certify the results.

For the vented attic with HPA prescriptive approach, additional requirements apply (Refer to Chapter 3.5 of the Single-Family Compliance Manual for more information on this option):

1. Ducts are insulated to a level required in Table 170.2-K.
2. Ceiling and below roof deck insulation must meet the levels required in Table 170.2-A Option B. Roof deck insulation must be installed with an air space present between the roofing and the roof deck, such as is typical with standard installation of concrete or clay tile.
3. Roofing products must meet the reflectance and emittance values in Table 170.2-A Option B.
4. A radiant barrier is required is climate zones 2, 3, and 5 – 7 per Table 170.2-A Option B.

If a building is not able to meet all the requirements listed above, it must use the performance approach. Multifamily buildings with vented attics may have ductwork in the attic above the top floor units with lower floor unit ductwork in conditioned space. To comply prescriptively, the top floor units need to meet the requirement for ducts in a vented attic, which may include HPA depending on climate zone. The lower floor units need to meet all the requirements for DCS. «»

iii. Central fan integrated ventilation systems—systems serving individual dwelling units. Central forced air system fans used to provide outside air shall have an air-handling unit fan efficacy less than or equal to the maximum W/cfm specified in a or b below. The airflow rate and fan efficacy requirements in this section shall be confirmed through field verification and diagnostic testing in accordance with all applicable procedures specified in Reference Residential Appendix RA3.3. Central Fan Integrated Ventilation Systems shall be certified to the Energy Commission as Intermittent Ventilation Systems as specified in Reference Residential Appendix RA3.7.4.2.

a. 0.45 W/cfm for gas furnace air-handling units; or

b. 0.58 W/cfm for air-handling units that are not gas furnaces.

«» Commentary for Section 170.2(c)3Biii:

CFI ventilation uses a central forced air heating and/or cooling system that operates regularly to pull outside air into the air distribution system and distribute air around the dwelling unit. There is a prescriptive requirement that CFI systems meet the same mandatory fan efficacy requirements for other forced air cooling systems. This requires no greater than 0.45 W/CFM for gas furnaces and 0.58 W/CFM for all other air handler including heat pumps. This can be traded-off using the performance approach. Verification must be conducted by a ECC-Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings, verification only needs to be conducted and certified by the installing contractor, and neither a ECC-Rater nor registration with a ECC-Provider is required. **«»**

iv. Balanced ventilation systems with heat/energy recovery in climate zones 1, 2, 4, 11-14, and 16. A balanced ventilation system with heat or energy recovery shall be used to meet Section 160.2(b)2Aivb1, and shall meet the applicable requirements of a, or b below:

a. In Climate Zones 1, 2, 4, 11-14, and 16, balanced ventilation systems serving individual dwelling units shall:

1. Be an energy recovery ventilator (ERV) or heat recovery ventilator (HRV),
2. Have a minimum sensible recovery efficiency of 67 percent, rated at 32 degrees Fahrenheit (0 degrees Celsius), and
3. Have a fan efficacy less than or equal to 0.6 W per cfm.

These measures shall be confirmed through field verification in accordance with the procedures in RA3.7.4.4 for buildings with three habitable stories or less, or the procedures in NA2.2.4.1.5 for buildings with four or more habitable stories.

b. In Climate Zones 1, 2, 4, 11-14, and 16, balanced ventilation systems serving multiple dwelling units in buildings with four or more habitable stories shall:

1. Be an ERV or HRV,
2. Have a minimum sensible recovery efficiency or effectiveness of 67 percent, rated at 32 degrees Fahrenheit (0 degrees Celsius),
3. Meet the fan power requirements of Section 170.2(c)4A, and
4. Have recovery bypass or control to directly economize with ventilation air based on outdoor air temperature limits specified in Table 170.2-G.

These measures shall be field verified in accordance with NA7.18.4.

v. In buildings with three habitable stories or less in Climate Zones 5–10 and Climate Zone 15, when a heat pump space-conditioning system is installed to meet the requirements of Section 170.2(c)3Ai, balanced ventilation systems without an ERV or HRV shall have a fan efficacy less than or equal to 0.4 W/cfm.

Exception to Section 170.2(c)3B: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four habitable stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

«» Commentary for Section 170.2(c)3Biv:

Balanced Ventilation

If a balanced system is used to satisfy mandatory requirements, the prescriptive requirements of Section 170.2(c)3Biv requires multifamily units to install HRVs or ERVs in climate zones 1, 2, 4, 11 – 14 and 16. Multifamily units that do not trigger this requirement may still choose to use an HRV or ERV.

For multifamily buildings up to three stories in Climate Zones 5 – 10 and 15, balanced ventilation systems without heat or energy recovery are required by Section 170.2(c)3 to have a fan efficacy of 0.4 W/CFM or less. For example, if the balanced ventilation system includes a bathroom exhaust fan and an in-line supply fan, the total rated fan efficacy must be less than 0.4 W/CFM. The total fan efficiency for the ventilation system is calculated using the parameters in the following equation:

$$Total\ fan\ efficiency = \frac{Total\ rated\ power\ of\ exhaust\ and\ supply\ fan\ at\ ventilation\ flow\ rate\ (W)}{Outdoor\ air\ ventilation\ flow\ rate\ (CFM)}$$

Compliance with the fan efficiency requirements for ventilation can be verified by reviewing product certification data from the HVI database or the AHAM Certified Range Hood Directory. Linear interpolation of rated performance parameters may be used when calculating the fan efficacy at the required outdoor airflow rate as described in Reference Residential Appendix RA3.7.4.4. The HVI database can be found at https://www.hvi.org/hvi-certified-products-directory/. The AHAM Directory can be found at https://www.aham.org/AHAM/What_We_Do/Kitchen_Range_Hood_Certification.

CFI Ventilation Systems Fan Watt Draw

When using the prescriptive approach, the fan efficacy of CFI systems must be verified by a ECC-Rater (for multifamily dwelling units in buildings up to three habitable stories) or an ATT (for multifamily dwelling units in buildings four or more habitable stories) using the same methods as required for furnaces and air handlers. (See Reference Residential Appendix RA3.3.) For verification, the central system air handler must be operating in ventilation mode with the outdoor air damper open and with outdoor ventilation air flowing into the return plenum from the supply duct. Furthermore, the airflow that must be measured is the total airflow through the air handler (system airflow), which is the sum of the return airflow, and the outside air ducted to the return plenum (ventilation airflow).

The watt draw must be less than or equal to 0.45 W/CFM for furnaces, 0.58 W/CFM for air handlers that are not gas furnaces, and 0.62 W/CFM for small duct, high-velocity systems. If not, the performance approach must be used.

ERV/HRV Fan Efficacy and Heat Recovery

For Climate Zones 1, 2, 4, 11 – 14, and 16, in addition to requiring heat recovery for ventilation, the prescriptive requirements require that HRVs and ERVs serving a single dwelling unit must have a fan efficacy of 0.6 W/CFM or less per Section 170.2(c)3Biva3.

Central ERVs or HRVs (serving multiple dwelling units) must meet fan efficacy requirements per Section 170.2(c)4A using the fan power allowance formula below. For ERVs and HRVs, the fan power allowance must be separately calculated for the supply and return airflows, and then summed.

$$FPA_{adj} = \frac{Q_{comp}}{Q_{sys}} \times FPA_{comp}$$

Where,

1. FPA_{adj} = The corrected fan power allowance for component in W/CFM
2. Q_{comp} = The airflow through component in CFM
3. Q_{sys} = The system airflow
4. FPA_{comp} = The fan power allowance of the component from Table 170.2-B or Table 170.2-C

ERV and HRV systems meeting the Section 170.2(c)3Biv prescriptive requirements must also meet a minimum sensible recovery efficiency or effectiveness of 67%, rated at 32°F.

Compliance with the requirements for unitary equipment can be verified by reviewing product certification data from the HVI database at the URL below. See Reference Residential Appendix RA3.7.4.4 for more information on verification of unitary equipment performance parameters.

Central equipment must have a bypass function for free cooling, in which the incoming outdoor air bypasses the heat exchanger when the outdoor air temperature is below the cooling set point. This allows the ventilation system to operate in economizing mode taking advantage of cool outdoor temperatures. The bypass mode is an important feature, particularly in mild climates where heat recovery without bypass can increase cooling loads. The controls must meet the air economizer high limit shut off control requirements in Table 170.2-G.

For ERV or HRV systems that are not meeting the prescriptive requirements, the fan efficacy need only meet the mandatory requirement of 1.0 W/CFM or less. «»

C. HVAC system bypass ducts. Bypass ducts that deliver conditioned supply air directly to the space-conditioning system return duct airflow shall not be used.

4. **Common use area space-conditioning systems**. A building complies with this section by being designed with and having constructed and installed a space-conditioning system that meets the applicable requirements of Subsections A through O.

   A. **Fan systems**. Each fan system moving air into, out of, or between spaces or circulating air for the purpose of conditioning air within a space shall meet the requirements of Items i, ii and iii below.

      i. **Fan power budget.** For each fan system that includes at least one fan or fan array with fan electrical input power ≥ 1 kW, fan system electrical input power (Fan $kW_{design,system}$) determined per Section 170.2(c)4Aib at the fan system design airflow shall not exceed Fan kW_{budget} as calculated per Section 170.2(c)4Aia.

a. Calculation of fan power budget (Fan kW_{budget}). For each fan system:

I. Determine the fan system airflow and choose the appropriate table(s) for fan power allowance.

A. For single-cabinet fan systems, use the fan system airflow and the power allowances in both Tables 170.2-B and Table 170.2-C.

B. For supply-only fan systems, use the fan system airflow and power allowances in Table 170.2-B.

C. For relief fan systems, use the design relief airflow and the power allowances in Table 170.2-C.

D. For exhaust, return and transfer fan systems, use the fan system airflow and the power allowances in Table 170.2-C.

E. For complex fan systems, separately calculate the fan power allowance for the supply and return/exhaust systems and sum them. For the supply airflow, use supply airflow at the fan system design conditions, and the power allowances in Table 170.2-B. For the return/exhaust airflow, use return/exhaust airflow at the fan system design conditions, and the power allowances in Table 170.2-C.

II. For each fan system, determine the components included in the fan system and sum the fan power allowances of those components. All fan systems shall include the system base allowance. If, for a given component, only a portion of the fan system airflow passes through the component, calculate the fan power allowance for that component per this equation:

$$FPA_{adj} = \frac{Q_{comp}}{Q_{sys}} \times FPA_{comp}$$

Where:

FPA_{adj} = The correct/ed fan power allowance for the component in w/cfm

Q_{comp} = The airflow through component in cfm

Q_{sys} = The fan system airflow in cfm

FPA_{comp} = The fan power allowance of the component from Table 170.2-B or Table 170.2-C

III. Multiply the fan system airflow by the sum of the fan power allowances for the fan system.

IV. Divide by 1000 to convert to Fan kW_{budget}.

V. For building sites at elevations greater than 3,000 feet, multiply Fan kW_{budget} by the correction factor in Table 170.2-D.

b. Determining fan system electrical input power (Fan $kW_{design,system}$). Fan $kW_{design,system}$ is the sum of Fan kW_{design} for each fan or fan array included in the fan system with Fan kW_{design} ≥ 1 kW. If variable speed drives are used, their efficiency losses shall be included. Fan input power shall be calculated with two times the clean filter pressure drop, which is the mean of the clean filter pressure drop and design final filter pressure drop. The Fan kW_{design} for each fan or fan array shall be determined using one of the following methods. There is no requirement to use the same method for all fans in a fan system:

I. Use the default Fan kW_{design} in Table 170.2-E-1 for one or more of the fans. This method cannot be used for complex fan systems.

II. Use the Fan kW_{design} at fan system design conditions provided by the manufacturer of the fan, fan array, or equipment that includes the fan or fan array calculated per a test procedure included in USDOE 10 CFR Part 430, USDOE 10 CFR Part 431, ANSI/AMCA Standard 208-2018, ANSI/AMCA Standard 210-2016, AHRI Standard 430-2020, AHRI Standard 440-2019 or ISO 5801-2017.

III. Use the Fan kW_{design} provided by the manufacturer, calculated at fan system design conditions per one of the methods listed in Section 5.3 of ANSI/AMCA 208-2018.

IV. Determine the Fan kW_{design} by using the maximum electrical input power provided on the motor nameplate.

ii. **VAV systems.**

a. Static pressure sensor location. Static pressure sensors used to control variable air volume fans shall be placed in a position such that the controller setpoint is no greater than one-third the total design fan static pressure, except for systems with zone reset control complying with Section 170.2(c)4Aiib. If this results in the sensor being located downstream of any major duct split, multiple sensors shall be installed in each major branch with fan capacity controlled to satisfy the sensor furthest below its setpoint; and

b. Setpoint reset. For systems with direct digital control of individual zone boxes reporting to the central control panel, static pressure setpoints shall be reset based on the zone requiring the most pressure, i.e., the setpoint is reset lower until one zone damper is nearly wide open.

iii. **Fractional HVAC motors for fans.** HVAC motors for fans that are less than 1 hp and 1/12 hp or greater shall be electronically commutated motors or shall have a minimum motor efficiency of 70 percent when rated in accordance with NEMA Standard MG 1-2006 at full load rating conditions. These motors shall also have the means to adjust motor speed for either balancing or remote control. Belt-driven fans may use sheave adjustments for airflow balancing in lieu of a varying motor speed.

Exception 1 to Section 170.2(c)4Aiii: Motors in fan-coils and terminal units that operate only when providing heating to the space served.

Exception 2 to Section 170.2(c)4Aiii: Motors in space-conditioning equipment certified under Section 110.1 or 110.2.

Exception 1 to 170.2(c)4A: Fan system power caused solely by process loads.

TABLE 170.2-B: Supply Fan Power Allowances (watts/cfm)

Component	Multi-Zone VAV Systems ≤5,000 cfm	Multi-Zone VAV Systems >5,000 and ≤10,000 cfm	Multi-Zone VAV Systems >10,000 cfm	All Other Fan Systems ≤5,000 cfm	All Other Fan Systems >5,000 and ≤10,000 cfm	All Other Fan Systems >10,000 cfm
Supply System Base Allowance for AHU Serving Spaces < 6 Floors Away.	0.395	0.453	0.413	0.232	0.256	0.236
Supply System Base Allowance for AHU Serving Spaces > 6 Floors Away	0.508	0.548	0.501	0.349	0.356	0.325
MERV 13 to MERV 16 Filter Upstream of Thermal Conditioning Equipment (two times the clean filter pressure drop)[2]	0.136	0.114	0.105	0.139	0.120	0.107
MERV 13 to MERV 16 Final Filter Downstream of Thermal Conditioning Equipment. (two times the clean filter pressure drop) [2]	0.225	0.188	0.176	0.231	0.197	0.177
Filtration Allowance for > Merv 16 or HEPA Filter (two times the clean filter pressure drop) [2]	0.335	0.280	0.265	0.342	0.292	0.264
Central Hydronic Heating Coil Allowance	0.046	0.048	0.052	0.046	0.050	0.054
Electric Heat Allowance	0.046	0.038	0.035	0.046	0.040	0.036

TABLE 170.2-B: Supply Fan Power Allowances (watts/cfm) (Continued)

Component	Multi-Zone VAV Systems ≤5,000 cfm	Multi-Zone VAV Systems >5,000 and ≤10,000 cfm	Multi-Zone VAV Systems >10,000 cfm	All Other Fan Systems ≤5,000 cfm	All Other Fan Systems >5,000 and ≤10,000 cfm	All Other Fan Systems >10,000 cfm
Gas Heat Allowance	0.069	0.057	0.070	0.058	0.060	0.072

Hydronic/DX Cooling Coil, or Heat Pump Coil (wet) Allowance	0.135	0.114	0.105	0.139	0.120	0.107
Solid or Liquid Desiccant System Allowance	0.157	0.132	0.123	0.163	0.139	0.124
Reheat Coil for Dehumidification Allowance	0.045	0.038	0.035	0.046	0.040	0.036
Allowance for evaporative humidifier/cooler in series with a cooling coil. Value shown is allowed watts/cfm per 1.0 in. wg. Determine pressure loss (in. wg) at 400 fpm or maximum velocity allowed by the manufacturer, whichever is less. *[Calculation required, see note 4]*	0.224	0.188	0.176	0.231	0.197	0.177
Allowance for 100% outdoor air system meeting the requirements of Note 5.	0.000	0.000	0.000	0.070	0.100	0.107
Energy Recovery Allowance for 0.50 ≤ ERR <0.55 [6]	0.135	0.114	0.105	0.139	0.120	0.107
Energy Recovery Allowance for 0.55 ≤ ERR <0.60 [6]	0.160	0.134	0.124	0.165	0.141	0.126
Energy Recovery Allowance for 0.60 ≤ ERR <0.65 [6]	0.184	0.155	0.144	0.190	0.163	0.146
Energy Recovery Allowance for 0.65 ≤ ERR <0.70 [6]	0.208	0.175	0.163	0.215	0.184	0.165
Energy Recovery Allowance for 0.70 ≤ ERR <0.75 [6]	0.232	0.196	0.183	0.240	0.205	0.184
Energy Recovery Allowance for 0.75 ≤ ERR <0.80 [6]	0.257	0.216	0.202	0.264	0.226	0.203
Energy Recovery Allowance for ERR ≥ 0.80 [6]	0.281	0.236	0.222	0.289	0.247	0.222
Coil Runaround Loop	0.135	0.114	0.105	0.139	0.120	0.107
Allowance for gas phase filtration required by code or accredited standard. Value shown is allowed w/cfm per 1.0 in. wg air pressure drop. *[Calculation required, see note 4]*	0.224	0.188	0.176	0.231	0.197	0.177

TABLE 170.2-B: Supply Fan Power Allowances (watts/cfm) (Continued)

Component	**Multi-Zone VAV Systems ≤5,000 cfm**	**Multi-Zone VAV Systems >5,000 and ≤10,000 cfm**	**Multi-Zone VAV Systems >10,000 cfm**	**All Other Fan Systems ≤5,000 cfm**	**All Other Fan Systems >5,000 and ≤10,000 cfm**	**All Other Fan Systems >10,000 cfm**
Economizer Return Damper	0.045	0.038	0.035	0.046	0.040	0.036
Air Blender Allowance	0.045	0.038	0.035	0.046	0.040	0.036
Allowance for sound attenuation section [fans serving spaces with design background noise goals below NC35].	0.034	0.029	0.026	0.035	0.030	0.027
Deduction for systems that feed a terminal unit with a fan with electrical input power < 1kW.	-0.100	-0.100	-0.100	-0.100	-0.100	-0.100
Low-turndown single-zone VAV fan systems meeting the requirements in note 7.	0.000	0.000	0.000	.070	0.100	0.089

Footnote to TABLE 170.2-B:

1. See FAN SYSTEM, MULTI-ZONE VARIABLE AIR VOLUME (VAV) in definition a Multi-Zone VAV System.
2. Filter fan power allowance can only be counted once per fan system.
3. RESERVED.
4. Power allowance requires further calculation by multiplying the actual in. wg. of the device/ component by the watts/ cfm in Table 170.2-B.
5. The 100% outdoor air system must serve 3 or more HVAC zones and airflow during non-economizer operating periods must not exceed 135% of minimum requirements in Section 120.1(c)(3).
6. Energy Recovery Ratio (ERR) calculated per ANSI/ASHRAE 84-2020.
7. A low-turndown single-zone VAV fan system must be capable of and configured to reduce airflow to 50 percent of design airflow and use no more than 30 percent of the design wattage at that airflow. No more than 10 percent of the design load served by the equipment shall have fixed loads.

TABLE 170.2-C: EXHAUST, RETURN, RELIEF, TRANSFER FAN POWER ALLOWANCES (WATT/CFM)

Component	**Multi-Zone VAV Systems ≤5,000 cfm[1]**	**Multi-Zone VAV Systems >5,000 and ≤10,000 cfm[1]**	**Multi-Zone VAV Systems >10,000 cfm[1]**	**All Other Fan Systems ≤5,000 cfm**	**All Other Fan Systems >5,000 and ≤10,000 cfm**	**All Other Fan Systems >10,000 cfm**
Exhaust System Base Allowance	0.221	0.246	0.236	0.186	0.184	0.190
Filter (any MERV value)[2]	0.046	0.041	0.036	0.046	0.041	0.035
Energy Recovery Allowance for 0.50 ≤ ERR <0.55 [3]	0.139	0.120	0.107	0.139	0.123	0.109
Energy Recovery Allowance for 0.55 ≤ ERR <0.60 [3]	0.165	0.142	0.126	0.165	0.144	0.128
Energy Recovery Allowance for 0.60 ≤ ERR <0.65 [3]	0.190	0.163	0.146	0.191	0.166	0.148
Energy Recovery Allowance for 0.65 ≤ ERR <0.70 [3]	0.215	0.184	0.165	0.216	0.188	0.167
Energy Recovery Allowance for 0.70 ≤ ERR <0.75 [3]	0.240	0.206	0.184	0.241	0.209	0.186
Energy Recovery Allowance for 0.75 ≤ ERR <0.80 [3]	0.265	0.227	0.203	0.266	0.231	0.205
Energy Recovery Allowance for ERR ≥ 0.80 [3]	0.289	0.248	0.222	0.291	0.252	0.225
Coil Runaround Loop	0.139	0.120	0.107	0.139	0.123	0.109

TABLE 170.2-C: EXHAUST, RETURN, RELIEF, TRANSFER FAN POWER ALLOWANCES (WATT/CFM) (Continued)

Component	**Multi-Zone VAV Systems ≤5,000 cfm[1]**	**Multi-Zone VAV Systems >5,000 and ≤10,000 cfm[1]**	**Multi-Zone VAV Systems >10,000 cfm[1]**	**All Other Fan Systems ≤5,000 cfm**	**All Other Fan Systems >5,000 and ≤10,000 cfm**	**All Other Fan Systems >10,000 cfm**
Return or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms	0.116	0.100	0.089	0.116	0.102	0.091
Return and/or exhaust airflow control devices required for space pressurization control	0.116	0.100	0.089	0.116	0.102	0.091
Laboratory and vivarium exhaust systems in high-rise buildings for vertical duct exceeding 75 ft. Value shown is allowed w/cfm per 0.25 in. wg for each 100 feet exceeding 75 feet. [Calculation required, see note 4]	0.058	0.051	0.045	0.058	0.052	0.046
Biosafety cabinet. Value shown is allowed w/cfm per 1.0 in. wg air pressure drop. [Calculation required, see note 4]	0.231	0.198	0.177	0.232	0.202	0.179
Exhaust filters, scrubbers, or other exhaust treatment required by code or standard. Value shown is allowed w/cfm per 1.0 in. wg air pressure drop. [Calculation required, see note 4]	0.231	0.198	0.177	0.232	0.202	0.179
Sound attenuation section [Fans serving spaces with design background noise goals below NC35.]	0.035	0.030	0.027	0.035	0.031	0.028

Footnote to TABLE 170.2-C:

1. For requirements to be classified as a Multi-Zone VAV System see definition for Multi-Zone Variable Air Volume Fan System.
2. Filter pressure loss can only be counted once per fan system.
3. Energy Recovery Ratio (ERR) calculated per ANSI/ASHRAE 84-2020.
4. Power allowance requires further calculation, multiplying the actual pressure drop (in. wg.) of the device/ component by the watts/cfm in the Table 170.2-C.

TABLE 170.2-D AIR DENSITY CORRECTION FACTORS

Altitude (ft)	Correction factor
<3,000	1.000
≥3,000 and <4,000	0.896
≥4,000 and <5,000	0.864
≥5,000 and <6,000	0.832
≥6,000	0.801

TABLE 170.2-E-1: Default values for Fan kW_{design} Based on Motor Nameplate HP[1,2]

Motor Nameplate HP	Default Fan kW_{design} with variable speed drive (Fan kW_{design})	Default Fan kW_{design} without variable speed drive (Fan kW_{design})
<1	0.96	0.89
≥1 and <1.5	1.38	1.29
≥1.5 and <2	1.84	1.72
≥2 and <3	2.73	2.57
≥3 and <5	4.38	4.17
≥5 and <7.5	6.43	6.15
≥7.5 and <10	8.46	8.13
≥10 and <15	12.47	12.03
≥15 and <20	16.55	16.04
≥20 and <25	20.58	19.92
≥25 and <30	24.59	23.77
≥30 and <40	32.74	31.70
≥40 and <50	40.71	39.46
≥50 and <60	48.50	47.10
≥60 and <75	60.45	58.87
≥75 and ≤100	80.40	78.17

Footnote to TABLE 170.2-E-1:

1. This table cannot be used for Motor Nameplate Horsepower values greater than 100.
2. This table is to be used only with motors with a service factor ≤1.15. If the service factor is not provided, this table may not be used.

«» Commentary for Section 170.2(c)4A:

Maximum fan power is regulated in individual fan systems where the power of at least one fan or fan array in the fan system is greater than or equal to 1kW of fan electrical input power at design conditions (see Section 100.1 for definitions). A system consists of only the components that must function together to deliver air to a given area; fans that can operate independently of each other comprise separate systems. Included are all fans associated with moving air from a given space-conditioning system to the conditioned spaces and back to the source, or to exhaust air to the outdoors.

The 1 kW total criteria apply to:

1. All supply and return fans within the space-conditioning system that operate at peak load conditions.
2. All exhaust fans at the system level that operate at peak load conditions. Exhaust fans associated with economizers are not counted, provided they do not operate at peak conditions, including fans that circulate air for the purpose of conditioning air within the space.
3. Fan-powered VAV boxes if these fans run during the cooling peak. This is always the case for fans in series type boxes. Fans in parallel boxes may be ignored if they are controlled to operate only when zone heating is required, are normally off during the cooling peak, and there is no design heating load, or they are not used during design heating operation.
4. Elevator equipment room exhausts (or other exhausts that draw air from a conditioned space) through an otherwise unconditioned space, to the outdoors.

The criteria are applied individually to each space-conditioning system. In buildings having multiple space-conditioning systems, the criteria apply only to the systems having a fan or fan array whose demand exceeds 1 kW of fan electrical input power.

Meeting the fan power limit is accomplished in two parts. First, the designer calculates the allowable fan input power for their fan systems (Fan kW_{budget}). Second, the designer calculates the actual electrical input power (Fan kW_{design}, system) values of the fans in the system by summing up the Fan kW_{design} value of each fan in the fan system. The total power input must be less than the allowable power input for the fan system to comply.

To calculate the fan kW_{budget}, the designer must know the following pieces of information:

1. The type of fan system (described below)
2. The fan system control type (i.e., either Multi-Zone VAV or all other fan systems) and airflow passing through each component of the fan system
3. Knowledge of the status of all components (e.g., presence or absence of DX cooling coils, gas furnace, energy recovery wheel, economizer return damper, etc.) in the fan system. This determines which allowances from the given allowance table (e.g., Table 170.2-B, Table 170.2-C, etc.) apply to the fan system when calculating Fan kWbudget.
4. The altitude of the building to account for reduced air density (if greater than 3,000 feet).

The fan system type contributes to the determination of how the fan power budget is calculated. The fan system types are listed and described below.

Single-cabinet Fan System

This is a fan system where a single fan, single fan array, a single set of fans operating in parallel, or fans or fan arrays in series and embedded in the same cabinet that both supply air to a space and recirculate the air. Designers of this type of system will use the applicable allowances from the given supply fan power allowance table (e.g., Table 170.2-B) and exhaust/return/relief/transfer fan power allowance table (e.g., Table 170.2-C) at the fan system design airflow.

Examples include:

1. A rooftop unit with a single fan that both supplies air to the space and recirculates air.
2. An air handler with a supply and return fan in the same cabinet.
3. A rooftop unit with a relief fan that only runs during economizer operation.

Supply-only Fan System

This is a fan system that provides supply air to interior spaces and does not recirculate the air. Designers of this type of system will use the applicable allowances from the given supply table (e.g., Table 170.2-B) at the fan system design supply airflow.

Examples include:

1. An air handler with only a supply fan where the return fan is not in the same cabinet.
2. The supply fan of an ERV, even if there is an exhaust fan in the same cabinet.
3. The fan of a make-up air unit where air is exhausted from the building by a different fan.

Relief Fan System

This is a fan system dedicated to the removal of air from interior spaces to the outdoors that operates only during economizer operation. Designers of this type of system will use the applicable allowances from the given exhaust/return/relief/transfer fan power allowance table (e.g., Table 170.2-C) at the fan system design relief airflow.

Exhaust, Return, and Transfer Fan Systems

An exhaust fan system is a fan system dedicated to the removal of air from interior spaces to the outdoors that may operate at times other than economizer operation. A return fan system is a fan system dedicated to removing air from interior where some or all the air is to be recirculated except during economizer operation. A transfer fan system is a fan system that exclusively moves air from one occupied space to another. Designers of any of these three system types will use the applicable allowances from the given exhaust/return/relief/transfer fan power allowance table (e.g., Table 170.2-C) at the fan system design airflow.

Complex Fan System

This is a fan system that combines a single-cabinet fan system with other supply fans, exhaust fans, or both. The designer will separately calculate the fan power allowance for the supply component and then return/exhaust component, and then arrive at a total fan power allowance. This approach differs from a single-cabinet fan system in that for the single-cabinet fan system, the individual allowances from the supply and exhaust/return/relief/transfer tables are added before arriving at a Fan kW budget value, whereas for complex fan systems, a supply power allowance value is calculated using its allowances, a return/exhaust power value is calculated using its allowances, and then the two are added together to determine the overall Fan kW budget value.

Once the required information and fan system classification has been determined, the designer will apply the appropriate allowances from the appropriate budget table before calculating the overall Fan kW_{budget} value. All fan systems should use the base allowance from the applicable table, as well as other allowances that apply to their individual fan system. For fan system components that only receive a fraction of the airflow passing through the rest of the system, the adjusted fan power allowance should be calculated according to the following formula.

$$FPA_{adj} = \frac{Q_{comp}}{Q_{sys}} \times FPA_{comp}$$

Where,

1. FPA_{adj} = The corrected fan power allowance for the component in w/cfm
2. Q_{comp} = The airflow through component in cfm
3. Q_{sys} = The fan system airflow in cfm
4. FPA_{comp} = The fan power allowance of the component from the applicable table (e.g., Table 170.2-B or Table 170.2-C)

If the site is at an altitude of 3,000 feet above sea level or greater, the designer should apply the appropriate correction factor from Table 170.2-D to the resulting Fan kW_{budget} value.

Fan electrical input power (Fan kW_{design}) is the electrical input power in kilowatts required to operate an individual fan or fan array at design conditions. It includes the power consumption of motor controllers, if present. This value encompasses all wire-to-air losses, including motor controller, motor, and belt losses.

There are four methods available to determine Fan kW_{design} for an individual fan in a fan system. There is no requirement to use the same method for different fans in the fan system. For all methods, fan input power shall be calculated with twice the clean filter pressure drop.

1. Use the default values for Fan kW_{design} (Table 170.2-E-1) based on minimum U.S. DOE motor efficiencies. There are values for input power with and without a motor controller. This method can be used if only the motor nameplate horsepower is known. This table will likely provide a conservative estimate of fan input electrical power. This method cannot be used for complex fan systems.
2. Use the fan input power at fan system design conditions provided by the manufacturer of the fan, fan array, or equipment that includes the fan or fan array calculated per a test procedure included in USDOE 10 CFR 430, USDOE 10 CFR 431, ANSI/AMCA Standard 208, ANSI/AMCA Standard 210, AHRI Standard 430:2020, AHR Standard 440:2019 and ISO 5801:2017.
3. Use one of the options listed in Section 5.3 of ANSI/AMCA Standard 208 at design conditions. This method can be used in cases where the fan shaft input power is provided by the manufacturer, and the designer needs to calculate the input power to the motor or motor controller.
4. Use the maximum electrical input power included on the fan motor nameplate. Note that this value does not account for the loading of the fan in question (which will usually be lower than this value) and thus is likely to be a conservative method.

Once the designer has calculated the fan power budget value (Fan kW_{budget}) and their fan system's input electrical power at design conditions (Fan kW_{design}, system), the two values are compared against each other to determine if the fan system complies.

$$Fan\ kW_{design,system} \leq Fan\ kW_{budget}$$

If the above inequality is valid, then the fan system complies with the fan power budget.

Selected Fan Power Budget Allowance

The types of devices listed in Tables 170.2-B and 170.2-C that qualify for additional fan power are as follows:

1. Return or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms. The basic input power allowance is based on the assumption that return air passes through an open plenum on its way back to the fan system. For systems where all of the return air is ducted back to the return, an additional allowance equivalent to a pressure drop of 0.5 inches of water is allowed. This allowance may not be applied for air systems that have a mixture of ducted and non-ducted return.
2. Return and/or exhaust airflow control devices required for space pressurization control. Some types of spaces, such as laboratories, test rooms, and operating rooms, require that an airflow control device be provided at both the supply air delivery point and at the exhaust. The exhaust airflow control device is typically modulated to maintain a negative or positive space pressure relative to surrounding spaces. An additional pressure drop and associated input power adjustment are permitted when this type of device is installed. The allowance may be taken when some spaces served by an air handler have exhaust airflow devices and other spaces do not. However, the allowance is taken only for the cfm of air that is delivered to spaces with a qualifying exhaust airflow device.
3. Exhaust filters, scrubbers, or other exhaust treatment. Some applications require the air leaving the building be filtered to remove dust or contaminants. Exhaust air filters are also associated with some types of heat recovery systems, such as run-around coils. In this application, the purpose of the filters is to help keep the coils clean, which is necessary to maintain the effectiveness of the heat recovery system. When such devices are specified and installed, the pressure drop of the device at the fan system design condition may be included as an allowance. When calculating the additional input power, only consider the volume of air that is passing through the device under fan system design conditions.
4. Particulate filtration allowance: greater than MERV 16 and electronically enhanced filters. The primary purpose of filters is to keep the fans, coils, and ducts clean, and to reduce maintenance costs. A secondary purpose is to improve indoor air quality. MERV ratings are used as the basis of this allowance. These ratings indicate the amount of particulate removed from the airstream. A higher MERV rating is more efficient and removes more material. The allowance for filters with a MERV rating of 16 and greater and all electronically enhanced filters is based on two times the clean pressure drop of the filter at fan system design conditions. These clean pressure drop data are taken from manufacturers' literature.
5. Carbon and other gas-phase air cleaners. For carbon and other gas-phase air cleaners, additional input power is based on the rated clean pressure drop of the air-cleaning device at fan system design conditions.
6. Biosafety cabinet. If the device is listed as a biosafety cabinet, you can use this allowance.

7. Energy recovery device. Energy recovery devices exchange heat between the outside air intake stream and the exhaust airstream. There are two common types of heat recovery devices: heat wheels and air-to-air heat exchangers. Both increase the pressure drop and require a system with a larger input power. The allowance increases linearly with an increasing energy recovery ratio. There are seven rows, but designers can only choose one allowance corresponding to their energy recovery device's energy recovery ratio. The allowance is a function of the enthalpy recovery ratio. This is intended to encourage designers to select energy recovery devices that have low pressure drops and high enthalpy recovery ratios, and thus provide a net energy reduction. This allows systems that have trouble meeting the fan power limit to gain a higher fan power allowance — by using larger energy recovery devices with higher enthalpy recovery ratios.
8. Coil runaround loop. The coil runaround loop is a form of energy recovery device that uses separate coils in the exhaust and outdoor air intakes with a pump in between. The allowance is to account for the increased air pressure of these two coils.
9. Exhaust systems that serve fume hoods. Exhaust systems that serve fume hoods get an allowance equivalent to an additional 0.35 inches of water to account for the pressure through the fume hood, ductwork, and zone valve or balancing devices. This allowance applies to the exhaust fans only.

«»

B. **Space-conditioning zone controls.** Each space-conditioning zone shall have controls designed in accordance with i or ii:

   i. Each space-conditioning zone shall have controls that prevent:

      a. Reheating; and

      b. Recooling; and

      c. Simultaneous provisions of heating and cooling to the same zone, such as mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled either by cooling equipment or by economizer systems; or

«» Commentary for Section 170.2(c)4Bi:

Each space-conditioning zone shall have controls that prevent:

1. Reheating of air that has been previously cooled by mechanical cooling equipment or an economizer.
2. Recooling of air that has been previously heated. This does not apply to air returned from heated spaces.
3. Simultaneous heating and cooling in the same zone, such as mixing supply air that has been previously mechanically heated with air that has been previously cooled, either by mechanical cooling or by economizer systems.

«»

ii. Zones served by variable air-volume systems that are designed and controlled to reduce, to a minimum, the volume of reheated, recooled, or mixed air are allowed only if the controls meet all of the following requirements:

a. For each zone with direct digital controls (DDC), the volume of primary air that is reheated, recooled, or mixed air supply shall not exceed the larger of:

I. 50 percent of the peak primary airflow; or

II. The design zone outdoor airflow rate as specified by Section 160.2(c)3.

b. The volume of primary air in the deadband shall not exceed the design zone outdoor airflow rate as specified by Section 160.2(c)3.

c. The first stage of heating consists of modulating the zone supply air temperature setpoint up to a maximum setpoint no higher than 95 F degrees F while the airflow is maintained at the deadband flow rate.

d. The second stage of heating consists of modulating the airflow rate from the deadband flow rate up to the heating maximum flow rate.

e. For each zone without DDC, the volume of primary air that is reheated, recooled, or mixed air supply shall not exceed the larger of the following:

I. 30 percent of the peak primary airflow; or

II. The design zone outdoor airflow rate as specified by Section 160.2(c)3.

Exception 1 to Section 170.2(c)4B: Zones with special pressurization relationships or cross-contamination control needs.

Exception 2 to Section 170.2(c)4B: Zones served by space-conditioning systems in which at least 75 percent of the energy for reheating, or providing warm air in mixing systems, is provided from a site-recovered or site-solar energy source.

Exception 3 to Section 170.2(c)4B: Zones in which specific humidity levels are required to satisfy exempt process loads. Computer rooms or other spaces where the only process load is from IT equipment may not use this exception.

Exception 4 to Section 170.2(c)4B: Zones with a peak supply-air quantity of 300 cfm or less.

«» Commentary for Section 170.2(c)4Bii:

VAV System is a space conditioning system that maintains comfort levels by varying the volume of conditioned air to the zones served. This system delivers conditioned air to one or more zones. There are two styles of VAV systems, single-duct VAV (where mechanically cooled air is typically supplied and reheated through a duct mounted coil) and dual-duct VAV (where heated and cooled streams of air are blended at the zone level). In single-duct VAV systems, the duct serving each zone is provided with a motorized damper that is modulated by a signal from the zone thermostat. The thermostat also controls the reheat coil. In dual-duct VAV systems, the ducts serving each zone are provided with motorized dampers that blend the supply air based on a signal from the zone thermostat.

Space Conditioning Zone Controls

Zones served by VAV systems are designed with controls to reduce the volume of reheated, recooled, or mixed air to a minimum. The controls must meet all of the following.

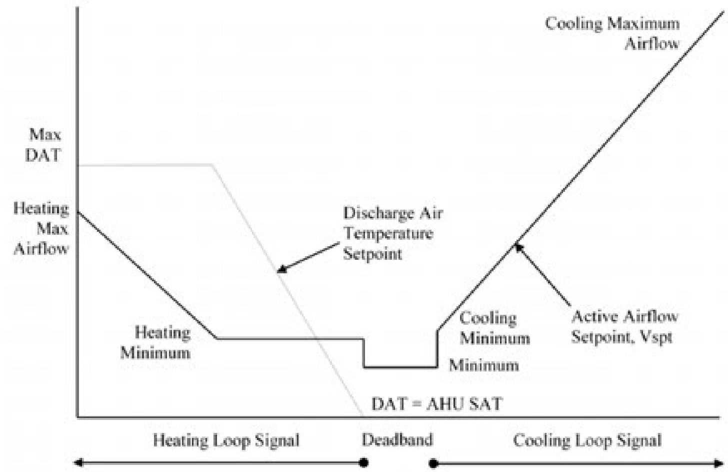
For each zone with DDC:

1. The volume of primary air that is reheated, re-cooled, or mixed air supply shall not exceed the larger of 50 percent of the peak primary airflow or the design zone outdoor airflow rate, per Section 160.2(c)3.
2. The volume of primary air in the dead band shall not exceed the design zone outdoor airflow rate, per Section 160.2(c)3.
    - The first stage of heating consists of modulating the zone supply air temperature set point up to a maximum set point no higher than 95 °F while the airflow is maintained at the deadband flow rate.
    - The second stage of heating consists of modulating the airflow rate from the deadband flow rate up to the heating maximum flow rate.
    - For each zone without DDC, the volume of primary air that is reheated, re-cooled, or mixed air supply shall not exceed the larger of 30 percent of the peak primary airflow or the design zone outdoor airflow rate, per Section 160.2(c)3.

For systems with DDC to the zone level, the controls must be able to support two different maximums -- one each for heating and cooling. This control is depicted in Figure 4-18: Dual-Maximum VAV Box Control Diagram with Minimum Flow in Deadband below. In cooling, this control scheme is similar to a traditional VAV reheat box control. The difference is what occurs in the deadband between heating and cooling and in the heating mode. With traditional VAV control logic, the minimum airflow rate is typically set to the largest rate allowed by code. This airflow rate is supplied to the space in the deadband and heating modes. With the "dual maximum" logic, the minimum rate is the lowest allowed by code (e.g., the minimum ventilation rate) or the minimum rate the controls system can be set to (which is a function of the VAV box velocity pressure sensor amplification factor and the accuracy of the controller to convert the velocity pressure into a digital signal). As the heating demand increases, the dual maximum control first resets the discharge air temperature (typically from the design cold deck temperature up to 85 or 90 °F) as a first stage of heating then, if more heat is required, it increases airflow rate up to a “heating” maximum airflow set point, which is the same value as what traditional control logic uses as the minimum airflow set point. Using this control can save significant fan, reheat and cooling energy while maintaining better ventilation effectiveness as the discharge heating air is controlled to a temperature that will minimize stratification.

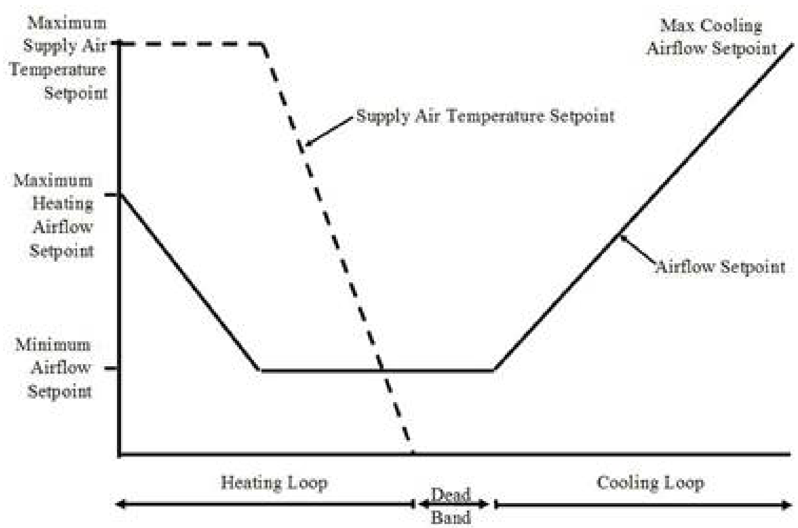
This control requires a discharge air sensor and may require a programmable VAV box controller. The discharge air sensor is very useful for diagnosing control and heating system problems even if they are not actively used for control.

Figure 4-18: Dual-Maximum VAV Box Control Diagram with Minimum Flow in Deadband



Source: California Energy Commission

Figure 4-19: Dual-Maximum VAV Box Control Diagram (for systems without DDC)



Source: California Energy Commission

For systems without DDC to the zone (such as electric or pneumatic thermostats), the airflow that is reheated is limited to a maximum of either 30 percent of the peak primary airflow or the minimum airflow required to ventilate the space, whichever is greater.

Certain exceptions exist for space conditioned zones with one of the following:

1. Special pressurization relationships or cross contamination control needs (laboratories are an example of spaces that might fall in this category)
2. Site-recovered or site-solar energy providing at least 75 percent of the energy for reheating, or providing warm air in mixing systems
3. Specific humidity requirements to satisfy exempt process needs (computer rooms are explicitly not covered by this exception)
4. Zones with a peak supply air quantity of 300 cfm or less

«»

C. **Economizers**.

i. Each cooling air handler that has a design total mechanical cooling capacity over 33,000 Btu/hr, or chilled-water cooling systems without a fan or that use induced airflow that has a cooling capacity greater than the systems listed in Table 170.2-E-2, shall include either:

a. An air economizer capable of modulating outside-air and return-air dampers to supply 100 percent of the design supply air quantity as outside air; or

b. A water economizer capable of providing 100 percent of the expected system cooling load, at outside air temperatures of 50°F dry-bulb and 45°F wet-bulb and below.

Exception 1 to Section 170.2(c)4Ci: Where special outside air filtration and treatment, for the reduction and treatment of unusual outdoor contaminants, makes compliance infeasible.

Exception 2 to Section 170.2(c)4Ci: Where the use of outdoor air for cooling will affect other systems, such as humidification or dehumidification, so as to increase overall building LSC energy use.

Exception 3 to Section 170.2(c)4Ci: Systems serving dwelling units.

Exception 4 to Section 170.2(c)4Ci: Where comfort cooling systems have the cooling efficiency that meets or exceeds the cooling efficiency improvement requirements in Table 170.2-F.

Exception 5 to Section 170.2(c)4Ci: Fan systems primarily serving computer rooms. See Section 140.9(a) for computer room economizer requirements.

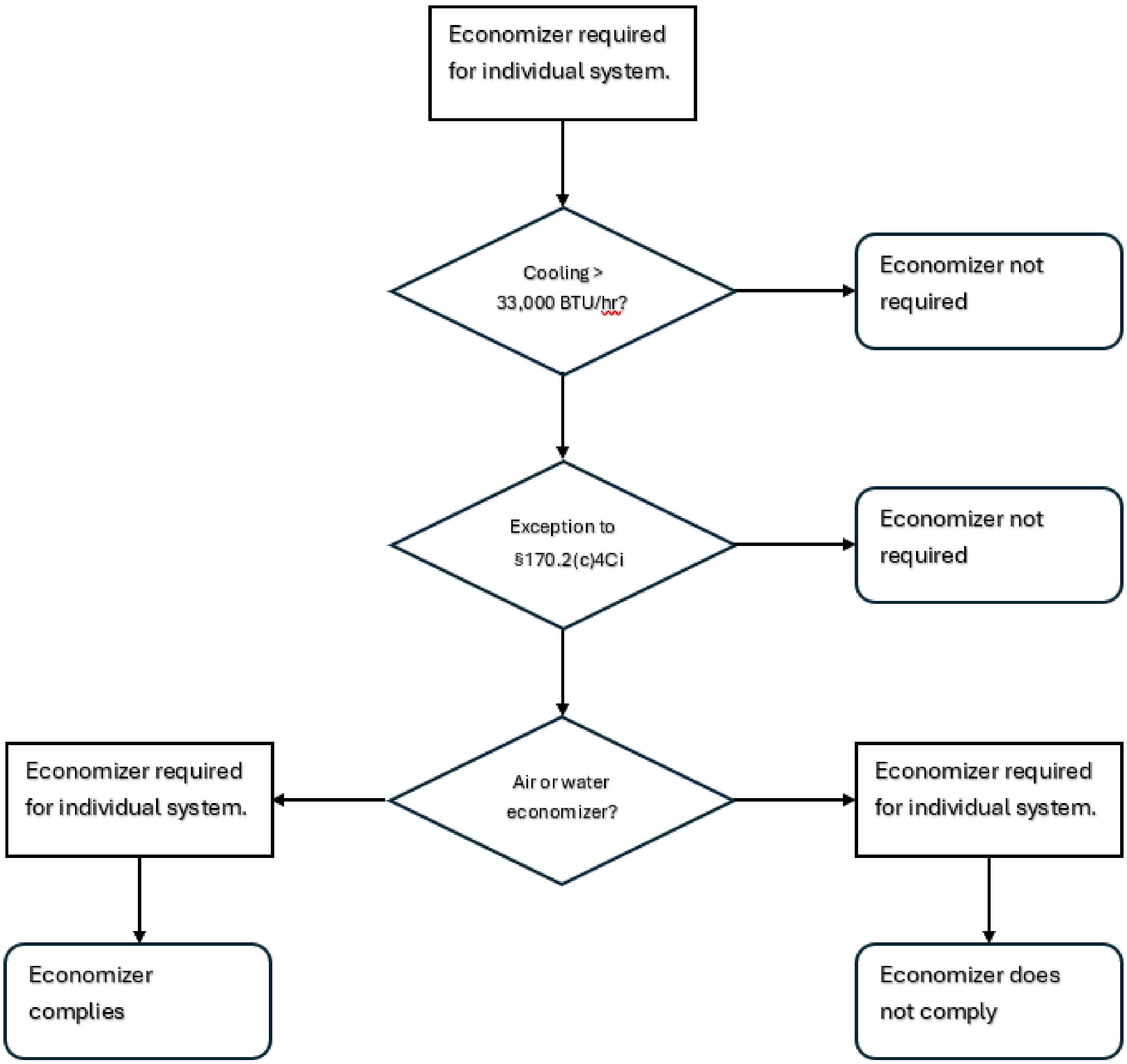
Exception 6 to Section 170.2(c)4Ci: In all climate zones, each air handler that has a design total mechanical cooling capacity less than 54,000 Btu/hr where ventilation is provided by a dedicated outdoor air system (DOAS) with exhaust air heat recovery in accordance with Section 140.4(p) and the following:

A. The DOAS unit shall meet the exhaust air heat recovery ratio as specified in Section 140.4(q)1 and include bypass or control to disable energy recovery as specified in Section 140.4(q)2.

B. The DOAS unit shall provide at least the minimum ventilation air flow rate as specified in Section 120.1(c)3 and provide no less than 0.3 cfm/ft[2] during economizer conditions.

«» Commentary for Section 170.2(c)4C:

Figure 4-20: Economizer Flowchart



Source: California Energy Commission

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TABLE 170.2-E-2 CHILLED WATER SYSTEM COOLING CAPACITY

Climate Zones	Building Water-Cooled Chilled Water System	Air-Cooled Chilled Water Systems or District Chilled Water Systems
15	≥ 960,000 Btu/h (280 kW)	≥ 1,250,000 Btu/h (365 kW)
1-14	≥720,000 Btu/h (210 kW)	≥940,000 Btu/h (275 kW)
16	≥1,320,000 Btu/h (385 kW)	≥1,720,000 Bu/h (505 kW)

Note for Table 170.2-E-2:

Total Building Chilled Water System Capacity, Minus Capacity of the Cooling units with Air Economizers

TABLE 170.2-F ECONOMIZER TRADE-OFF TABLE FOR COOLING SYSTEMS

Climate Zone	Efficiency Improvement [a]
1	70%
2	65%
3	65%
4	65%
5	70%
6	30%
7	30%
8	30%
9	30%
10	30%
11	30%
12	30%
13	30%
14	30%
15	30%
16	70%

Footnote to TABLE 170.2-F:

a. If a unit is rated with an annualized or part-load metric, then to eliminate the required economizer, only the annualized or part-load minimum cooling efficiency of the unit must be increased by the percentage shown. If the unit is only rated with a full load metric, like EER2 or COP cooling, then that metric must be increased by the percentage shown. To determine the efficiency required to eliminate economizer, when the unit *equipment efficiency* is rated with an energy-input divided by work-output metric, the metric shall first be converted to COP prior to multiplying by the *efficiency* improvement percentage and then converted back to the rated metric.

ii. If an economizer is required by Section 170.2(c)4Ci, and an air economizer is used to meet the requirement, then it shall be:

a. Designed and equipped with controls so that economizer operation does not increase the building heating energy use during normal operation; and

Exception to Section 170.2(c)4Ciia: Systems that provide 75 percent of the annual energy used for mechanical heating from site-recovered energy or a site-solar energy source.

b. Capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

c. Designed and equipped with a device type and high limit shut off complying with Table 170.2-G.

TABLE 170.2-G AIR ECONOMIZER HIGH LIMIT SHUT OFF CONTROL REQUIREMENTS

Device Type[a]	Climate Zones	Required High Limit (Economizer Off When): Equation[b]	Required High Limit (Economizer Off When): Description
Fixed Dry Bulb	1, 3, 5, 11-16	$T_{OA} > 75°F$	Outdoor air temperature exceeds 75°F
Fixed Dry Bulb	2, 4, 10	$T_{OA} > 73°F$	Outdoor air temperature exceeds 73°F
Fixed Dry Bulb	6, 8, 9	$T_{OA} > 71°F$	Outdoor air temperature exceeds 71°F
Fixed Dry Bulb	7	$T_{OA} > 69°F$	Outdoor air temperature exceeds 69°F
Differential Dry Bulb	1, 3, 5, 11-16	$T_{OA} > T_{RA}°F$	Outdoor air temperature exceeds return air temperature
Differential Dry Bulb	2, 4, 10	$T_{OA} > T_{RA}-2°F$	Outdoor air temperature exceeds return air temperature minus 2°F
Differential Dry Bulb	6, 8, 9	$T_{OA} > T_{RA}-4°F$	Outdoor air temperature exceeds return air temperature minus 4°F
Differential Dry Bulb	7	$T_{OA} > T_{RA}-6°F$	Outdoor air temperature exceeds return air temperature minus 6°F

Fixed Enthalpy[c] + Fixed Drybulb	All	h_{OA} > 28 Btu/lb[c] or T_{OA} > 75°F	Outdoor air enthalpy exceeds 28 Btu/lb of dry air[c] or Outdoor air temperature exceeds 75°F

Footnote to TABLE 170.2-G:

a. Only the high limit control devices listed are allowed to be used and at the setpoints listed. Others such as Dew Point, Fixed Enthalpy, Electronic Enthalpy, and Differential Enthalpy Controls, may not be used in any Climate Zone for compliance with Section 170.2(c)4Ci unless approval for use is provided by the Energy Commission Executive Director.

b. Devices with selectable (rather than adjustable) setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.

c. At altitudes substantially different than sea level, the Fixed Enthalpy limit value shall be set to the enthalpy value at 75°F and 50% relative humidity. As an example, at approximately 6,000 foot elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.

«» Commentary for Section 170.2(c)4Cii:

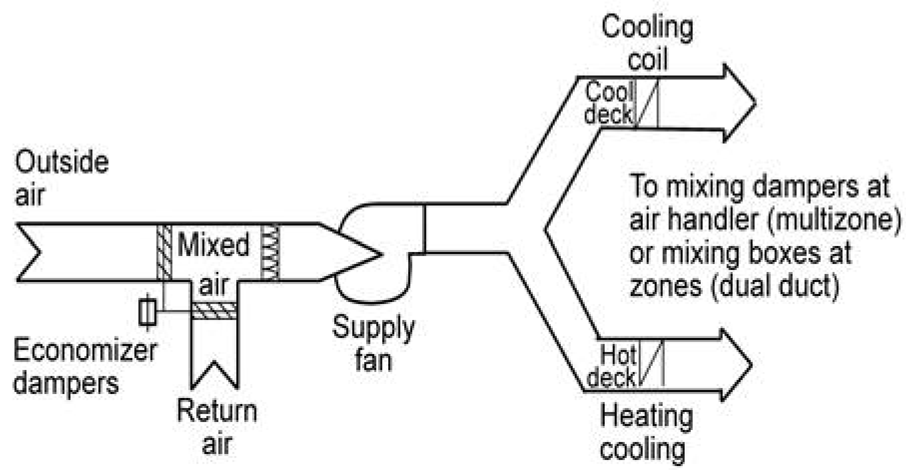
If an economizer is required, it must be:

1. Designed and equipped with controls that do not increase the building heating energy use during normal operation. This prohibits the application of single-fan dual-duct systems and traditional multizone systems using the Prescriptive Approach of compliance (Figure 4-21: Single-Fan Dual-Duct System). With these systems, the operation of the economizer to precool the air entering the cold deck also precools the air entering the hot deck and thereby increases the heating energy. An exception is available when at least 75 percent of the annual heating is provided by site-recovered or site-solar energy.
2. Fully integrated into the cooling system controls so that the economizer can provide partial cooling even when mechanical cooling is required to meet the remainder of the cooling load. On packaged units with stand-alone economizers, a two-stage thermostat is necessary to meet this requirement.

The requirement that economizers be designed for concurrent operation is not met by some popular water economizer systems, such as those that use the chilled water system to convey evaporatively-cooled condenser water for “free” cooling. Such systems can provide all of the cooling load, but when the point is reached where condenser water temperatures cannot be sufficiently cooled by evaporation; the system controls throw the entire load to the mechanical chillers. Because this design cannot allow simultaneous economizer and refrigeration system operation, it does not meet the requirements of this section. An integrated water-side economizer which uses condenser water to precool the Chilled Water Return (CHWR) before it reaches the chillers (typically using a plate-and-frame heat exchanger) can meet this integrated operation requirement.

The Energy Code eliminated the use of fixed enthalpy, differential enthalpy, and electronic enthalpy controls unless approval for use is provided by the Executive Director. Research on the accuracy and stability of enthalpy controls led to their elimination (with the exception of use when combined with a fixed dry-bulb sensor). The enthalpy-based controls can be employed if the project uses the performance approach.

Figure 4-21: Single-Fan Dual-Duct System



Source: California Energy Commission

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iii. The air economizer and all air dampers shall have the following features:

a. **Warranty.** 5-year manufacturer warranty of economizer assembly.

b. **Damper reliability testing.** Suppliers of economizers shall certify that the economizer assembly, including but not limited to outdoor air damper, return air damper, drive linkage and actuator, has been tested and is able to open and close against the rated airflow and pressure of the system for 60,000 damper opening and closing cycles.

c. **Damper leakage.** Economizer outdoor air and return air dampers shall have a maximum leakage rate of 10 cfm/sf at 250 Pascals (1.0 in. of water) when tested in accordance with AMCA Standard 500-D. The economizer outside air and return air damper leakage rates shall be certified to the Energy Commission in accordance with Section 110.0.

d. **Adjustable setpoint.** If the high-limit control is fixed dry-bulb or fixed enthalpy + fixed dry-bulb then the control shall have an adjustable setpoint.

e. **Sensor accuracy.** Outdoor air, return air, mixed air and supply air sensors shall be calibrated within the following accuracies.

I. Drybulb and wetbulb temperatures accurate to ±2°F over the range of 40°F to 80°F;

II. Enthalpy accurate to ±3 Btu/lb over the range of 20 Btu/lb to 36 Btu/lb;

III. Relative humidity (RH) accurate to ±5 percent over the range of 20 percent to 80 percent RH.

f. **Sensor calibration data.** Data used for control of the economizer shall be plotted on a sensor performance curve.

g. **Sensor high limit control.** Sensors used for the high limit control shall be located to prevent false readings, including but not limited to being properly shielded from direct sunlight.

h. **Relief air system.** Relief air systems shall be capable of providing 100 percent outside air without over-pressurizing the building.

iv. The space-conditioning system shall include the following:

a. Unit controls shall have mechanical capacity controls interlocked with economizer controls such that the economizer is at 100 percent open position when mechanical cooling is on and does not begin to close until the leaving air temperature is less than 45 degree F.

b. Direct Expansion (DX) units greater than 65,000 Btu/hr that control the capacity of the mechanical cooling directly based on occupied space temperature shall have a minimum of two stages of mechanical cooling capacity.

c. DX units not within the scope of Section 170.2(c)4Ciib shall (i) comply with the requirements in Table 170.2-H, and (ii) have controls that do not false load the mechanical cooling system by limiting or disabling the economizer or by any other means except at the lowest stage of mechanical cooling capacity.

TABLE 170.2-H DIRECT EXPANSION (DX) UNIT REQUIREMENTS FOR COOLING STAGES AND COMPRESSOR DISPLACEMENT

Cooling Capacity	Minimum Number of Mechanical Cooling Stages	Minimum Compressor Displacement
≥ 65,000 Btu/h and < 240,000 Btu/h	3 stages	≤ 35% full load
≥ 240,000 Btu/h	4 stages	≤ 25% full load

v. Systems that include a water economizer to meet Section 170.2(c)4Ci shall include the following:

a. Maximum pressure drop. Precooling coils and water-to-water heat exchangers used as part of a water economizer shall either have a waterside pressure drop of less than 15 feet of water, or a secondary loop shall be installed so that the coil or heat exchanger pressure drop is not contributing to pressure drop when the system is in the normal cooling (non-economizer) mode.

b. Economizer systems shall be integrated with the mechanical cooling system so that they are capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load. Controls shall not false load the mechanical cooling system by limiting or disabling the economizer or by any other means, such as hot gas bypass, except at the lowest stage of mechanical cooling.

«» Commentary for Section 170.2(c)4Cv:

Unlike air-side economizers, water economizers have parasitic energy losses that reduce the cooling energy savings. One of these losses comes from increases in pumping energy. To limit the losses, the Energy Code requires that precooling coils and water-to-water heat exchangers used as part of a water economizer system have either:

1. A water-side pressure drop of less than 15 feet of water, or
2. A secondary loop so that the coil or heat exchanger pressure drop is not seen by the circulating pumps when the system is in the normal cooling (non-economizer) mode.

Water economizer systems must also be integrated with the mechanical cooling system so that they are capable of providing partial cooling, even when additional mechanical cooling is required to meet the remainder of the cooling load. This includes controls that do not false load the mechanical cooling system by limiting or disabling the economizer, or by any other means, such as hot gas bypass, except at the lowest stage of mechanical cooling. **«»**

D. **Supply air temperature reset controls.** Space-conditioning systems supplying heated or cooled air to multiple zones shall include controls that automatically reset supply-air temperatures. Air distribution systems serving zones that are likely to have constant loads shall be designed for the air flows resulting from the fully reset supply air temperature. Supply air temperature reset controls shall be:

i. In response to representative building loads or to outdoor air temperature; and

ii. At least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

Exception 1 to Section 170.2(c)4D: Systems that meet the requirements of Section 170.2(c)3Bi, without using Exception 1 to that section.

Exception 2 to Section 170.2(c)4D: Where supply-air temperature reset would increase overall building energy use.

Exception 3 to Section 170.2(c)4D: Systems supplying zones in which specific humidity levels are required to satisfy process loads. Computer rooms or other spaces with only IT equipment may not use this exception.

«» Commentary for Section 170.2(c)4D:

Mechanical space-conditioning systems supplying heated or cooled air to multiple zones must include controls that automatically reset the supply-air temperature in response to representative building loads or to outdoor air temperature. The controls must be capable of resetting the supply-air temperature by at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

For example, if the design supply temperature is 55 °F and the design room temperature is 75 °F, then the difference is 20 °F, of which 25 percent is 5 °F. Therefore, the controls must be capable of resetting the supply temperature from 55 °F to 60 °F.

Air distribution zones that are likely to have constant loads, such as interior zones, shall have airflow rates designed to meet the load at the fully reset temperature. Otherwise, these zones may prevent the controls from fully resetting the temperature or will unnecessarily limit the hours when the reset can be used.

Supply air reset is required for VAV reheat systems even if they have variable-speed drive (VSD) fan controls. The recommended control sequence is to lead with supply temperature set point reset in cool weather where reheat might dominate the equation and to keep the chillers off as long as possible. Thereafter the system can return to a fixed low set point in warmer weather when the chillers are likely to be on. During reset a demand-based control is employed that uses the warmest supply air temperature to satisfy all of the zones in cooling.

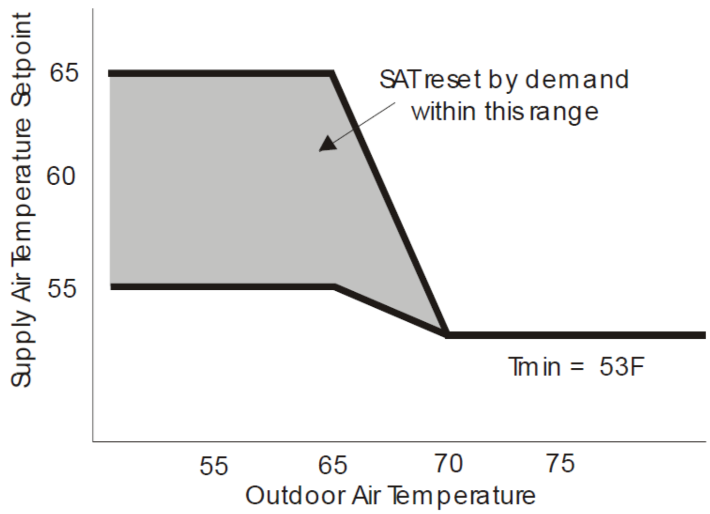
This sequence is described as follows: during occupied mode the set point is reset from T-min (53 °F) (when the outdoor air temperature is 70 °F and above) proportionally up to T-max (when the outdoor air temperature is 65 °F and below). T-max shall range from 55 °F to 65 °F and shall be the output of a slow reverse-acting proportional-integral loop that maintains the cooling loop of the zone served by the system with the highest cooling loop at a set point of 90 percent (See Figure 4-22: Energy Efficient Supply Air Temperature Reset Control for VAV Systems).

Supply temperature reset is also required for constant volume systems with reheat justified on the basis of special zone pressurization relationships or cross-contamination control needs.

Supply-air temperature reset is not required when:

1. The space-conditioning zone has controls that prevent reheating and recooling and simultaneously provide heating and cooling to the same zone.
2. Where it can be demonstrated that supply air reset would increase overall building energy use.
3. The zone(s) must have specific humidity levels required to meet exempt process needs. Computer rooms cannot use this exception.

Figure 4-22: Energy Efficient Supply Air Temperature Reset Control for VAV Systems



Source: California Energy Commission

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E. **Electric-resistance heating.** Electric-resistance heating systems shall not be used for space heating.

Exception 1 to Section 170.2(c)4E: Where an electric-resistance heating system supplements a heating system in which at least 60 percent of the annual energy requirement is supplied by site-solar or recovered energy.

Exception 2 to Section 170.2(c)4E: Where an electric-resistance heating system supplements a heat pump heating system, and the heating capacity of the heat pump is more than 75 percent of the design heating load calculated in accordance with Section 170.2(c)1 at the design outdoor temperature specified in Section 170.2(c)2.

Exception 3 to Section 170.2(c)4E: Where the total capacity of all electric-resistance heating systems serving the entire building is less than 10 percent of the total design output capacity of all heating equipment serving the entire building.

Exception 4 to Section 170.2(c)4E: Where the total capacity of all electric-resistance heating systems serving the entire building, excluding those allowed under Exception 2, is no more than 3 kW.

Exception 5 to Section 170.2(c)4E: Heating systems serving as emergency backup to gas heating equipment.

«» Commentary for Section 170.2(c)4E:

The Energy Code strongly discourages the use of electric-resistance space heat. **«»**

F. **Heat rejection systems.** Heat rejection equipment used in comfort cooling systems such as air-cooled condensers, open cooling towers, closed-circuit cooling towers and evaporative condensers shall include the following:

   i. **Fan speed control.** Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at 2/3 of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature or pressure of the heat rejection device.

   Exception 1 to Section 170.2(c)4Fi: Heat rejection devices included as an integral part of the equipment listed in Table 110.2-A through Table 110.2-N.

   Exception 2 to Section 170.2(c)4Fi: Condenser fans serving multiple refrigerant circuits.

   Exception 3 to Section 170.2(c)4Fi: Condenser fans serving flooded condensers.

   Exception 4 to Section 170.2(c)4Fi: Up to one-third of the fans on a condenser or tower with multiple fans where the lead fans comply with the speed control requirement.

   ii. **Tower flow turndown.** Open cooling towers configured with multiple condenser water pumps shall be designed so that all cells can be run in parallel with the larger of:

      a. The flow that is produced by the smallest pump; or

      b. 50 percent of the design flow for the cell.

«» Commentary for Section 170.2(c)4Fii:

The Energy Code requires that open cooling towers with multiple condenser water pumps be designed so that all cells can be run in parallel with the larger of the flow that is produced by the smallest pump or 50 percent of the design flow for the cell.

Cooling towers are very efficient at unloading the fan energy drops off as the cube of the airflow. It is always more efficient to run the water through as many cells as possible- two fans at half speed use less than one third of the energy of one fan at full speed for the same load. Unfortunately, there is a limitation with flow on towers. The flow must be sufficient to provide full coverage of the fill. If the nozzles do not fully wet the fill, air will go through the dry spots providing no cooling benefit and cause the water at the edge of the dry spot to flash evaporate, depositing dissolved solids on the fill.

Fortunately, the cooling tower manufacturers do offer low-flow nozzles (and weirs on basin type towers) to provide better flow turndown. As low-flow nozzles can eliminate the need for a tower isolation control point, this option provides energy savings at a reduced first cost. **«»**

iii. **Limitation on centrifugal fan cooling towers.** Open cooling towers with a combined rated capacity of 900 gpm and greater at 95°F condenser water return, 85°F condenser water supply and 75°F outdoor wet-bulb temperature shall use propeller fans and shall not use centrifugal fans.

Exception 1 to Section 170.2(c)4Fiii: Cooling towers that are ducted (inlet or discharge) or have an external sound trap that requires external static pressure capability.

Exception 2 to Section 170.2(c)4Fiii: Cooling towers that meet the energy efficiency requirement for propeller fan towers in Section 110.2, Table 110.2-F.

«» Commentary for Section 170.2(c)4Fiii:

The 95 °F condenser water return, 85 °F condenser water supply and 75 °F outdoor wet-bulb temperature are test conditions for determining the rated flow capacity in gpm. Centrifugal fans use approximately twice the energy as propeller fans for the same duty. **«»**

iv. **Multiple cell heat rejection equipment.** Multiple cell heat rejection equipment with variable speed fan drives shall:

a. Operate the maximum number of fans allowed that comply with the manufacturer's requirements for all system components, and

b. Control all operating fans to the same speed. Minimum fan speed shall comply with the minimum allowable speed of the fan drive as specified by the manufacturer's recommendation. Staging of fans is allowed once the fans are at their minimum operating speed.

v. **Cooling tower efficiency.** Axial fan, open-circuit cooling towers serving condenser water loops for chilled water plants with a total of 900 gpm or greater shall have a minimum rated efficiency based on Table 170.2-I when rated in accordance with the conditions as listed in Table 110.2-F.

Table 170.2-I MINIMUM EFFICIENCY FOR PROPELLER OR AXIAL FAN OPEN-CIRCUIT COOLING TOWERS (GPM/hp)

CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16

42.1	70	60	70	70	80	80	80	80	80	60	70	80	60	80	42.1

Exception 1 to Section 170.2(c)4Fv: Replacement of existing cooling towers that are inside an existing building or on an existing roof.

«» Commentary for Section 170.2(c)4Fv:

Prescriptively, axial fan open-circuit cooling towers with a combined rated capacity of 900 gpm or greater must achieve a rated efficiency as specified in Table 170.2-I. This efficiency is rated at specific temperature conditions which are 95 °F condenser water return; 85 °F condenser water supply; and 75 °F outdoor wet-bulb temperature as listed in Table 110.2-E. **«»**

G. **Minimum chiller efficiency.** Chillers shall meet or exceed Path B from Table 110.2-D.

Exception 1 to Section 170.2(c)4G: Chillers with electrical service > 600 V.

Exception 2 to Section 170.2(c)4G: Chillers attached to a heat recovery system with a design heat recovery capacity > 40 percent of the design chiller cooling capacity.

Exception 3 to Section 170.2(c)4G: Chillers used to charge thermal energy storage systems where the charging temperature is < 40°F.

Exception 4 to Section 170.2(c)4G: In buildings with more than three chillers, only three chillers are required to meet the Path B efficiencies.

«» Commentary for Section 170.2(c)4G:

In Table 110.2-D, there are two paths of efficiency for almost every size and type of chiller. Path A represents fixed speed compressors and Path B represents variable speed compressors. For each path, there are two efficiency requirements: a full load efficiency and an integrated part-load efficiency. Path A typically has a higher full load efficiency and a lower part-load efficiency than Path B. In all California climates, the cooling load varies enough to justify the added cost for a Path B chiller. This is a prescriptive requirement, so Path B is used in the base case model in the performance method. **«»**

H. **Limitation of air-cooled chillers.** Chilled water plants shall not have more than 300 tons provided by air-cooled chillers.

«» Commentary for Section 170.2(c)4H:

New chilled water plants and cooling plant expansions will be limited on the use of air-cooled chillers. For both types, the limit is 300 tons per plant. **«»**

Exception 1 to Section 170.2(c)4H: Where the water quality at the building site fails to meet manufacturer's specifications for the use of water-cooled chillers.

«» Commentary for Exception 1 to Section 170.2(c)4H:

This exception recognizes that some parts of the state have exceptionally high quantities of dissolved solids that could foul systems or cause excessive chemical treatment or blow down. **«»**

Exception 2 to Section 170.2(c)4H: Chillers that are used to charge a thermal energy storage system with a design temperature of less than 40°F (4°C).

«» Commentary for Exception 2 to Section 170.2(c)4H:

This addresses the fact that air-cooled chillers can operate very efficiently at low ambient air temperatures. Since thermal energy storage systems operate for long hours at night, these systems may be as efficient as a water-cooled plant. The chiller must be provided with head pressure controls to achieve these savings. **«»**

I. **Hydronic system measures**.

i. **Hydronic variable flow systems.** HVAC chilled and hot water pumping shall be designed for variable fluid flow and shall be capable of reducing pump flow rates to no more than the larger of: a) 50 percent or less of the design flow rate; or b) the minimum flow required by the equipment manufacturer for the proper operation of equipment served by the system.

Exception 1 to Section 170.2(c)4I: Systems that include no more than three control valves.

Exception 2 to Section 170.2(c)4I: Systems having a total pump system power less than or equal to 1.5 hp.

«» Commentary for Section 170.2(c)4Ii:

Hot water and chilled-water systems are required to be designed for variable flow. Variable flow is provided by using 2-way control valves. The Energy Code only requires that flow is reduced to whichever value is greater: 50 percent or less of design flow or the minimum flow required by the equipment manufacturer for operation of the central plant equipment.

There are two exceptions for this requirement:

1. Systems that include no more than three control valves.
2. Systems having a total pump system power less than or equal to 1.5 hp.

It is not necessary for each individual pump to meet the variable flow requirement. These requirements can be met by varying the total flow for the entire pumping system in the plant. Strategies that can be used to meet these requirements include but are not limited to variable frequency drives on pumps and staging of the pumps. **«»**

ii. **Chiller isolation.** When a chilled water system includes more than one chiller, provisions shall be made so that flow through any chiller is automatically shut off when that chiller is shut off while still maintaining flow through other operating chiller(s). Chillers that are piped in series for the purpose of increased temperature differential shall be considered as one chiller.

iii**. Boiler isolation.** When a hot water plant includes more than one boiler, provisions shall be made so that flow through any boiler is automatically shut off when that boiler is shut off while still maintaining flow through other operating boiler(s).

iv**. Chilled and hot water temperature reset controls.** Systems with a design capacity exceeding 500,000 Btu/hr supplying chilled or heated water shall include controls that automatically reset supply water temperatures as a function of representative building loads or outside air temperature.

Exception to Section 170.2(c)4Iiv: Hydronic systems that use variable flow to reduce pumping energy in accordance with Section 170.2(c)4Ii.

v. **Water-cooled air conditioner and hydronic heat pump systems.** Water circulation systems serving water-cooled air conditioners, hydronic heat pumps or both, that have total pump system power exceeding 5 hp, shall have flow controls that meet the requirements of Section 170.2(c)4Ivi. Each such air conditioner or heat pump shall have a two-position automatic valve interlocked to shut off water flow when the compressor is off.

vi. **Variable flow controls.**

a. Variable speed drives. Individual pumps serving variable flow systems and having a motor horsepower exceeding 5 hp shall have controls or devices (such as variable speed control) that will result in pump motor demand of no more than 30 percent of design wattage at 50 percent of design water flow. The pumps shall be controlled as a function of required differential pressure.

b. Pressure sensor location and setpoint.

c. For systems without direct digital control of individual coils reporting to the central control panel, differential pressure shall be measured at the most remote heat exchanger or the heat exchanger requiring the greatest differential pressure.

d. For systems with direct digital control of individual coils with a central control panel, the static pressure setpoint shall be reset based on the valve requiring the most pressure, and the setpoint shall be no less than 80 percent open. Pressure sensors may be mounted anywhere.

Exception 1 to Section 170.2(c)4Ivi: Heating hot water systems.

Exception 2 to Section 170.2(c)4Ivi: Condenser water systems serving only water-cooled chillers.

vii. **Hydronic heat pump (WLHP) controls.** Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are capable of providing a heat pump water supply temperature deadband of at least 20°F between initiation of heat rejection and heat addition by the central devices.

Exception to Section 170.2(c)4Ivii: Where a system loop temperature optimization controller is used to determine the most efficient operating temperature based on real-time conditions of demand and capacity, deadbands of less than 20°F shall be allowed.

J. Reserved.

K. **Fan control.** Each cooling system listed in Table 170.2-H shall be designed to vary the indoor fan airflow as a function of load and shall comply with the following requirements:

i. DX and chilled water cooling systems that control the capacity of the mechanical cooling directly based on occupied space temperature shall (i) have a minimum of two stages of fan control with no more than 66 percent speed when operating on stage 1; and (ii) draw no more than 40 percent of the fan power at full fan speed, when operating at 66 percent speed.

ii. All other systems, including but not limited to DX cooling systems and chilled water systems that control the space temperature by modulating the airflow to the space, shall have proportional fan control such that at 50 percent air flow the power draw is no more than 30 percent of the fan power at full fan speed.

iii. Systems that include an air side economizer to meet Section 170.2(c)4Ci shall have a minimum of two speeds of fan control during economizer operation.

Exception to Section 170.2(c)4K: Modulating fan control is not required for chilled water systems with all fan motors <1 HP, or for evaporative systems with all fan motors < 1 HP, if the systems are not used to provide ventilation air and all indoor fans cycle with the load.

L. **Mechanical system shut-off.** Any directly conditioned common use area space with operable wall or roof openings to the outdoors shall be provided with interlock controls that disable or reset the temperature setpoint to 55°F for mechanical heating and disable or reset the temperature setpoint to 90°F for mechanical cooling to that space when any such opening is open for more than 5 minutes.

Exception 1 to Section 170.2(c)4L: Interlocks are not required on doors with automatic closing devices.

Exception 2 to Section 170.2(c)4L: Any space without a thermostatic control (thermostat or a space temperature sensor used to control heating or cooling to the space).

«» Commentary for Section 170.2(c)4L:

If a directly conditioned zone has a thermostat and one or more manually operable wall or roof openings to the outdoors, then the openings must all have sensors that communicate to the HVAC system. The HVAC controller must be capable of shutting off the heating or cooling to that zone if the sensor detects that the opening has remained open for more than five minutes. This can be accomplished by resetting the heating set point to 55 °F or the heating can be disabled altogether. If the HVAC system is in cooling mode, then similarly this requirement can be satisfied by resetting the cooling set point to 90 °F, unless the outside air temperature is less than the space temperature, in which case the cooling set point can be reset, or not. If the zone is in cooling and the outside air temperature is less than the space temperature, then additional infiltration from the opening provides economizer-free cooling and is not an additional cooling load on the mechanical system.

This requirement does not require any openings to the outdoors to be operable. However, if operable openings are present, then they must comply with this requirement.

Mechanical ventilation as required by Section 160.2(c)3 must still be provided. The mechanical system shut off pertains to the space conditioning equipment only. Mechanical ventilation must still be provided if the space does not fall under the natural ventilation criteria. Systems that meet the ventilation requirements with natural ventilation, rather than mechanical ventilation, are not exempt from the window/door switch requirement. Thus, in the same way that most homeowners typically choose between opening the windows and running the heating/cooling, window/door switches will now cause occupants to choose between opening windows/doors and allowing full heating/cooling.

Manually operable openings to the outdoors include manually operable windows, skylights, and doors that do not have automatic closing devices (e.g., sliding balcony doors). Motorized openings (e.g., motorized skylights) are still considered manually operable if occupants can move the openings as desired and they will stay open until manually closed.

If a zone serves more than one room, then only the openings in the room with the thermostat are required to be interlocked. For example, if three perimeter private offices are served by a single VAV box then only the operable openings in the office with the thermostat need to be interlocked. The windows in the offices that do not have a thermostat do not need to be interlocked.

If there is a large room with more than one zone, then only the zones with operable windows in them need to be interlocked. For example, if a large open office has a perimeter zone and an interior zone in the same room and there are operable windows in the perimeter zone but not the interior zone then only the perimeter zone thermostat needs to be interlocked to the windows.

Alterations to existing buildings are exempt from this requirement. Additions to existing buildings only have to comply if the operable opening(s) and associated zone are new. **«»**

M**. Exhaust system transfer air.** Conditioned supply air delivered to any space with mechanical exhaust shall not exceed the greater of:

i. The supply flow required to meet the space heating or cooling load; or

ii. The ventilation rate required by the authority having jurisdiction, the facility Environmental Health and Safety Department or Section 160.2(c)3; or

iii. The mechanical exhaust flow minus the available transfer air. Available transfer air shall be from another conditioned space or return air plenums on the same floor and same smoke or fire compartment, and that at their closest point are within 15 feet of each other.

Exception 1 to Section 170.2(c)4M: Spaces that are required by applicable codes and standards to be maintained at a positive pressure differential relative to adjacent spaces.

Exception 2 to Section 170.2(c)4M: Spaces where the highest amount of transfer air that could be used for exhaust makeup may exceed the available transfer airflow rate and where the spaces have a required negative pressure relationship.

«» Commentary for Section 170.2(c)4M:

The standard prescriptively requires the use of transfer air for exhaust air makeup in most cases. The purpose is to avoid supply air that requires increased outdoor air intake, which would require conditioning, for exhaust makeup when return or relief air from neighboring spaces can be used instead. The requirement limits the supply of conditioned air to not exceed the larger of the supply flow required for space heating or space cooling, the required ventilation rate, or the exhaust flow, minus the available transfer air from conditioned spaces or plenums on the same floor and within 15 ft and not in different smoke or fire compartments. Available transfer air does not include air required to maintain pressurization and air that cannot be transferred based on-air class as defined in Section 160.2(c)8. **«»**

N. **Dedicated outdoor air systems (DOAS).** HVAC systems that utilize a dedicated outdoor air system (DOAS) such as a DX-DOAS, HRV or ERV unit to condition, temper or filter 100 percent outdoor air separate from local or central space-conditioning systems serving the same space shall meet the following criteria:

1. DOAS unit fan systems with input power less than 1 kW shall not exceed a total combined fan power of 1.0 W/cfm. DOAS with fan power greater than or equal to 1 kW shall meet the requirements of Section 140.4(c).

2. The DOAS supply air shall be delivered directly to the occupied space or at the outlet of any terminal heating or cooling coils and shall cycle off any zone heating and cooling equipment fans, circulation pumps and terminal unit fans when there is no call for heating or cooling in the zone.

   Exception 1 to Section 170.2(c)4N2: Active chilled beam systems.

   Exception 2 to Section 170.2(c)4N2: Sensible-only cooling terminal units with pressure-independent variable-airflow regulating devices limiting the DOAS supply air to the greater of latent load or minimum ventilation requirements.

   Exception 3 to Section 170.2(c)4N2: Any configuration where a DOAS unit provides ventilation air to a downstream fan (a terminal box, air handling unit or other space-conditioning equipment) where the total system airflow can be reduced to ventilation minimum or the downstream fan power is no greater than 0.12 watts per cfm when space temperatures are within the thermostat deadband (at low speed per manufacturer's literature).

3. DOAS supply and exhaust fans shall have a minimum of three speeds to facilitate system balancing.
4. DOAS with mechanical cooling providing ventilation to multiple zones and operating in conjunction with zone heating and cooling systems shall not use heating or heat recovery to warm supply air above 60°F when representative building loads or outdoor air temperature indicates that the majority of zones require cooling.

«» Commentary for Section 170.2(c)4N:

Under certain climate zones and air handler design scenarios, DOAS units may also require Exhaust Air Heat Recovery (EAHR) requirements under Section 170.2(c)4O. **«»**

O. **Exhaust air heat recovery.** Fan systems designed to operate to the criteria listed in either Table 170.2-I or Table 170.2-J shall include an exhaust air heat recovery system that meets the following:

i. A sensible energy recovery ratio of at least 60 percent or an enthalpy recovery ratio of at least 50 percent for both heating and cooling design conditions.

ii. Energy recovery bypass or control to disable energy recovery and to directly economize with ventilation air based on outdoor air temperature limits specified in Table 170.2-G. For energy recovery systems where the transfer of energy cannot be stopped, bypass shall prevent the total airflow rate of either outdoor air or exhaust air through the energy recovery exchanger from exceeding 10 percent of the full design airflow rate.

iii. For a DOAS unit and a separate independent space-conditioning system meeting the requirements of Section 170.2(c)4Nia, the design supply fan airflow rate shall be the total airflow of only the DOAS unit.

EXCEPTION 1 to Section 170.2(c)4Oii: DOAS units with the capability to shut off when a separate independent space-conditioning system meets the economizer requirements specified by section 170.2(c)4Cia is economizing.

Exception 1 to Section 170.2(c)4O: Systems meeting Section 140.9(c) prescriptive requirements for laboratory and factory exhaust systems.

Exception 2 to Section 170.2(c)4O: Systems serving spaces that are not cooled and that are heated to less than 60°F.

Exception 3 to Section 170.2(c)4O: Where more than 60 percent of the outdoor air heating energy is provided from site-recovered energy in Climate Zone 16.

Exception 4 to Section 170.2(c)4O: Sensible recovery ratio requirements at heating design conditions are not required for Climate Zone 15.

Exception 5 to Section 170.2(c)4O: Sensible recovery ratio requirements at cooling design conditions are not required for Climate Zone 1.

Exception 6 to Section 170.2(c)4O: Where the sum of the airflow rates exhausted and relieved within 20 feet of each other is less than 75 percent of the design outdoor airflow rate, excluding exhaust air that is either:

i. used for another energy recovery system;

ii. not allowed by the California Mechanical Code (Title 24, Part 4) for use in energy recovery systems with leakage potential; or

iii. of Class 4 as specified in Section 160.2(c)8.

Exception 7 to Section 170.2(c)4O: Systems expected to operate less than 20 hours per week.

«» Commentary for Section 170.2(c)4O:

HVAC systems (including DOAS) must comply with Exhaust Air Heat Recovery (EAHR) requirements if their air handling systems meet design specifications that trigger compliance. For most HVAC systems these requirements are triggered if the full design airflow meets the criteria in Table 170.2-J for air handlers designed to operate continuously or Table 170.2-I for all other air handlers.

These requirements are also triggered if a decoupled DOAS system is utilizing EAHR instead of meeting economizer requirements per Section 170.2(c)Nia.

Balanced ventilation must be used with HRV/ERV in climate zones 1, 2, 4, 11 – 14, and 16 under prescriptive requirements. FIDs are prescriptively required for HRV/ERV systems, or projects could choose to install an HERV/ERV without an FID and incur a penalty in the modeling software that assumes 10 percent lower ventilation fan efficacy and 10 percent lower SRE for an HRV/ERV. Thus, the three options for multifamily projects in climate zones 1, 2, 4, 11 – 14 and 16 are following the prescriptive path which calls for an HRV/ERV system with an FID, install an HRV/ERV system without an FID and incur an energy efficiency penalty, or do not install an HRV/ERV system but meet performance efficiency requirement under another measure. **«»**

TABLE 170.2-I: ENERGY RECOVERY REQUIREMENTS BY CLIMATE ZONE AND PERCENT OUTDOOR AIR AT FULL DESIGN AIRFLOW (<8,000 HOURS / YEAR)

% Outdoor Air at Full Design Airflow	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
≥10% and <20%	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
≥20% and <30%	≥15,000	≥20,000	NR	NR	NR	NR	NR	NR	NR	NR	≥18,500	≥18,500	≥18,500	≥18,500	≥18,500	≥18,500
≥30% and <40%	≥13,000	≥15,000	NR	NR	NR	NR	NR	NR	NR	NR	≥15,000	≥15,000	≥15,000	≥15,000	≥15,000	≥15,000
≥40% and <50%	≥10,000	≥12,000	NR	NR	NR	NR	NR	NR	NR	≥22,000	≥10,000	≥10,000	≥10,000	≥10,000	≥10,000	≥10,000
≥50% and <60%	≥9,000	≥10,000	NR	≥18,500	NR	NR	NR	NR	NR	≥17,000	≥8,000	≥8,000	≥8,000	≥8,000	≥8,000	≥8,000
≥60% and <70%	≥7,000	≥7,500	NR	≥16,500	NR	NR	NR	NR	≥20,000	≥15,000	≥7,000	≥7,000	≥7,000	≥7,000	≥7,000	≥7,000
≥70% and <80%	≥6,500	≥7,000	NR	≥15,000	NR	NR	NR	NR	≥17,000	≥14,000	≥5,000	≥5,000	≥5,000	≥5,000	≥5,000	≥5,000
≥80%	≥4,500	≥6,500	NR	≥14,000	NR	NR	NR	NR	≥15,000	≥13,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000

FOOTNOTES TO TABLE 170.2-I:

1. Flow rates in Table 140.4-G represent the design supply fan airflow rate in CFM.
2. For a DOAS unit providing outdoor air to another space-conditioning system, the full design supply fan airflow rate shall be the total airflow of only the DOAS unit.

TABLE 170.2-J: ENERGY RECOVERY REQUIREMENTS BY CLIMATE ZONE AND PERCENT OUTDOOR AIR AT FULL DESIGN AIRFLOW (≥8,000 HOURS / YEAR)

% Outdoor Air at Full Design Airflow	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
≥10% and <20%	≥10,000	≥10,000	NR	NR	NR	NR	NR	NR	NR	≥40,000	≥40,000	≥20,000	≥10,000	≥10,000	≥10,000	≥10,000
≥20% and <30%	≥2,000	≥5,000	≥13,000	≥9,000	≥9,000	NR	NR	NR	NR	≥15,000	≥15,000	≥5,000	≥5,000	≥5,000	≥5,000	≥5,000
≥30% and <40%	≥2,000	≥3,000	≥10,000	≥6,500	≥6,500	NR	NR	NR	≥15,000	≥7,500	≥7,500	≥3,000	≥3,000	≥3,000	≥3,000	≥3,000
≥40% and <50%	≥2,000	≥2,000	≥8,000	≥6,000	≥6,000	NR	NR	NR	≥12,000	≥6,000	≥6,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000
≥50% and <60%	≥2,000	≥2,000	≥7,000	≥6,000	≥6,000	NR	NR	≥20,000	≥10,000	≥5,000	≥5,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000
≥60% and <70%	≥2,000	≥2,000	≥6,000	≥6,000	≥6,000	NR	NR	≥18,000	≥9,000	≥4,000	≥4,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000
≥70% and <80%	≥2,000	≥2,000	≥6,000	≥5,000	≥5,000	NR	NR	≥15,000	≥8,000	≥3,000	≥3,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000

≥80%	≥2,000	≥2,000	≥6,000	≥5,000	≥5,000	NR	NR	≥12,000	≥7,000	≥3,000	≥3,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000

Footnotes to TABLE 170.2-J:

1. Flow rates in Table 140.4-G represent the design supply fan airflow rate in CFM.
2. For a DOAS unit providing outdoor air to another space-conditioning system, the full design supply fan airflow rate shall be the total airflow of only the DOAS unit.

TABLE 170.2-K MECHANICAL COMPONENT PACKAGE – Multifamily Standard Building Design

Component	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Unitary[4] – Balanced Ventilation System[1] HRV/ERV Sensible Recovery Efficiency	0.67	0.67	NR	0.67	NR	NR	NR	NR	NR	NR	0.67	0.67	0.67	0.67	NR	0.67
Unitary[4] – Balanced Ventilation System[1] HRV/ERV Fan Efficacy (W/cfm)	0.6	0.6	1.0	0.6	1.0	1.0	1.0	1.0	1.0	1.0	0.6	0.6	0.6	0.6	1.0	0.6
Unitary[4] – Balanced Ventilation System[1] Non-HRV/ERV Fan Efficacy (W/cfm)	NR	NR	NR	NR	0.4	0.4	0.4	0.4	0.4	0.4	NR	NR	NR	NR	0.4	NR
Unitary[4] – Heat Pump[3], HSPF2[2]	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
Unitary[4] – Dual-Fuel Heat Pump[3], AFUE	MIN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	MIN
Unitary[4] – Refrigerant Charge Verification or Fault Indicator Display	NR	REQ	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR
Unitary[4] – SEER2	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
Central[5] - Balanced Ventilation Systems[1] Sensible Recovery Efficiency or Effectiveness	0.67	0.67	NR	0.67	NR	NR	NR	NR	NR	NR	0.67	0.67	0.67	0.67	NR	0.67
Central[5] - Balanced Ventilation Systems[1] Bypass Function	REQ	REQ	NR	REQ	NR	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	NR	REQ
Central[5] – Central Fan Integrated Ventilation System Fan Efficacy	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ

Duct Insulation in Unconditioned Space	R 8	R 8	R 6	R 8	R 6	R 6	R 6	R 8	R 8	R 8	R 8	R 8	R 8	R 8	R 8	R 8
Water Heating - All Buildings System Shall meet Section 170.2(d)	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ

Footnotes to TABLE 170.2-K:

1. Requirements only apply when using Balanced Ventilation to meet 160.2(b)2Aivb.
2. HSPF2 means "heating seasonal performance factor."
3. A supplemental heating unit may be installed in a space served directly or indirectly by a primary heating system, provided that the unit thermal capacity does not exceed 2 kilowatts or 7,000 Btu/hr and is controlled by a time-limiting device not exceeding 30 minutes.
4. Unitary system serving one dwelling unit
5. Central system serving multiple dwelling units

«» Commentary for Table 170.2-K:

Table 170.2-K provides efficiency requirements for various mechanical components. Equipment used in multifamily standard building design not listed here must meet mandatory minimum requirements or federal minimum requirements. This includes room air conditioners which must meet minimum CEER requirements. «»

SECTION 180.1 – ADDITIONS

Additions to existing multifamily buildings shall meet the applicable requirements of Sections 110.0 through 110.9; Sections 160.0, 160.1, and 160.2(c) and (d); Sections 160.3 through 160.7; and either Section 180.1(a) or 180.1(b).

Exception 4 to Section 180.1: Space-conditioning system. When heating or cooling will be extended to an addition from the existing system(s), the existing heating and cooling equipment need not comply with Part 6. The heating system capacity must be adequate to meet the minimum requirements of CBC Section 1204.1.

Exception 5 to Section 180.1: Space-conditioning system ducts. When any length of duct is extended from an existing duct system to serve the addition, the existing duct system and the extended duct shall meet the applicable requirements specified in Sections 180.2(b)2Ai and 180.2(b)2Aii.

Exception 7 to Section 180.1: Dwelling unit space heating system. New or replacement space heating systems serving an addition may be a heat pump or gas heating system.

«» Commentary for Section 180.1:

New or altered mechanical systems serving alterations or additions for dwelling units or common use areas must meet all applicable mandatory requirements and comply with either the prescriptive or performance approach. If a building does not meet all applicable prescriptive requirements, then the performance method using an approved compliance software is the alternative.

All HVAC systems serving additions generally are required to meet the newly constructed building prescriptive requirements, with few exceptions. Table 4-6: HVAC Requirements for Prescriptive Additions summarizes the requirements.

Table 4-6: HVAC Requirements for Prescriptive Additions

Component	Additions
New or replaced space conditioning system(s)	All prescriptive requirements per Section 170.2 except the system may be a heat pump or gas heating system
Use existing space conditioning system(s)	No requirements for the heating/cooling equipment except that heating system must have adequate capacity
New duct system(s)	All prescriptive requirements per Section 170.2
Extend existing duct system(s)	Duct sealing and duct insulation per Section 180.2(b)2Aii

Source: California Energy Commission

If the heating and cooling system is unchanged as part of an addition or alteration, compliance for the HVAC system is not necessary. However, changing, altering, or replacing any component of a system triggers prescriptive requirements for that component. If the extended ducts are serving dwelling units, the combined new and existing duct system must meet the requirement to seal the ducts and verify that duct leakage is no greater than 15% of system airflow. If 15% leakage or lower cannot be attained, there are alternatives, including sealing all accessible leaks and confirming by a visual inspection.

When the HVAC system is entirely new or a complete replacement, then additional mandatory and prescriptive requirements apply.

The Energy Code makes a distinction between two HVAC changeout situations:

1. Entirely new or complete replacement space conditioning systems.
2. Altered space conditioning systems.

«»

(a) Prescriptive approach. The envelope and lighting of the addition; any newly installed space-conditioning or ventilation system, electrical power distribution system, or water-heating system; any addition to an outdoor lighting system; and any new sign installed in conjunction with an indoor or outdoor addition shall meet the applicable requirements of Sections 110.0 through 110.12**;** 160.0, 160.1, and 160.2(c) and (d); and 160.3 through 170.2.

2. **Mechanical ventilation for indoor air quality.** Additions to existing buildings shall comply with Section 160.2 subject to the requirements specified in Subsections A and B below. When field verification and diagnostic testing are required by Section 180.1(a)2, buildings with three habitable stories or less shall use the applicable procedures in the Residential Appendices, and buildings with four or more habitable stories shall use the applicable procedures in Nonresidential Appendices NA1 and NA2.

   Exception to Section 180.1(a)2: A dwelling unit air leakage test is not required for additions.

   A. **Whole-dwelling unit mechanical ventilation**.

      i. Dwelling units that meet the conditions in Subsection a or b below shall not be required to comply with the whole-dwelling unit ventilation airflow specified in Section 160.2(b)2Aiv or 160.2(b)2Av.

         a. Additions to an existing dwelling unit that increase the conditioned floor area of the existing dwelling unit by less than or equal to 1000 square feet.

b. Junior Accessory Dwelling Units (JADU) that are additions to an existing building.

ii. Additions to an existing dwelling unit that increase conditioned floor area by more than 1,000 square feet shall have mechanical ventilation airflow in accordance with Section 160.2(b)2Aiv or 160.2(b)2Av, as applicable. The mechanical ventilation airflow rate shall be based on the conditioned floor area of the entire dwelling unit comprising the existing dwelling unit conditioned floor area plus the addition conditioned floor area.

Exception to Section 180.1(a)2Aii: Mechanical ventilation systems in additions shall be supply, balanced or the existing ventilation type.

iii. New dwelling units that are additions to an existing building shall have mechanical ventilation airflow provided in accordance with Section 160.2(b)2Aiv or 160.2(b)2Av as applicable. The mechanical ventilation airflow rate shall be based on the conditioned floor area of the new dwelling unit.

«» Commentary for Section 180.1(a)2A:

Additions

The whole-dwelling unit ventilation requirements in Section 160.2(b)2Aiv or Section 160.2(b)2Av apply to additions greater than 1,000 square feet and additions that add a new dwelling unit.

1. An addition to an existing dwelling unit that increases the conditioned floor area by more than 1,000 square feet must have the required whole-dwelling unit ventilation airflow calculated by using the entire dwelling unit conditioned floor area. This is the existing conditioned floor area plus the added conditioned floor area. For additions, mechanical ventilation systems may be supply, balanced or the existing ventilation type. This allows additions to use exhaust ventilation systems if it is used in the existing dwelling unit. Newly constructed dwelling units require the mechanical ventilation system to only be either supply system or balanced system under 160.2(b)2Aiv.
2. An addition that adds a new dwelling unit to an existing building must have the required whole-dwelling unit ventilation airflow calculated by using the conditioned floor area of the new dwelling unit.

Additions less than 1,000 square feet of conditioned floor area and additions that add a junior accessory dwelling unit (JADUs) do not need to meet the whole-dwelling unit ventilation requirements. «»

B. **Local mechanical exhaust**. Additions to existing buildings shall comply with all applicable requirements specified in Sections 160.2(b)2Avi and 160.2(b)2B.

(b) Performance approach. Performance calculations shall meet the requirements of Sections 170.0 through 170.2(a), pursuant to the applicable requirements in Items 1, 2 and 3 below.

1. **For additions alone.** The addition complies if the addition alone meets the energy budgets expressed in terms of Long-Term System Cost (LSC) energy.

2. **Existing plus alteration plus addition.** The standard design for existing plus alteration plus addition energy use is the combination of the existing building's unaltered components to remain; existing building altered components that are the more efficient, in LSC energy, of either the existing conditions or the requirements of Section 180.2(c); plus the proposed addition's energy use meeting the requirements of Section 180.1(a). The proposed design energy use is the combination of the existing building's unaltered components to remain and the altered components' energy features, plus the proposed energy features of the addition.

   Exception to Section 180.1(b)2: Existing structures with a minimum R-11 insulation in framed walls showing compliance with Section 180.1(b) are not required to show compliance with Section 160.1(b).

«» Commentary for Section 180.1(b)2:

Additions

New or altered mechanical systems serving additions for dwelling units or common use areas must meet all applicable mandatory requirements and comply with either the prescriptive or performance approach. If a building does not meet all applicable prescriptive requirements, then the performance method using an approved compliance software is the alternative.

All HVAC systems serving additions generally are required to meet the newly constructed building prescriptive requirements, with few exceptions. Table 4-7 summarizes the requirements.

Table 4-7: HVAC Requirements for Prescriptive Additions

Component	Additions
New or replaced space conditioning system(s)	All prescriptive requirements per Section 170.2 except the system may be a heat pump or gas heating system
Use existing space conditioning system(s)	No requirements for the heating/cooling equipment except that heating system must have adequate capacity

New duct system(s)	All prescriptive requirements per Section 170.2
Extend existing duct system(s)	Duct sealing and duct insulation per Section 180.2(b)2Aii

Source: California Energy Commission

If the heating and cooling system is unchanged as part of an addition, compliance for the HVAC system is not necessary. However, changing, altering, or replacing any component of a system triggers prescriptive requirements for that component. If the extended ducts are serving dwelling units, the combined new and existing duct system must meet the requirement to seal the ducts and verify that duct leakage is no greater than 15% of system airflow. If 15% leakage or lower cannot be attained, there are alternatives, including sealing all accessible leaks and confirming by a visual inspection. «»

3. **Mechanical ventilation for indoor air quality**. Additions to existing buildings shall comply with Section 160.2 subject to the requirements specified in Subsections A and B below. When field verification and diagnostic testing are required by Section 180.1(b)3, buildings with three habitable stories or less shall use the applicable procedures in the Residential Appendices, and buildings with four or more habitable stories shall use the applicable procedures in Nonresidential Appendices NA1 and NA2.

   A. **Whole-dwelling unit mechanical ventilation**.

      i. Dwelling units that meet the conditions in Subsection a or b below shall not be required to comply with the whole-dwelling unit ventilation airflow specified in Section 160.2(b)2Aiv or 160.2(b)2Av.

         a. Additions to an existing dwelling unit that increase the conditioned floor area of the existing dwelling unit by less than or equal to 1,000 square feet.

         b. Junior Accessory Dwelling Units (JADU) that are additions to an existing building.

      ii. Additions to an existing dwelling unit that increase the conditioned floor area of the existing dwelling unit by more than 1,000 square feet shall have mechanical ventilation airflow in accordance with Section 160.2(b)2Aiv or 160.2(b)2Av as applicable. The mechanical ventilation airflow rate shall be based on the conditioned floor area of the entire dwelling unit comprised of the existing dwelling unit conditioned floor area plus the addition conditioned floor area.

      iii. New dwelling units that are additions to an existing building shall have mechanical ventilation airflow provided in accordance with Section

160.2(b)2Aiv or 160.2(b)2Av as applicable. The mechanical ventilation airflow rate shall be based on the conditioned floor area of the new dwelling unit.

B. **Local Mechanical Exhaust**. Additions to existing buildings shall comply with all applicable requirements specified in 160.2(b)2Avi and 160.2(b)2B.

«» Commentary for Section 180.1(b)3B:

Additions

The whole-dwelling unit ventilation requirements in Section 160.2(b)2Aiv or Section 160.2(b)2Av apply to additions greater than 1,000 square feet and additions that add a new dwelling unit.

1. An addition to an existing dwelling unit that increases the conditioned floor area by more than 1,000 square feet must have the required whole-dwelling unit ventilation airflow calculated by using the entire dwelling unit conditioned floor area. This is the existing conditioned floor area plus the added conditioned floor area.
2. An addition that adds a new dwelling unit to an existing building must have the required whole-dwelling unit ventilation airflow calculated by using the conditioned floor area of the new dwelling unit.

Additions less than 1,000 square feet of conditioned floor area and additions that add a junior accessory dwelling unit (JADUs) do not need to meet the whole-dwelling unit ventilation requirements. «»

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 180.2 – ALTERATIONS

Alterations to components of existing multifamily buildings, including alterations made in conjunction with a change in building occupancy to a multifamily occupancy, shall meet Item (a), and either Item (b) or (c) below:

Exception 1 to Section 180.2: When heating, cooling or service water heating for an alteration is provided by expanding existing systems, the existing systems and equipment need not comply with Sections 110.0 through 110.10; Sections 160.0 through 160.7; and Section 170.2(c) or 170.2(d).

Exception 2 to Section 180.2: When existing heating, cooling or service water-heating systems or components are moved within a building, the existing systems or components need not comply with Sections 110.0 through 110.10; Sections 160.0 through 160.7; and Section 170.2(c) or 170.2(d).

Exception 3 to Section 180.2: Where an existing system with electric reheat is expanded when adding variable air volume (VAV) boxes to serve an alteration, total electric reheat capacity may be expanded not to exceed 20 percent of the existing installed electric capacity in any one permit and the system need not comply with Section 170.2(b)4E. Additional electric reheat capacity in excess of 20 percent may be added subject to the requirements of Section 170.2(b)4E.

Exception 4 to Section 180.2: The requirements of Section 160.3(a)2H shall not apply to alterations of space-conditioning systems or components.

(b) Prescriptive approach. The altered component and any newly installed equipment serving the alteration shall meet the applicable requirements of Sections 110.0 through 110.9 and all applicable requirements of Sections 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c) and 160.5; and

2. **Space-conditioning systems**.

   A. Space-conditioning systems serving dwelling units.

      i. **Entirely new or complete replacement space-conditioning systems** installed as part of an alteration shall include all the system heating or cooling equipment, including but not limited to: condensing unit, cooling or heating coil, and air handler for split systems; or complete replacement of a packaged unit; plus entirely new or replacement duct system [Section 180.2(b)2Aiib]. Entirely new or complete replacement space-conditioning systems shall meet the requirements of Sections 160.2(a)1, 160.3(a)1, 160.3(b)1 through 3, 160.3(b)5, 160.3(b)6, 160.3(c)1, 170.2(c)3B, 180.2(b)2Av, and Table 180.2-C.

«» Commentary for Section 180.2(b)2Ai:

An entirely new or complete replacement must meet all applicable mandatory and prescriptive requirements as described below.

1. Section 160.2(b)1: Air filtration requirements.
2. Section 160.3(a)1: Setback thermostats or controlled by EMCS.
3. Section 160.3(b)1-2: Cooling and heating load calculations.
4. Section 160.3(b)3: Outdoor condensing unit requirements.
5. Section 160.3(b)4: Heating furnace temperature rise requirements.
6. Section 160.3(b)5A-J: Duct insulation, labeling, & damper requirements.
7. Section 160.3(b)5L: Static pressure probe, airflow, and fan efficacy requirements (or alternative return duct sizing as per Table 160.3-A and B). Multifamily buildings in Climate Zone 1 with four or more habitable stories are exempt from this requirement.
8. Section 160.3(b)6: Pipe insulation.
9. Section 170.2(c)3A: Prescriptive heating system type: the new or complete replacement space-conditioning system may be a heat pump or gas heating system.
10. Section 170.2(c)3Bi: Prescriptive refrigerant charge verification.
11. Section 170.2(c)3Biii: Prescriptive central fan integrated ventilation system airflow and fan efficacy.
12. Table 180.2-C: Prescriptive duct insulation.

A system installed in an existing dwelling unit as part of an alteration must be considered entirely new when both of the following conditions are met:

1. The air handler and all 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.
2. The duct system is entirely new (including systems with less than 40 ft. in length).

An entirely new duct system may be part of an entirely new space conditioning system, or it may be connected to an existing space conditioning system. Duct systems are classified as entirely new when:

1. At least 75% of the duct material is new. Up to 25% may be composed of reused parts from the existing duct system.
2. All remaining components from the previous system are accessible and can be sealed.

In addition, entirely new duct systems must meet the following mandatory requirements:

1. Section 160.2(b)1: Air filtration requirements.
2. Section 160.3(b)5L: Static pressure probe, airflow, and fan efficacy requirements (or alternative return duct sizing as per Table 160.3-A and B). Multifamily buildings in Climate Zone 1 with four or more habitable stories are exempt from this requirement.

When an entirely new duct system and the furnace or air handler it is connected to are in a vented attic the following prescriptive requirements also must be met.

1. Section 180.2(b)1Bi: Attic insulation and air sealing requirements.

Altered duct systems that are not entirely new or complete replacements are treated as an extension of an existing system. «»

ii. **Altered duct systems—duct sealing**: In all climate zones, when more than 25 feet of new or replacement space-conditioning system ducts are installed, the ducts shall comply with the applicable requirements of Subsections a and b below. New ducts located in unconditioned space shall meet the applicable requirements of Sections 160.3(b)5A through J and the duct insulation requirements of Table 180.2-C, and

a. The altered duct system, regardless of location, shall be sealed as confirmed through field verification and diagnostic testing in accordance with all applicable procedures for duct sealing of altered existing duct systems as specified in Reference Residential Appendix RA3.1, utilizing the leakage compliance criteria specified in Subsection I or II below.

TABLE 180.2-C DUCT INSULATION R-VALUE

Climate Zones 3, 5 through 7	Climate Zones 1, 2, 4, 8 through 16
R-6	R-8

«» Commentary for Section 180.2(b)2Aii:

New and Altered Duct System – Insulation

When more than 25 linear ft. of new ducts are installed in an unconditioned space, the new ducts must be insulated per Table 180.2-C. When 25 ft. or less of ducts are installed in an unconditioned space, they must be insulated to the minimum mandatory insulation level of R-6 in all climate zones.

When new ducts are installed in conditioned space, the ducts must be insulated to the minimum mandatory insulation level of R-6 unless an exception or alternative mandatory minimum applies. For multifamily buildings four habitable or more stories, this can be confirmed by visual verification of the enforcement agency. For multifamily buildings up to three habitable stories, the entire duct system must be tested and confirmed to be in conditioned space by a ECC-Rater per RA3.1.4.3.8.

Altered System Duct Sealing

In all climate zones, altered existing duct systems must be sealed and tested. An existing duct system is considered altered under any of the following conditions:

1. An outdoor condensing unit of a split system air conditioner or heat pump is installed or replaced.
2. A packaged system is completely replaced.
3. A cooling or heating coil is installed or replaced.
4. An air handler is installed or replaced.
5. More than 25 ft. of new or replacement ducts are installed.
6. The ducts are extended to serve an addition, regardless of the length of duct.

If a dwelling unit has more than one duct system, only the altered ducts or ducts connected to the altered equipment need to be sealed and verified.

There are three options for showing compliance for altered existing duct systems listed below. Compliance must at least be attempted with one of the first two options (15% total leakage or 10% leakage to outside); then the third option (sealing all accessible leaks) any of the other options can be used.

1. Total leakage is less than 15% of nominal system fan airflow (RA3.1.4.3.1).
2. Leakage to the outside is less than 10% of system fan airflow (RA3.1.4.3.4).
3. If the first two option leakage targets cannot be met, then compliance can be achieved by sealing all accessible leaks and conducting a smoke test (RA3.1.4.3.7).

Some judgment is required in determining if ducts are accessible. The local code enforcement agency will make a determination when it is not immediately obvious.

«»

I. **Entirely new or complete replacement duct system.** If the new ducts form an entirely new or complete replacement duct system directly connected to the air handler, the duct system shall meet one of the following requirements:

   A. The total leakage of the duct system shall not exceed 12 percent of the air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1, or

   B. The duct system leakage to outside shall not exceed 6 percent of the air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4.

   Entirely new or complete replacement duct systems installed as part of an alteration are constructed of at least 75 percent new duct material, and up to 25 percent may consist of reused parts from the dwelling unit's existing duct system, including but not limited to registers, grilles, boots, air handler, coil, plenums and duct material, if the reused parts are accessible and can be sealed to prevent leakage.

Entirely new or complete replacement duct systems shall also conform to the requirements of Sections 160.2(a)1 and 160.3(b)5L. If the air handler and ducts are located within a vented attic, the requirements of Section 180.2(b)1Bi shall also be met.

«» Commentary for Section 180.2(b)2AiiaI:

New and Altered Duct System – Insulation

An entirely new duct system may be part of an entirely new space conditioning system, or it may be connected to an existing space conditioning system. Duct systems are classified as entirely new when:

1. At least 75% of the duct material is new. Up to 25% may be composed of reused parts from the existing duct system.
2. All remaining components from the previous system are accessible and can be sealed.

«»

II. **Extension of an existing duct system.** If the new ducts are an extension of an existing duct system serving multifamily dwellings, the combined new and existing duct system shall meet one of the following requirements:

A. The measured duct leakage shall be equal to or less than 15 percent of air handler airflow as confirmed by field verification and diagnostic testing utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1; or

B. The measured duct leakage to outside shall be equal to or less than 10 percent of air handler airflow as confirmed by field verification and diagnostic testing utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4; or

C. If it is not possible to meet the duct sealing requirements of either Section 180.2(b)2AiicI or II then all accessible leaks shall be sealed and verified through a visual inspection and a smoke test by a certified ECC-Rater utilizing the methods specified in Reference Residential Appendix RA3.1.4.3.5.

Exception to Section 180.2(b)2AiiaII: duct sealing. Existing duct systems that are extended, which are constructed, insulated or sealed with asbestos.

Exception 1 to 180.2(b)2Aii: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

«» Commentary for Section 180.2(b)2Aii:

New and Altered Duct System – Insulation

For multifamily buildings with up to three habitable stories, ECC-verification is required. For other multifamily buildings, testing only needs to be conducted and certified by the installing contractor, and neither a ECC-Rater nor registration with a ECC-Provider is required. «»

iii. **Altered space-conditioning system—duct sealing.** In all climate zones, when a space-conditioning system serving a multifamily dwelling is altered by the installation or replacement of space-conditioning system equipment, including replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, or cooling or heating coil, the duct system that is connected to the altered space-conditioning system equipment shall be sealed, as confirmed through field verification and diagnostic testing in accordance with the applicable procedures for duct sealing of altered existing duct systems as specified in Reference Residential Appendix RA3.1 and the leakage compliance criteria specified in Subsection a, b or c below.

A. The measured duct leakage shall be equal to or less than 15 percent of air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1; or

b. The measured duct leakage to outside shall be equal to or less than 10 percent of air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4; or

c. If it is not possible to meet the duct sealing requirements of either Section 180.2(b)2Aiiia or b, then all accessible leaks shall be sealed and verified through a visual inspection and a smoke test by a certified ECC-Rater utilizing the methods specified in Reference Residential Appendix RA3.1.4.3.5.

Exception 1 to Section 180.2(b)2Aiii: duct sealing. Duct systems that are documented to have been previously sealed as confirmed through field verification and diagnostic testing in accordance with procedures in Reference Residential Appendix RA3.1.

Exception 2 to Section 180.2(b)2Aiii: duct sealing. Duct systems with less than 40 linear feet as determined by visual inspection.

Exception 3 to Section 180.2(b)2Aiii: duct sealing. Existing duct systems constructed, insulated or sealed with asbestos.

Exception 4 to Section 180.2(b)2Aiii: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

«» Commentary for Section 180.2(b)2Aiii:

New and Altered Duct System – Insulation

For multifamily buildings with up to three habitable stories, ECC-verification is required. For other multifamily buildings, testing only needs to be conducted and certified by the installing contractor, and neither a ECC-Rater nor registration with a ECC-Provider is required. «»

iv. **Altered space-conditioning system mechanical cooling.** When a space-conditioning system is an air conditioner or heat pump that is altered by the installation or replacement of refrigerant-containing system components such as the compressor, condensing coil, evaporator coil, refrigerant metering device or refrigerant piping, the altered system shall comply with the following requirements:

a. All thermostats associated with the system shall be replaced with setback thermostats meeting the requirements of Section 110.2(c).

«» Commentary for Section 180.2(b)2Aiva:

When an existing system has a refrigerant containing system component added or replaced, the thermostat must be upgraded to a setback type that meets Section 110.2(c). «»

b. In Climate Zones 2 and 8 through 15, air-cooled air conditioners and air-source heat pumps, including but not limited to ducted split systems, ducted package systems, small duct high velocity air systems, and minisplit systems, shall comply with Subsections I and II, unless the system is of a type that cannot be verified using the specified procedures. Systems that cannot comply with the requirements of Section 180.2(b)2Aivb shall comply with Section 180.2(b)2Aivc.

Exception to Section 180.2(b)2Aivb: Entirely new or complete replacement packaged systems for which the manufacturer has verified correct system refrigerant charge prior to shipment from the factory are not required to have refrigerant charge confirmed through field verification and diagnostic testing. The installer of these packaged systems shall certify that the packaged system was pre-charged at the factory and has not been altered in a way that would affect the charge. Ducted systems shall comply with the minimum system airflow rate requirement in Section 180.2(b)2AivbI, provided that the system is of a type that can be verified using the procedure specified in RA3.3 or an approved alternative in RA1.

I. The minimum system airflow rate shall comply with the applicable Subsection A or B below as confirmed through field verification and diagnostic testing in accordance with the procedures specified in Reference Residential Appendix Section RA3.3 or an approved alternative procedure as specified in Section RA1.

A. Small duct high velocity systems shall demonstrate a minimum system airflow rate greater than or equal to 250 cfm per ton of nominal cooling capacity; or

B. All other air-cooled air conditioner or air-source heat pump systems shall demonstrate a minimum system airflow rate greater than or equal to 300 cfm per ton of nominal cooling capacity.

Exception 1 to Section 180.2(b)2AivbI: Systems unable to comply with the minimum airflow rate requirement shall demonstrate compliance using the procedures in Section RA3.3.3.1.5, and the system's thermostat shall conform to the specifications in Section 110.12.

Exception 2 to Section 180.2(b)2AivbI: Entirely new or complete replacement space-conditioning systems, as specified by Section 180.2(b)2Ai, without zoning dampers may comply with the minimum airflow rate by meeting the applicable requirements in Table 160.3-A or 160.3-B as confirmed by field verification and diagnostic testing in accordance with the procedures in Reference Residential Appendix Sections RA3.1.4.4 and RA3.1.4.5. The design clean-filter pressure drop requirements of Section 160.2(a)1C for the system air filter device(s) shall conform to the requirements given in Tables 160.3-A and 160.3-B.

II. The installer shall charge the system according to manufacturer’s specifications. Refrigerant charge shall be verified according to one of the following options, as applicable.

A. The installer and rater shall perform the standard charge verification procedure as specified in Reference Residential Appendix Section RA3.2.2, or an approved alternative procedure as specified in Section RA1; or

B. The installer shall perform the weigh-in charging procedure as specified by Reference Residential Appendix Section RA3.2.3.1, provided the system is of a type that can be verified using the RA3.2.2 standard charge verification procedure and RA3.3 airflow rate verification procedure or approved alternatives in RA1. The ECC-Rater shall verify the charge using RA3.2.2 and RA3.3 or approved alternatives in RA1.

Exception 1 to Section 180.2(b)2AivbII: When the outdoor temperature is less than 55 degrees F and the installer utilizes the weigh-in charging procedure in Reference Residential Appendix Section RA3.2.3.1 to demonstrate compliance, the installer may elect to utilize the verification procedure in Reference Residential Appendix Section RA3.2.3.2. If the verification procedure in Section RA3.2.3.2 is used for compliance, the system's thermostat shall conform to the specifications in Section 110.12. Ducted systems shall comply with the minimum system airflow rate requirements in Section 180.2(b)2AivbI.

EXCEPTION 2 to Section 180.2(b)2Aivb: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

«» Commentary for Section 180.2(b)2Aivb:

When refrigerant charge verification is required for compliance, the system must also comply with the minimum airflow of 300 CFM/ton according to the procedures specified in RA3.3.

Entirely new or complete replacement space-conditioning systems must meet the minimum 350 CFM/ton airflow rate compliance criterion or the duct design alternative along with the other prescriptive and mandatory requirements described above.

Verification of refrigerant charge and airflow must be conducted by a ECC-Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings, testing only needs to be conducted and certified by the installing contractor and neither a ECC-Rater nor registration with a ECC-Provider is required. **«»**

v. **Altered Space-Heating System.** Altered or replacement space-heating systems shall not use electric resistance as the primary heat source.

EXCEPTION 1 to Section 180.2(b)2Av: Non-ducted electric resistance space heating systems if the existing space heating system is electric resistance.

EXCEPTION 2 to Section 180.2(b)2Av: Ducted electric resistance space heating systems if the existing space heating system is electric resistance and a ducted space cooling system is not being replaced or installed.

EXCEPTION 3 to Section 180.2(b)2Av: Electric resistance space heating systems, if the existing space heating system is electric resistance in Climate Zones 6, 7, 8, or 15.

«» Commentary for Section 180.2(b)2Av:

Heating System Replacements

Prescriptive compliance requires new heating systems be limited to a heat pump or a gas or propane system. Altered systems must not use electric resistance as the primary heat source unless the existing space heating system is electric resistance and one of the following conditions are met:

1. Non-ducted electric resistance system when the existing system is electric resistance.
2. Ducted electric resistance systems only when a ducted space cooling system is not being replaced or installed as part of the alteration.
3. Any electric resistance systems in climate zones 6, 7, 8 or 15.

«»

B. **Common Use Area Space Conditioning Systems**

i. New or Replacement Space-Conditioning Systems or Components other than new or replacement space-conditioning system ducts shall meet the requirements of Sections 170.2(c)1, 2, and 4, applicable to the systems or components being altered. For compliance with Section 170.2(c)4A, additional fan power adjustment credits are available as specified in TABLE 180.2-D.

TABLE 180.2-D Fan Power Limitation Pressure Drop Adjustment

Airflow	Multi-Zone VAV Systems[1] ≤5,000 cfm	Multi-Zone VAV Systems[1] >5,000 and ≤10,000 cfm	Multi-Zone VAV Systems[1] >10,000 cfm	All Other Fan Systems ≤5,000 cfm	All Other Fan Systems >5,000 and ≤10,000 cfm	All Other Fan Systems >10,000 cfm
Supply Fan System Additional Allowance	0.135	0.114	0.105	0.139	0.12	0.107
Supply Fan System Additional Allowance In Unit with Adapter Curb	0.033	0.033	0.043	0.000	0.000	0.000
Exhaust/ Relief/ Return/ Transfer Fan System Additional Allowance	0.07	0.061	0.054	0.07	0.062	0.055
Exhaust/ Relief/ Return/ Transfer Fan System Additional Allowance In Unit with Adapter Curb	0.016	0.017	0.022	0.000	0.000	0.000

Footnotes to Table 180.2-D:

1. See FAN SYSTEM, MULTI-ZONE VARIABLE AIR VOLUME (VAV) for the definition of a Multi-Zone VAV System.

Exception 1 to Section 180.2(b)2Bi: Section 180.2(b)2Av does not apply to replacement of electric reheat of equivalent or lower capacity electric resistance space heaters when natural gas is not available.

Exception 2 to Section 180.2(b)2Bi: Operable wall or roof openings that have been previously installed without interlock controls are exempt from complying with Section 170.2(c)4L.

Exception 3 to Section 180.2(b)2Bi: Section 170.2(c)4Ci is not applicable to systems that meet both of the following:

The system is not a single package air-cooled commercial unitary air conditioner or heat pump; and

The cooling capacity of the system is less than 54,000 Btu/h.

«» Commentary for Section 180.2(b)2Bi:

Multifamily HVAC Alterations

An economizer is required for replacement of HVAC single packaged units per Section 170.2(c)4. Exception 3 to Section 180.2(b)2Bi requires single packaged air-cooled commercial unitary air conditioners or heat pumps with cooling capacity less than 54,000 Btu per hour to meet the economizer requirements in Section 170.2(c)4Ci. This exception does not require economizers for replacements of VRF, split systems, or systems that are not single packaged units. **«»**

ii. **Altered duct systems.** When new or replacement space-conditioning system ducts are installed to serve an existing building, the new ducts shall meet the requirements of Section 160.3(c)2 and meet a or b below:

a. Reserved.

b. Entirely new or replacement duct systems installed as part of an alteration shall be leakage-tested in accordance with Section 160.2(c)2H. Entirely new or replacement duct systems installed as part of an alteration shall be constructed of at least 75 percent new duct material, and up to 25 percent may consist of reused parts from the building's existing duct system, including registers, grilles, boots, air handlers, coils, plenums, and ducts, if the reused parts are accessible and can be sealed to prevent leakage.

EXCEPTION 1 to Section 180.2(b)2Biib: When it is not possible to achieve the duct leakage criteria in Section 180.2(b)2Biib, all accessible leaks shall be sealed and verified through a visual inspection and a smoke test performed by a certified mechanical acceptance test technician utilizing the methods specified in Reference Nonresidential Appendix NA7.5.3.

EXCEPTION 2 to Section 180.2(b)2Biib: Duct Sealing. Existing duct systems that are extended, which are constructed, insulated or sealed with asbestos are not required to comply with subsection 180.2(b)2Biib.

c. If the new ducts are an extension of an existing duct system, the combined new and existing duct system meets the criteria in Subsections I, II, and III below. The duct system shall be sealed to a leakage rate not to exceed 15 percent of the nominal air handler airflow rate as confirmed through acceptance testing, in accordance with Reference Nonresidential Appendix NA7.5.3:

I. The duct system provides conditioned air to an occupiable space for a constant volume, single zone, space-conditioning system; and

II. The space conditioning system serves less than 5,000 square feet of conditioned floor area; and

III. The combined surface area of the ducts located in the following spaces is more than 25 percent of the total surface area of the entire duct system:

A. Outdoors;

B. In a space directly under a roof that

C. Has a U-factor greater than the U-factor of the ceiling, or if the roof does not meet the requirements of Section 170.2(a)1B, or

D. Has fixed vents or openings to the outside or unconditioned spaces; or

E. In an unconditioned crawl space; or

F. In other unconditioned spaces.

«» Commentary for Section 180.2(b)2Bii:

Once the ducts have been sealed and tested to leak less than the amounts required in Section 180.2(b)2Bii, a ECC-rater will be contacted by the contractor to validate the accuracy of the duct sealing measurement on a sample of the systems repaired as described in Reference Nonresidential Appendix NA1. Certified ATTs may perform these field verifications only if the ATTCP has been approved to provide this service. **«»**

iii. **Altered space-conditioning systems.** When a space-conditioning system is altered by the installation or replacement of space-conditioning system equipment (including replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, or cooling or heating coil:

a. For all altered units where the existing thermostat does not comply with the requirements for demand responsive controls specified in Section 110.12, the existing thermostat shall be replaced with a demand responsive thermostat that complies with Section 110.12. All newly installed space-conditioning systems requiring a thermostat shall be equipped with a demand responsive thermostat that complies with Section 110.12; and

b. The duct system that is connected to the new or replaced space-conditioning system equipment shall be sealed, if the duct system meets the criteria of Section 120.4(g), as confirmed through acceptance testing, in accordance with the applicable procedures for duct sealing of altered existing duct systems as specified in Reference Nonresidential Appendix NA7.5.3, and conforming to the applicable leakage compliance criteria in Section 180.2(b)2Bii.

Exception 1 to Section 180.2(b)2Biiib: duct sealing. Buildings altered so that the duct system no longer meets the criteria of Section 170.2(c)4Ji are not required to comply with Subsection 180.2(b)2Biiib.

Exception 2 to Section 180.2(b)2Biiib: duct sealing. Duct systems that are documented to have been previously sealed as confirmed through acceptance testing in accordance with procedures in the Reference Nonresidential Appendix NA7.5.3 are not required to comply with Subsection 180.2(b)2Biiib.

Exception 3 to Section 180.2(b)2Biiib: duct sealing. Existing duct systems constructed, insulated or sealed with asbestos are not required to comply with the requirements of Subsection 180.2(b)2Biiib.

5. **Mechanical ventilation and indoor air quality for dwelling units.** Alterations to existing buildings shall comply with Subsections A and B below as applicable. When field verification and diagnostic testing are required by Section 180.2(b)5, buildings with three habitable stories or less shall use the applicable procedures in the Residential Appendices, and buildings with four or more habitable stories shall use the applicable procedures in Nonresidential Appendices NA1 and NA2.

Exception to Section 180.2(b)5: A dwelling unit air leakage test is not required for alterations.

A. **Entirely new or complete replacement ventilation systems.** Entirely new or complete replacement ventilation systems shall comply with all applicable requirements in Section 160.2(b)2. An entirely new or complete replacement ventilation system includes a new ventilation fan component and an entirely new duct system. An entirely new or complete replacement duct system is constructed of at least 75 percent new duct material, and up to 25 percent may consist of reused parts from the dwelling unit's existing duct system, including but not limited to registers, grilles, boots, air filtration devices and duct material, if the reused parts are accessible and can be sealed to prevent leakage.

Exception: to Section 180.2(b)5A: The new or replacement ventilation type shall be supply, balanced, or the existing ventilation type being replaced.

B. **Altered ventilation systems**. Altered ventilation system components or newly installed ventilation equipment serving the alteration shall comply with Section 160.2(b)2 as applicable subject to the requirements specified in Subsections i and ii below.

i. **Whole-dwelling unit mechanical ventilation**.

a. **Whole-dwelling unit ventilation strategy.** The altered ventilation system shall be supply, balanced, or the existing ventilation type being altered.

b. **Whole-dwelling unit airflow**. If the whole-dwelling ventilation fan is altered or replaced, then one of the following Subsections 1 or 2 shall be used for compliance as applicable.

1. Dwellings that were required by a previous building permit to comply with the whole-dwelling unit airflow requirements in Section 160.2(b)2, 120.1(b) or 150.0(o) shall meet or exceed the whole-dwelling unit mechanical ventilation airflow specified in Section 160.2(b)2Aiv or 160.2(b)2Av as confirmed through field verification and diagnostic testing in accordance with the applicable procedures specified in Reference Appendix RA3.7 or NA2.2.

2. Dwellings that were not required by a previous building permit to have a whole-dwelling unit ventilation system to comply with Section 160.2(b)2, 120.1(b) or 150.0(o) shall not be required to comply with the whole-dwelling unit ventilation airflow specified in Section 160.2(b)2Aiv or 160.2(b)2Av.

c. **Replacement ventilation fans.** Whole-dwelling unit replacement ventilation fans shall be rated for airflow and sound in accordance with the requirements of ASHRAE 62.2 Sections 7.1 and 7.3. Additionally, when conformance to a specified whole-dwelling unit airflow rate is required for compliance, the replacement fans shall be rated at no less than the airflow rate required for compliance.

d. **Air filters**. If the air filtration device for a whole-dwelling unit ventilation system is altered or replaced, then one of the following Subsections 1 or 2 shall be used for compliance.

1. Dwellings that were required by a previous building permit to comply with the ventilation system air filtration requirements in Section 160.2(b)1, 120.1(b)1 or 150.0(m)12 shall comply with the air filtration requirements in Section 160.2(b)1.

2. Dwellings that were not required by a previous building permit to comply with the ventilation system air filtration requirements in Section 160.2(b)1, 120.1(b)1 or 150.0(m)12 shall not be required to comply with the air filtration requirements specified in Section 160.2(b)1.

ii. **Local mechanical exhaust**.

a. **Bathroom local mechanical exhaust**. Altered bathroom local mechanical exhaust systems shall comply with the applicable requirements specified in Section 160.0(b)2Avi.

b. **Kitchen local mechanical exhaust**. If the kitchen local ventilation fan is altered or replaced, then one of the following Subsections 1, 2 or 3 shall be used for compliance.

1. Dwellings that were required by a previous building permit to comply with the kitchen local exhaust requirements in Section 160.0(b)2Avi, 120.1(b)2vi or 150.0(o)1G shall meet or exceed the applicable airflow or capture efficiency requirements in Section 160.0(b)2Avi.

2. Dwellings that were required by a previous building permit to install a vented kitchen range hood or other kitchen exhaust fan shall install a replacement fan that meets or exceeds the airflow required by the previous building permit, or 100 cfm, whichever is greater.

«» Commentary for Section 180.2(b)5Biib:

Kitchen local mechanical exhaust systems that previously met indoor air quality requirements must continue to meet indoor air quality requirements after the additions or alterations are completed. They must either 1) meet or exceed the airflow and capture efficiency requirements in Sections 160.0(b)2Avi if a previous building permit required compliance with Section 160.0(b)2Avi, 120.1(b)2vi or 150.0(o)1G, or 2) meet or exceed the greater of airflow requirement by the previous building permit or 100 cfm if the previous permit required installing a vented kitchen range hood. **«»**

3. Dwellings that were not required to have a kitchen local ventilation exhaust system according to the conditions in either Subsection 1 or 2 above shall not be required to comply with the requirements of Section 160.0(b)2Avi.

c. **Replacement ventilation fans.** New or replacement local mechanical exhaust fans shall be rated for airflow and sound in accordance with the requirements of ASHRAE 62.2 Section 7.1 and Title 24, Part 6, Section 160.0(b)2Avif. Additionally, when compliance with a specified exhaust airflow rate is required, the replacement fan shall be rated at no less than the airflow rate required for compliance.

(c) Performance approach. The altered component(s) and any newly installed equipment serving the alteration shall meet the applicable requirements of Subsections 1, 2 and 3 below. The energy budget for alterations is expressed in terms of Long-Term System Cost (LSC) energy.

1. The altered components shall meet the applicable requirements of Sections 110.0 through 110.9, 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c), and 160.5. Entirely new or complete replacement mechanical ventilation systems as these terms are used in Section 180.2(b)5A shall comply with the requirements in Section 180.2(b)5A. Altered mechanical ventilation systems shall comply with the requirements of Sections 180.2(b)5B. Entirely new or complete replacement space-conditioning systems, and entirely new or complete replacement duct systems, as these terms are used in Sections 180.2(b)2Ai and 180.2(b)2Aiia, shall comply with the requirements of Sections 160.2(a)1 and 160.3(b)5L.
2. The standard design for an altered component shall be the higher efficiency of existing conditions or the requirements of Section 180.2(b). For components not being altered, the standard design shall be based on the unaltered existing conditions such that the standard and proposed designs for these components are identical. When the third-party verification option is specified, all components proposed for alteration for which the additional credit is taken, must be verified by a certified ECC-rater.
3. The proposed design shall be based on the actual values of the altered components.

NOTES TO SECTION 180.2(c):

1. If an existing component must be replaced with a new component, that component is considered an altered component for the purpose of determining the standard design altered component energy budget and must meet the requirements of Section 180.2(c)2.
2. The standard design shall assume the same geometry and orientation as the proposed design.
3. The "existing efficiency level" modeling rules, including situations where nameplate data is not available, are described in Section 10-109(c) and Section 10-116.

EXCEPTION 1 to Section 180.2(c): Any dual-glazed greenhouse or garden window installed as part of an alteration complies with the U-factor requirements in Section 170.2.

EXCEPTION 2 to Section 180.2(c): Where the space in the attic or rafter area is not large enough to accommodate the required R-value, the entire space shall be filled with insulation provided such installation does not violate Section 1203.2 of Title 24, Part 2.

Note: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

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INTRODUCTION

Chapter 5 Introduction

This chapter covers the requirements related to domestic hot water systems for all dwelling units and common use areas in multifamily buildings for newly constructed buildings and additions or alterations to existing buildings.

Guidance on general requirements is included in the Multifamily Compliance Manual Chapter 1: General Requirements. Guidance on administrative requirements is included in the Multifamily Compliance Manual Chapter 2: Compliance and Enforcement. This chapter includes guidance on water-heating system requirements.

Table 5-1: Excerpt From Table 100.0-A Application of Standards provides an overview of the location of the water-heating requirements that apply to multifamily occupancies in the Energy Code.

Table 5-1: Excerpt From Table 100.0-A Application of Standards

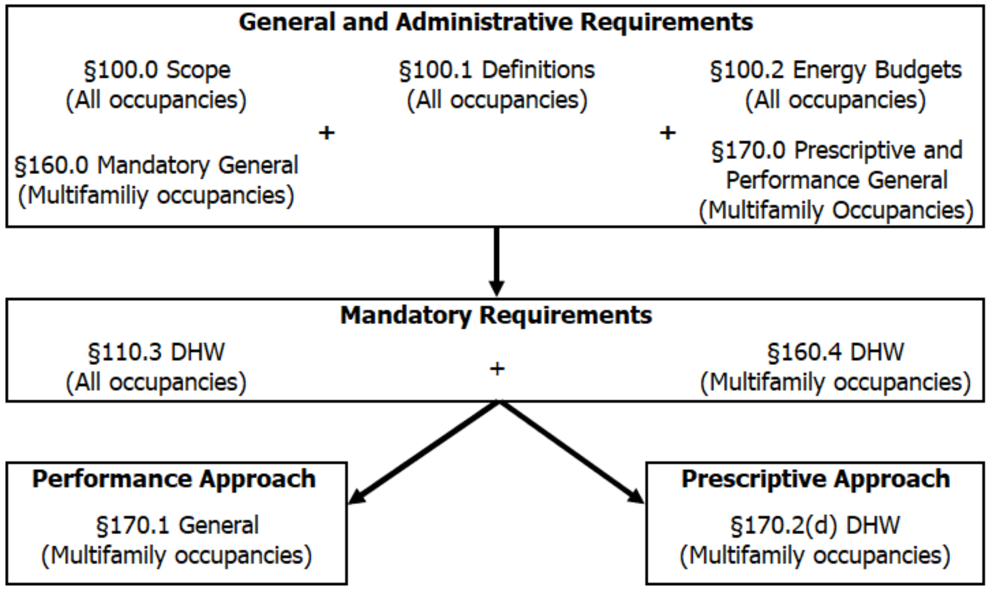
Application	Mandatory	Prescriptive	Performance	Additions/ Alterations
General[1]	160.0	170.0	170.0	180.0
Water-Heating	110.3, 160.4	170.2(d)	170.1	180.1, 180.2

1. Guidance on General Requirements from Sections 160.0, 170.0 and 180.0 are included in the Multifamily Compliance Manual Chapter 1 General Requirements. Guidance specific to multifamily water-heating is included in this chapter.

Source: California Energy Commission

Figure 5-1: Flowchart Guidance for Application of New Construction Multifamily Domestic Hot Water System Requirements and Figure 5-2: Flowchart Guidance for Application of Addition or Alteration Multifamily Domestic Hot Water System Requirements below illustrate the applicable sections for newly constructed buildings and additions or alterations to existing buildings.

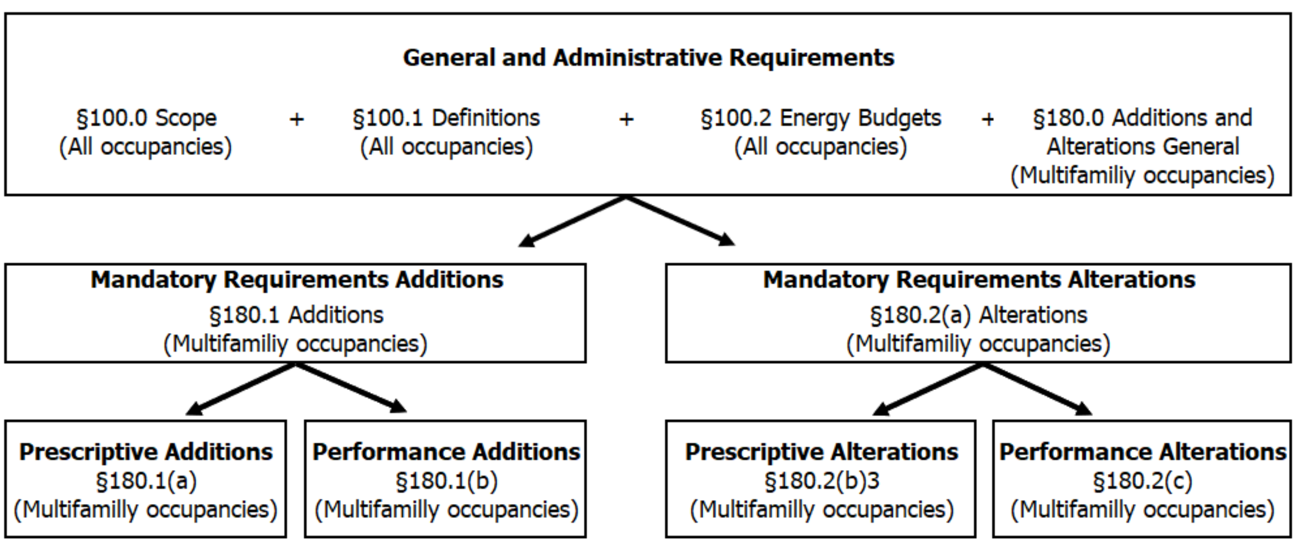
Figure 5-1: Flowchart Guidance for Application of New Construction Multifamily Domestic Hot Water System Requirements



Newly Constructed Buildings Compliance Approaches

Source: California Energy Commission

Figure 5-2: Flowchart Guidance for Application of Addition or Alteration Multifamily Domestic Hot Water System Requirements



Addition, Alteration Compliance Approaches

Source: California Energy Commission

SECTION 110.3 – MANDATORY REQUIREMENTS FOR SERVICE WATER-HEATING SYSTEMS AND EQUIPMENT

(a) Certification by manufacturers. Any service water- heating system or equipment may be installed only if the manufacturer has certified that the system or equipment complies with all of the requirements of this subsection for that system or equipment.

1. Temperature controls for service water-heating systems. Service water-heating systems shall be equipped with automatic temperature controls capable of adjustment from the lowest to the highest acceptable temperature settings for the intended use as listed in Table 3, Chapter 50 of the ASHRAE Handbook, HVAC Applications Volume or Table 613.1 of the California Plumbing Code for healthcare facilities.

   Exception to Section 110.3(a)1: Residential occupancies.

«» Commentary for Section 110.3(a)1:

Manufacturers must certify that their products comply with California's Title 20 Appliance Efficiency Regulations, Section 1605.1(f) at the time of manufacture. Regulated equipment must be listed in the California Energy Commission Appliance Efficiency Database. «»

(b) Efficiency. Equipment shall meet the applicable requirements of the Appliance Efficiency Regulations as required by Section 110.1, subject to the following:

1. If more than one standard is listed in the Appliance Efficiency Regulations, the equipment shall meet all the standards listed; and
2. If more than one test method is listed in the Appliance Efficiency Regulations, the equipment shall comply with the applicable standard when tested with each test method; and
3. Where equipment can serve more than one function, such as both heating and cooling, or both space heating and water heating, it shall comply with all the requirements applicable to each function; and
4. Where a requirement is for equipment rated at its "maximum rated capacity" or "minimum rated capacity," the capacity shall be as provided for and allowed by the controls, during steady-state operation.

«» Commentary for Section 110.3(b):

Water heaters are regulated under California's Title 20 Appliance Efficiency Regulations, Section 1605.1(f). These regulations align with the federal efficiency standards for water heaters. Consumer water heaters and residential-duty commercial water heaters are both rated in Uniform Energy Factor (UEF). The draw pattern is based on the water heater's design first hour rating for storage water heater or gallons per minute (GPM) for instantaneous water heaters. For commercial water heaters, unlike consumer water heaters, these water heaters are not rated in UEF. The required minimum energy efficiency for commercial water heaters is in terms of thermal efficiency and standby loss. «»

(c) Installation. Any service water-heating system or equipment may be installed only if the system or equipment complies with all of the applicable requirements of this subsection for the system or equipment.

1. **Outlet temperature controls.** On systems that have a total capacity greater than 167,000 Btu/hr, outlets that require higher than service water temperatures as listed in the ASHRAE Handbook, Applications Volume, shall have separate remote heaters, heat exchangers or boosters to supply the outlet with the higher temperature.

   Exception to Section 110.3(c)1: Systems covered by California Plumbing Code Section 613.0 shall instead follow the requirements of that section.

2. **Controls for hot water distribution systems.** Service hot water systems with circulating pumps or with electrical heat trace systems shall be capable of automatically turning off the system.

   Exception to Section 110.3(c)2: Systems serving healthcare facilities.

3. **Insulation.** Unfired service water heater storage tanks and backup tanks for solar water-heating systems shall have:

   A. External insulation with an installed R-value of at least R-3.5; or

   B. Internal and external insulation with a combined R-value of at least R-16; or

   C. The heat loss of the tank surface based on an 80°F water-air temperature difference shall be less than 6.5 Btu per hour per square foot.

4. **Water heating recirculation loops serving multiple dwelling units, high-rise residential, hotel/motel, and nonresidential occupancies.** A water heating recirculation loop is a type of hot water distribution system that reduces the time needed to deliver hot water to fixtures that are distant from the water heater, boiler or other water heating equipment. The recirculation loop is comprised of a supply portion, connected to branches that serve multiple dwelling units, guest rooms, or fixtures and a return portion that completes the loop back to the water heating equipment. A water heating recirculation loop shall meet the following requirements:

   A. **Air release valve or vertical pump installation.** An automatic air release valve shall be installed on the recirculation loop piping on the inlet side of the recirculation pump and no more than 4 feet from the pump. This valve shall be mounted on top of a vertical riser at least 12 inches in length and shall be accessible for replacement and repair. Alternatively, the pump shall be installed on a vertical section of the return line.

«» Commentary for Section 110.3(c)4A:

The constant supply of new water in combination with the continuous operation of pumps creates the possibility of the pump cavitation because of the presence of air in the water. Cavitation is the formation of bubbles in the low-pressure liquid on the suction side of the pump. The cavities or bubbles will collapse when they pass into the higher regions of pressure, causing noise and vibration that may damage many components. In addition, there is a loss in capacity, and the pump can no longer build the same head (pressure). This reduction in pressure ultimately affects the efficiency and life expectancy of the pump. Cavitation must be minimized either by installing an air release valve or mounting the pump vertically. The air release valve must be located no more than 4 ft. from the inlet of the pump. The air release valve must also be mounted on a vertical riser with a length of at least 12 inches. See Figure 5-3: Mandatory Central Recirculation System Installation Requirements for illustration. **«»**

B. **Recirculation loop backflow prevention.** A check valve or similar device shall be located between the recirculation pump and the water heating equipment to prevent water from flowing backwards though the recirculation loop.

«» Commentary for Section 110.3(c)4B:

Temperature and pressure differences in the water throughout a recirculation system can create backflow. Backflow can result in cooler water from the bottom of the water heater tank and water near the end of the recirculation loop flowing backward toward the hot water load and reducing the delivered water temperature. To prevent this from occurring, the Energy Code requires that a check valve or similar device be located between the recirculation pump and the water-heating equipment. See Figure 5-3: Mandatory Central Recirculation System Installation Requirements for illustration. **«»**

C. **Equipment for pump priming.** A hose bibb shall be installed between the pump and the water heating equipment. An isolation valve shall be installed between the hose bibb and the water heating equipment. This hose bibb is used for bleeding air out of the pump after pump replacement.

D. **Pump isolation valves.** Isolation valves shall be installed on both sides of the pump. These valves may be part of the flange that attaches the pump to the pipe. One of the isolation valves may be the same isolation valve as in Item C.

«» Commentary for Section 110.3(c)4C and D:

Repair labor costs can be reduced significantly by planning and designing for pump replacement when the pump fails. Provision for pump priming and pump isolation valves helps reduce maintenance costs.

To meet the pump priming equipment requirement, a hose bib must be installed between the pump and the water heater. In addition, an isolation valve must be installed between the hose bib and the water-heating equipment. This configuration will allow the flow from the water heater to be shut off, allowing the hose bib to be used for bleeding air out of the pump after pump replacement.

The requirement for the pump isolation valves will allow replacement of the pump without draining a large portion of the system, saving water. The isolation valves must be installed on both sides of the pump. These valves may be part of the flange that attaches the pump to the pipe. One of the isolation valves may be the same isolation valve as for pump priming. See Figure 5-3: Mandatory Central Recirculation System Installation Requirements for illustration. **«»**

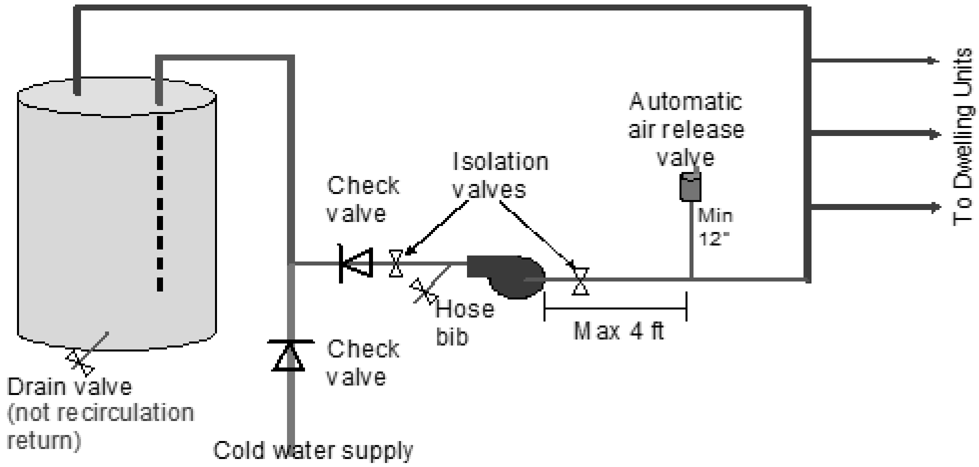
E. **Cold water supply and recirculation loop connection to hot water storage tank.** Storage water heaters and boilers shall be plumbed in accordance with the manufacturer's specifications The cold water piping and the recirculation loop piping shall not be connected to the hot water storage tank drain port.

F. **Cold water supply backflow prevention.** A check valve shall be installed on the cold water supply line between the hot water system and the next closest tee on the cold water supply line. The system shall comply with the expansion tank requirements as described in the California Plumbing Code Section 608.3.

«» Commentary for Section 110.3(c)4E and F:

The dynamic between the water in the heater and the cold water supply are similar to those in the recirculation loop. Thermosiphoning can occur on this side of this loop, just as it does on the recirculation side of the system. To prevent this, the Energy Code requires a check valve to be installed on the cold water supply line. The valve should be located between the hot water system and the next closest tee on the cold water supply line. The system must comply with the expansion tank requirements as described in the California Plumbing Code.

Figure 5-3: Mandatory Central Recirculation System Installation Requirements



Source: California Energy Commission

«»

5. **Service water heaters in state buildings.** Any newly constructed building constructed by the State shall derive its service water heating from a system that provides at least 60 percent of the energy needed for service water heating from site solar energy or recovered energy, per the statutory requirement of California Public Resources Code Section 25498.

   Exception to Section 110.3(c)5: Buildings for which the state architect determines that service water heating from site solar energy or recovered energy is economically or physically infeasible.

6. **Isolation valves.** Instantaneous water heaters with an input rating greater than 6.8 kBTU/hr (2 kW) shall have isolation valves on both the cold water supply and the hot water pipe leaving the water heater, and hose bibbs or other fittings on each valve for flushing the water heater when the valves are closed.

«» Commentary for Section 110.3(c)6:

All newly installed instantaneous water heaters (minimum input of 6.8 kBTU/hr) must have isolation valves on the incoming cold water supply and the hot water pipe leaving the water heater. Isolation valves assist in the flushing of the heat exchanger and help prolong the life of instantaneous water heaters. Instantaneous water heaters that have integrated drain ports for servicing are acceptable to meet the requirements of Section 110.3(c)6 and will not require additional isolation valves. «»

7. **Air-source** h**eat pump water heaters (HPWHs).** HPWH shall meet the following requirements:

   A. **Backup Heat.** Backup heat is required for systems when inlet air is unconditioned, unless the compressor cut-off temperature is below the Heating Winter Median of Extremes for the closest location listed in Table 2-3 from Reference Joint Appendix JA2. Backup heat may be internal or external to the HPWH.

«» Commentary for Section 110.3(c)7A:

Air-source Heat Pump Water Heaters (HPWHs) rely on the heat content of the surrounding air to produce high temperature refrigerant at the compressor outlet, which through a coil in the HPWH's storage volume generates hot water. System design and refrigerant type affect how low the ambient temperature can be while still extracting sufficient heat from the surrounding air. Below this minimum ambient temperature, the compressor is disabled, as it is no longer able to operate efficiently and begins to suffer rapid wear.

If the inlet air is unconditioned, there is a higher likelihood of the HPWH experiencing ambient temperature conditions below the compressor cutout temperature. If backup heat is not provided, then the HPWH will be unable to generate hot water.

In general, most R-134a based HPWH systems can only operate down to an ambient temperature of 40°F, while most R-744 (CO_2) based HPWH systems can operate down to temperatures below 0°F. For R-134a-based systems, the inclusion of backup heat is critical to provide adequate hot water. Most of California typically experiences winter temperatures below 40°F, and hot water demand is typically higher in the winter season.

However, if a HPWH is able to operate below the local Winter Median of Extremes, then the HPWH should be able to provide sufficient heat to generate hot water except in rare and brief extreme winter weather events. These systems therefore do not need backup heat.

If a HPWH does need backup heat, this backup heat can be external or internal to the HPWH system (such as the resistance heat elements built into the tank of consumer integrated HPWHs) and may use any permitted fuel (electric, natural gas, propane, etc.). **«»**

B. **Ventilation.** Consumer integrated HPWHs shall meet one of the ventilation requirements below. Minimum volume and opening size requirements shall be the sum of all HPWHs installed within the same space. Compressor capacity shall be determined using AHRI 540 Table 4 reference conditions for refrigeration with the "High" rating test point:

   ii. For HPWH installation without ducts, the installation space shall have a volume not less than the greater of 100 cubic feet per kBtu per hour of compressor capacity, or the minimum volume provided by the manufacturer for this method; or

iii. For HPWH installation without ducts, the installation space shall be vented to a communicating space via permanent openings, according to the following requirements:

   a. Communicating space shall meet the minimum volume of Section 110.3(c)7B2 above, minus the volume of the HPWH installation space; and

   b. Permanent openings shall consist of a single layer of fixed flat slat louvers or grilles, with a total minimum Net Free Area (NFA) the larger of 125 square inches plus 25 square inches per kBtu per hour of compressor capacity, or the minimum provided by the manufacturer for this method. The permanent openings shall be fully louvered doors or two openings of equal area, one in the upper half of the enclosure and one in the bottom half of the enclosure. The top of the upper opening must be 12 inches or less from the enclosure top and the bottom of the lower vent must be 12 inches or less from the enclosure bottom; or

iv. For HPWH installations with ducts, the following requirements shall be met:

   a. The space joined to the installation space via ducts shall meet the minimum volume of Section 110.3(c)7B2 above, minus the volume of the HPWH installation space; and

   b. All duct connections and building penetrations shall be sealed; and

   c. Exhaust air ducts and all ducts which cross pressure boundaries shall be insulated to minimum of R-6; and

   d. Where only the HPWH inlet or outlet is ducted, installation space shall include permanent openings that consist of a single layer of fixed flat slat louvers or grilles in the bottom half of the room, and/or a door undercut. With a ducted inlet, the minimum NFA shall be equal to the cross-sectional area of the duct. With a ducted exhaust, the minimum NFA shall be the larger of 20 square inches or the minimum NFA provided by the manufacturer for this method; and

   e. Where the inlet and outlet ducts both terminate within the same pressure boundary, airflow from the termination points shall be diverted away from each other.

   Note: Ducting only the inlet or the exhaust across the pressure boundary could interfere with balanced ventilation systems. This should be considered when specifying HPWH location and ventilation method.

«» Commentary for Section 110.3(c)7B:

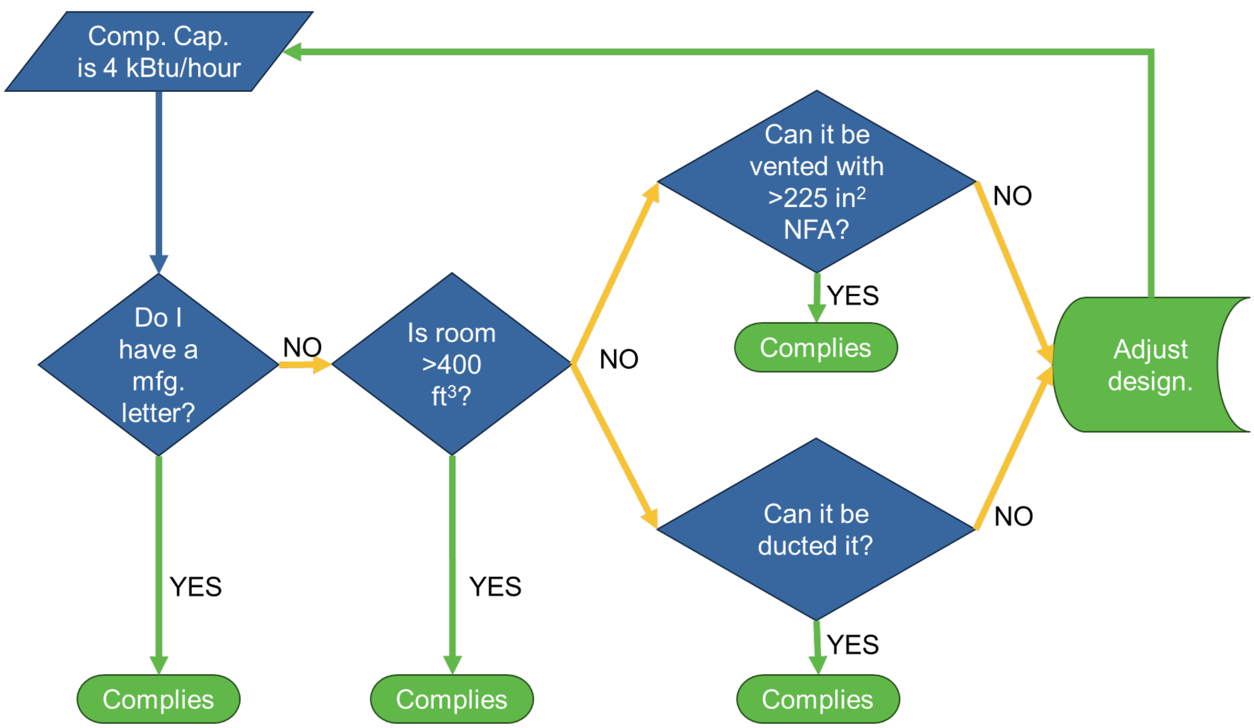
This section covers consumer-sized integrated air-source Heat Pump Water Heaters (referred to as "HPWHs" in this commentary). HPWHs rely on the heat content of the surrounding air to produce high temperature refrigerant at the compressor outlet, which through a coil in the HPWH's storage volume generates hot water. If the thermal resource of the air is not replenished through ventilation, the heat content and temperature of the ambient air will decrease until compressor cutout temperature is reached and the HPWH is unable to operate (see commentary for Section 110.3(c)7A).

Section 110.3(c)7B requires a minimum level of ventilation for HPWHs, regardless of building type and installation location. This can be provided in one of four ways:

1. Installation without ducts in a large room.
2. Installation without ducts in a smaller room that is vented.
3. Installation with ducts in any size room.
4. Installation using a method not covered above that is supported by the manufacturer.

Selection of ventilation method will depend on the building design and situation, but is up to the designer and installer. Below is a flow chart showing an example decision process with a HPWH with 4 kBtu/hour compressor capacity.

Figure 5-4: HPWH ventilation method selection process example, for a HPWH with a compressor capacity of 4 kBtu/hour.



Source: California Energy Commission

In this example, the process begins with checking whether the planned ventilation method is covered by code or is novel and must be certified by the manufacturer to the Energy Commission. It is highly recommended to include the certification documents with plan documents for reference by inspectors and in documentation provided to the building owner. If a certification is not required or obtained, then ventilation must be obtained by one of the other three covered methods. The simplest is the large room volume method. In this example, the minimum room volume would be 400 cubic feet. If 400 cubic feet is not available or not provided by the design, then either the 4 kBtu/hour HPWH's installation space must be vented with 225 square inches of net free area (NFA) or the HPWH must be ducted.

Ventilation grilles are affordable, can provide high NFA in small areas, and can be installed on doors and walls. Ducts can be very short and run through a closet wall, or even through the closet door. If none of these methods are feasible with the current equipment selection and design, then the design or equipment selection must be changed to comply with the requirements.

Requirements are the same for both interior and exterior installations, regardless of whether the HPWH uses conditioned or unconditioned inlet air, unless otherwise noted.

For all methods, if the manufacturer specifies a larger value for the same ventilation method, the manufacturer requirement becomes the minimum. For example, if installing a HPWH with a 4 kBtu/hour compressor, the minimum requirement for room volume with the large room method based on 100 cubic feet per kBtu/hour of compressor capacity is 400 cubic feet. However, if the manufacture installation manual specifies 700 cubic feet, the minimum requirement becomes 700 cubic feet.

As with all minimum requirements, the minimum values specified in Section 110.3(c)7B are minimums, and there are no specified maximums. More ventilation only improves HPWH performance. Designers and installers should consider providing increased ventilation, especially when there is very little cost difference, to the benefit of better customer satisfaction with the HPWH's performance.

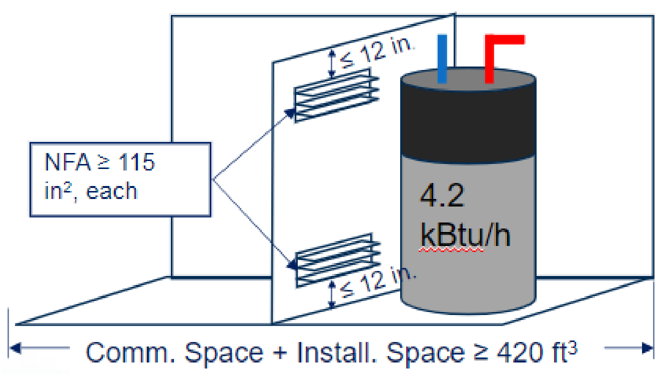
NFA is defined in Section 100.1(b) as the total open area in a vent through which air can freely flow. To calculate NFA for any vent with a series of equally sized louver gaps: (1) Measure the width of a louver gap and the thickness of the louver gap at the narrowest point. (2) Count the number of gaps. (3) Multiply the louver width by the louver thickness and by the number of gaps. The result is the NFA of the vent. For louvered closet doors, the area of the door undercut can be included in the total NFA for compliance. For example: A fully louvered door has 26 inch wide louvers. The gap between each louver is 3/16ths of an inch and there are 53 gaps. 26 x 0.1875 x 53 = 258.375 square inches. The door is also 30 inches wide and has a ¾ inch undercut. That undercut adds 22.5 square inches for a total NFA of 280.875 square inches. A closet with that door could accommodate a HPWH with a compressor capacity of 6.2 kBtu/hour.

When using the vented installation space or ducting methods, it is important to note that the communicating spaces joined to the installation space by the vents or ducts must be large enough that the combination of the installation space and the communicating space meet the minimum room volume requirements of Section 110.3(c)7B1.

When ducting HPWHs, care should be taken to consider the interactions with ventilation systems. For example, if a HPWH is installed inside the dwelling unit, but the exhaust is ducted and terminates outside the dwelling unit, the HPWH will negatively pressurize the dwelling unit whenever the HPWH is operating. This could result in increased infiltration from outside and adjacent dwelling units, and impact the operation of central and balanced ventilation systems. Ideally, HPWH air inlet and outlet termination points should be on the same side of the pressure boundary.

Figure 5-5: HPWH and Louvered Openings provides an example of a HPWH complying with Section 110.3(c)7B3.

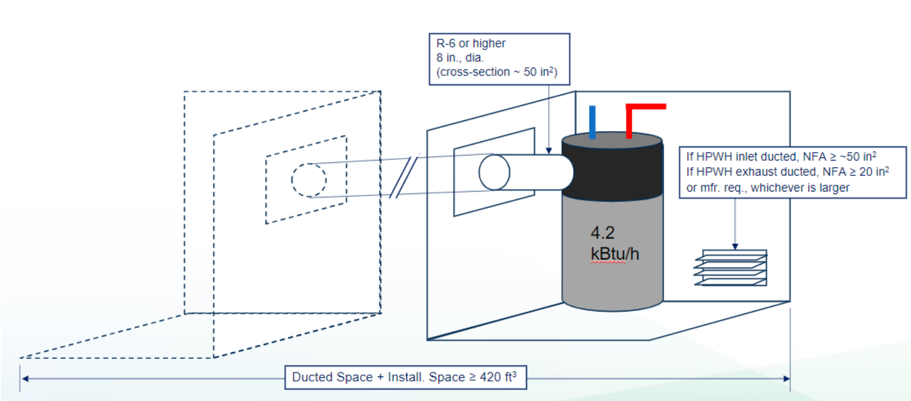
Figure 5-5: HPWH and Louvered Openings



Source: California Energy Commission

Figure 5-6: HPWH and Ducted Exhaust provides an example of a HPWH complying with Section 110.3(c)7B4.

Figure 5-6: HPWH and Ducted Exhaust



Source: California Energy Commission

«»

SECTION 160.4 – MANDATORY REQUIREMENTS FOR WATER HEATING SYSTEMS

(a) Water-heating recirculation loops serving multiple dwelling units shall meet the requirements of Section 110.3(c)4.

«» Commentary for Section 160.4(a):

A recirculation loop for multifamily buildings consists of a supply portion of larger diameter pipe connected to smaller diameter branches that serve multiple dwelling units, guest rooms, or common use area fixtures and a return portion that completes the loop back to the water-heating equipment. The large volume of water that is recirculated during high use periods creates situations that require the installation of certain controls and servicing mechanisms to optimize performance and allow for lower cost of maintenance and better energy performance. This section covers the mandatory requirements for system serving multiple dwelling units with recirculation loops. **«»**

(b) Solar water-heating systems and collectors shall be certified and rated by the Solar Rating and Certification Corporation (SRCC), the International Association of Plumbing and Mechanical Officials, Research and Testing (IAPMO R&T), or a listing agency that is approved by the Executive Director.

«» Commentary for Section 160.4(b):

For multifamily buildings, only systems with OG-100 collectors can be installed. For detailed instructions on installation of solar water heaters, refer to Reference Appendix RA4.4.20.

The database of Solar Rating and Certification Corporation (SRCC)-certified equipment is on the SRCC website at the following link: https://solar-rating.org/.

The database of IAPMO R&T-certified equipment is on the IAPMO R&T website at the following link: www.iapmort.org/Pages/SolarCertification.aspx. **«»**

(c) Instantaneous water heaters with an input rating greater than 6.8 kBTU/hr (2kW) shall meet the requirements of Section 110.3(c)6.

«» Commentary for Section 160.4(c):

All newly installed instantaneous water heaters (minimum input of 6.8 kBTU/hr) must have isolation valves on the incoming cold water supply and the hot water pipe leaving the water heater. Isolation valves assist in the flushing of the heat exchanger and help prolong the life of instantaneous water heaters. Instantaneous water heaters that have integrated drain ports for servicing are acceptable to meet the requirements of Section 110.3(c)6 and will not require additional isolation valves. **«»**

(d) Commercial boilers

1. Combustion air positive shut-off shall be provided on all newly installed boilers as follows:

   A. All boilers with an input capacity of 2.5 MMBtu/h (2,500,000 Btu/h) and above, in which the boiler is designed to operate with a nonpositive vent static pressure.

   B. All boilers where one stack serves two or more boilers with a total combined input capacity per stack of 2.5 MMBtu/h (2,500,000 Btu/h).

«» Commentary for Section 160.4(d)1:

Combustion air positive shutoff is a means of restricting air flow through a boiler combustion chamber during standby periods and is used to reduce standby heat loss. A flue damper and a vent damper are two examples of combustion air positive shut-off devices.

Installed dampers can be interlocked with the gas valve so that the damper closes and inhibits air flow through the heat transfer surfaces when the burner has cycled off, thus reducing standby losses. Natural draft boilers receive the most benefit from draft dampers because they have less resistance to airflow than forced draft boilers. Forced draft boilers rely on the driving force of the fan to push the combustion gases through an air path that has relatively higher resistance to flow than in a natural draft boiler. Positive shut off on a forced draft boiler is most important on systems with a tall stack height or multiple boiler systems sharing a common stack. **«»**

2. Boiler combustion air fans with motors 10 horsepower or larger shall meet one of the following for newly installed boilers:

   A. The fan motor shall be driven by a variable speed drive, or

   B. The fan motor shall include controls that limit the fan motor demand to no more than 30 percent of the total design wattage at 50 percent of design air volume.

«» Commentary for Section 160.4(d)2:

Electricity savings result from run time at part-load conditions. As the boiler firing rate decreases, the combustion air fan speed can be decreased. **«»**

3. Newly installed boilers with an input capacity 5 MMBtu/h (5,000,000 Btu/h) and greater shall maintain excess (stack-gas) oxygen concentrations at less than or equal to 5.0 percent by volume on a dry basis over firing rates of 20 percent to 100 percent. Combustion air volume shall be controlled with respect to firing rate or flue gas oxygen concentration. Use of a common gas and combustion air control linkage or jack shaft is prohibited.

   Exception to Section 160.4(d)3: Boilers with steady state full-load thermal combustion efficiency 90 percent or higher.

«» Commentary for Section 160.4(d)3:

One way to meet this requirement is with parallel position control. Boilers mix air with fuel (usually natural gas although sometimes diesel or oil) to supply oxygen during combustion. Stoichiometric combustion is the ideal air/fuel ratio where the mixing proportion is correct, the fuel is completely burned, and the oxygen is entirely consumed. Boilers operate most efficiently when the combustion air flow rate is slightly higher than the stoichiometric air-fuel ratio. However, common practice almost always relies on excess air to ensure complete combustion, avoid unburned fuel and potential explosion, and prevent soot and smoke in the exhaust. The drawbacks of excess air are increased stack heat loss and reduced combustion efficiency.

Parallel positioning controls optimize the combustion excess air based on the firing rate of the boiler to improve the combustion efficiency of the boiler, allowing the fuel supply valve and the combustion air damper to operate independently of each other. This system relies on preset fuel mapping (i.e. a pre-programmed combustion curve) to establish proper air damper positions (as a function of the fuel valve position) throughout the full range of burner fire rate.

Developing the combustion curve is a manual process. It is performed in the field with a flue-gas analyzer in the exhaust stack, determining the air damper positions as a function of the firing rate/fuel valve position. The combustion curve is developed at multiple points (firing rates), typically 10 to 25 points. Parallel positioning controls allow excess air to remain relatively low throughout the firing range of a burner. Maintaining low excess air levels at all firing rates provides significant fuel and cost savings while maintaining a safe margin of excess air to ensure complete combustion.

The other method of control of combustion air volume is by measuring the flue gas oxygen concentration to optimize combustion efficiency. This method of control is commonly called oxygen trim control. Oxygen trim control can also account for relative humidity of the combustion air. This control strategy relies on parallel positioning hardware and software as the basis but takes it a step further to allow operation closer to stoichiometric conditions. Oxygen trim control converts parallel positioning to a closed-loop control configuration with the addition of an exhaust gas analyzer and proportional-integral-derivative (PID) controller. This strategy continuously measures the oxygen content in the flue gas and adjusts the combustion air flow, thus continually tuning the air-fuel mixture. «»

(e) Pipe Insulation

All piping for multifamily domestic hot water systems shall be insulated and meet the applicable requirements 1 through 3 below:

1. **General Requirements.**

   A. The first 8 feet of inlet cold water piping from the storage tanks, including piping between a storage tank and a heat trap shall be insulated.

   B. Insulation on the piping and domestic hot water system appurtenances shall be continuous.

C. Pipe supports, hangers, and pipe clamps shall be attached on the outside of rigid pipe insulation to prevent thermal bridges.

D. All pipe insulation seams shall be sealed.

E. Insulation for pipe elbows shall be mitered, preformed, or site fabricated with PVC covers.

F. Insulation for tees shall be notched, preformed, or site fabricated with PVC covers.

G. Extended stem isolation valves shall be installed.

H. All plumbing appurtenances on hot water piping from a heating source to heating plant, at the heating plant, and distribution supply and return piping shall be insulated to meet the following requirements:

i. Where the outer diameter of the appurtenance is less than the outer diameter of the insulated pipe that it is attached to, the appurtenance shall be insulated flush with the insulation surrounding the pipe.

ii. Where the outer diameter of the appurtenance is greater than the outer diameter of the insulated pipe that it is attached to, the appurtenance shall be insulated with a minimum thickness of 1 inch.

iii. The insulation shall be removable and re-installable to ensure maintenance or replacement services can be completed.

iv. Valves shall be fully functional without impediment from the insulation.

«» Commentary for Section 160.4(e)1:

This section specifies the insulation requirements for piping in multifamily domestic hot water systems to ensure continuous insulation and minimize pipe heat losses as shown below. Proper insulation significantly reduces energy consumption at the heating plant and improves hot water delivery performance.

Figure 5-7: Continuous Pipe Insulation

Source: California Energy Commission, TRC Companies, Inc.

Previously, there was no explicit code language detailing the insulation requirements for various piping components such as valves, elbows, and tees. As a result, these components were often left uninsulated, leading to heat loss through convection to the surrounding air. The detailed requirements in this section address this issue by mandating that all parts of the piping system be insulated, including the first 8 feet of inlet cold water piping, and ensuring that insulation is continuous and sealed at all seams.

Additional measures include attaching pipe supports, hangers, and clamps on the outside of rigid pipe insulation to prevent direct metal (copper pipe) to metal (steel support/hanger) contact causing highly conductive heat flow paths known as thermal bridges as shown in Figure 5-8: Various types of hot water plumbing appurtenances. Also requiring that insulation for elbows and tees be mitered, preformed, or site-fabricated with PVC covers, the use of extended stem isolation valves and properly insulated plumbing appurtenances further enhance the system's thermal efficiency. These measures are essential for maintaining the integrity of the insulation and ensuring that the system operates efficiently.

Figure 5-8: Various types of hot water plumbing appurtenances

Source: California Energy Commission, TRC Companies, Inc.

It is important that the insulation be removable and re-installable to facilitate maintenance and replacement of valves and other piping components, and that valves (e.g. isolation valves, y strainers) remain fully functional without being impeded by the insulation. By following these requirements, installation and maintenance contractors can ensure that the hot water distribution system in multifamily buildings operates efficiently and with minimal energy loss over the life of the system.

A new definition for domestic hot water (DHW) appurtenances has been added to Section 100.1. DHW appurtenances include components such as valves, fittings, and other devices associated with the hot water piping system. Understanding this definition is critical for ensuring all relevant parts of the system are properly insulated according to the code requirements. Refer to section 100.1 for more detailed information. «»

2. **Insulation Thickness.** All piping for multifamily domestic hot water systems shall meet the insulation thickness requirements specified in Table 160.4-A.

   A. For insulation conductivity in the range shown in Table 160.4-A for the applicable fluid temperature range, the insulation shall have the applicable minimum thickness or R-value shown in Table 160.4-A.

   B. if the insulation conductivity falls outside the range provided in Table 160.4-A applicable fluid temperature range, the insulation shall meet a minimum R-value as indicated in Table 160.4-A. Or, it can have a thickness determined using Equation 160.4-A"

$$T = PR\left[\left(1+\frac{t}{PR}\right)^{\frac{K}{k}} - 1\right]$$

(Equation 160.4-A)

WHERE:

T = Minimum insulation thickness for material with conductivity K, inches.

PR = Pipe actual outside radius, inches.

t = Insulation thickness from TABLE 160.4-A, inches.

K = Conductivity of alternate material at the mean rating temperature indicated in TABLE 160.4-A for the applicable fluid temperature range, in Btu-inch per hour per square foot per °F.

k = The lower value of the conductivity range listed in TABLE 160.4-A for the applicable fluid temperature range, Btu-inch per hour per square foot per °F.

   C. Insulation conductivity shall be determined in accordance with ASTM C335 at the mean temperature listed in Table 160.4-A, and shall be rounded to the nearest 1/100 Btu-inch per hour per square foot per °F.

Exception 1 to Section 160.4(e): Piping that penetrates framing members shall not be required to have pipe insulation for the distance of the framing penetration. Piping that penetrates metal framing shall use grommets, plugs, wrapping or other insulating material to ensure that no contact is made with the metal framing. Insulation shall abut securely against all framing members.

Exception 2 to Section 160.4(e): Piping installed in interior or exterior walls shall not be required to have pipe insulation if all of the requirements are met for compliance with quality insulation installation (QII) as specified in Reference Residential Appendix RA3.5.

Exception 3 to Section 160.4(e): Piping surrounded with a minimum of 1 inch of wall insulation, 2 inches of crawl space insulation or 4 inches of attic insulation shall not be required to have pipe insulation.

TABLE 160.4-A PIPE INSULATION THICKNESS – Multifamily Domestic Hot Water Systems

Fluid Operating Temperature Range (°F)	Insulation Conductivity (Btu·in/h·ft² °F)	Insulation Conductivity Mean Rating Temp. (°F)	Nominal Pipe Diameter (in inches) < 1	Nominal Pipe Diameter (in inches) 1 to <1.5	Nominal Pipe Diameter (in inches) 1.5 to < 4	Nominal Pipe Diameter (in inches) 4 to < 8	Nominal Pipe Diameter (in inches) 8 and larger
105-140[1]	0.22-0.28	100	1.0 (R 7.7)	1.5 (R 12.5)	2.0 (R 16)	2.0 (R 12.5)	2.0 (R 11)

Footnote to TABLE 160.4-A:

1. Multifamily and hotel/motel domestic hot water systems with water temperature above 140°F shall use the row in table 120.3-A for the applicable water temperature.

«» Commentary for Section 160.4(e)2:

Most piping conveying mechanically heated or chilled fluids for space conditioning or water-heating must be insulated. The required thickness of piping insulation depends on the temperature of the fluid passing through the pipe, the pipe diameter, the function of the pipe within the system, and the thermal conductivity of the insulation. Table 160.4-A specifies the requirements in terms of inches of insulation with conductivity within a specific range. These conductivities are typical for fiberglass or foam pipe insulation. «»

3. **Insulation Protection.** Pipe Insulation shall be protected from damage due to sunlight, moisture, equipment maintenance and wind. Protection shall, at minimum, include the following:

   A. Pipe and appurtenance insulation exposed to weather shall be protected by a cover suitable for outdoor service. The cover shall be water retardant and provide shielding from solar radiation that can cause degradation of the material. Appurtenance insulation covers shall be removable and able to be reinstalled. Adhesive tape shall not be used to provide this protection.

   B. Pipe insulation covering chilled water piping and refrigerant suction piping located outside the conditioned space shall include, or be protected by, a Class I or Class II vapor retarder. All penetrations and joints shall be sealed.

   C. Pipe insulation buried below grade must be installed in a waterproof and noncrushable casing or sleeve.

«» Commentary for Section 160.4(e)3:

All piping insulation is required to be protected from damage from environmental elements. If hot water piping insulation is exposed to weather, it must be protected from physical damage, ultraviolet light deterioration, and moisture. Insulation is typically protected by aluminum, sheet metal, painted canvas, plastic cover, or a water-retardant coating that shields from solar radiation. Adhesive tape should not be used as insulation cover because removal of the tape will damage the integrity of the original insulation during preventive maintenance.

All DHW pipes that are buried below grade must be installed in a waterproof and non-crushable casing or sleeve. **«»**

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8 and 25943, Public Resources Code.

SECTION 170.1 – PERFORMANCE APPROACH

A building complies with the performance approach if the energy consumption calculated for the proposed design building is no greater than the energy budget calculated for the standard design building using Commission-certified compliance software as specified by Sections 10-109, 10-116 and the Alternative Calculation Method Reference Manual.

(a) Energy budget. The Energy budget is expressed in terms of long-term system cost (LSC) and source energy:

1. **Long-term system cost (LSC).** The LSC energy budget is determined by applying the mandatory and prescriptive requirements of the standard design to the proposed design building and has two components, the Efficiency LSC and the Total LSC.
   - A. The Efficiency LSC energy is the sum of the LSC energy for space-conditioning, water heating, mechanical ventilation, lighting and the self-utilization credit.
   - B. The Total LSC energy is the sum of the Efficiency LSC energy and LSC energy from the photovoltaic system, battery energy storage systems (BESS), and demand flexibility.
2. **Source energy.** The source energy budget is determined by applying the mandatory and prescriptive requirements of the standard design, except with a consumer gas or propane water heater, to the proposed design building.

«» Commentary for Section 170.1(a):

The standard design system for the performance approach are described in the *2025 Nonresidential and Multifamily Alternative Calculation Method Reference Manual*.

Systems designed with other options are allowed, and some of them are subject to HERS field verification.

Joint Appendix 14 Qualification Requirements for Central Heat Pump Water Heater Systems sets the requirements for central HPWH systems in multifamily buildings using the performance approach.

JA 14.3 requires that central HPWH equipment shall be certified by the Energy Commission, which includes submitting required performance data to the Commission. The process of data submission can be found on the Energy Commission website, https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment.

Each basic model that is claimed on the performance certificate of compliance must be certified. Manufacturers must determine performance data for each basic model, which means all units of a given type of product manufactured by one manufacturer, have the same primary energy sources, and have essentially identical electrical, physical, and functional (hydraulic) characteristics that affect energy consumption, energy efficiency, water consumption, or water efficiency. JA 14.3 further details the acceptable methods to determine performance data and the data reporting requirement:

1. When simulation is used, an alternative efficiency determination method (AEDM) as described in 10 CFR part 429.70(a)-(c) must be used to generate performance data required in JA 14.3.2.
2. When lab testing is used, testing must be conducted as described in Appendix E to Subpart G of 10 CFR Part 431 for each of the test conditions described in JA14.3.3.

JA 14.4 design condition documentation requirements are applicable for central HPWH designs using prescriptive and performance approach.

When the proposed DHW system is a central DHW system that uses electricity as the primary fuel source, the standard design is a central HPWH system that is based on the prescriptive requirement of a central HPWH in Section 170.2(d)2. The standard design central HPWH system has a recirculation system with single-pass compressors with primary storage tank that is decoupled from the recirculation loop storage tank.

For Central HPWH design, refer to the 2025 Nonresidential and Multifamily Alternative Calculation Method Reference Manual.

JA 13 provides qualification requirements for HPWH demand management systems. Qualifying HPWHs can optimize operation to reduce normal water heater operation during on-peak periods by biasing operation before the peak period. Future opportunities include overheating the storage tank above setpoint before the peak period, thus improving the electrical load profile of these systems. The compliance software includes a credit for this type of HPWH. JA13-certified HPWHs, which must have a mixing valve installed to prevent any scalding risks, are listed on the Energy Commission's website, https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment/ja13.

For water-heating systems serving individual dwelling units, any type or number of water heaters supported by the software can be installed, but the standard design is a single HPWH. The calculated energy use of the proposed design is compared to the standard design energy budget, based on either a single gas instantaneous water heater for gas water heaters with a standard distribution system or a HPWH with compact distribution system and DWHR, where applicable. Individual gas or propane water heaters must also meet the electric-ready requirements of section 160.9(e).

The compliance software does not include a hot water recirculation pump for the standard distribution system serving a single dwelling unit and does not allow credit for any additional DHW design features.

Alternative distribution systems are compared to the standard design by using distribution system multipliers, which effectively rate alternative options. Table 5-2: Applicability of Distribution Systems Options lists all the recognized distribution systems that can be used in the performance approach with the assigned distribution multiplier. The standard distribution system has a multiplier of 1.0. Distribution systems with a multiplier less than 1.0 represent an energy credit, while distribution systems with a multiplier greater than 1.0 are an energy penalty. For example, pipe insulation with HERS inspection required (PIC-H) has a multiplier of 0.8. That means that it is modeled at 20 percent less distribution loss than the standard distribution system.

Table 5-2: Applicability of Distribution Systems Options

Distribution System Types	Assigned Distribution System Multiplier	Systems Serving a Single Dwelling Unit	Central Recirculation Systems Serving Multiple Dwelling Units
No HERS Inspection Required			
Trunk and Branch -Standard (STD)	1.0	Yes	Yes
Parallel Piping (PP)	1.1	Yes	
Point of Use (POU)	0.3	Yes	
Recirculation: Nondemand Control Options (R-ND)	9.8	Yes	
Recirculation with Manual Demand Control (R-Dmn)	1.75	Yes	
Recirculation with Motion Sensor Demand Control (R-DAuto)	2.6	Yes	
HERS Inspection Required			
Pipe Insulation (PIC-H)	0.85	Yes	Yes
Parallel Piping with 5’ maximum length (PP-H)	1	Yes	
Recirculation with Manual Demand Control (R-DRmc-H)	1.6	Yes	
Recirculation with Sensor Demand Control (RDRsc-H)	2.4	Yes	

Source: California Energy Commission

Solar water-heating systems with a solar fraction higher than the specified prescriptive minimum can be used as a tradeoff under the performance approach. Users now input collector and system component specifications to calculate a corresponding solar fraction for the proposed system.

Buildings with uncontrolled recirculation systems will need other efficiency features to offset the less efficient method.

Dual-loop recirculation systems are a performance option. In a dual loop recirculation system, each recirculation branch loop serves roughly half of the dwelling units. Pipe diameters can be downsized in a dual-loop system compared to a single-loop system serving all dwelling units while still following California Plumbing Code requirements. The total pipe surface area is effectively reduced with smaller distribution pipe diameters, even though total pipe length remains similar to that of a single-loop system.

For example, for simple building footprints, locating the water-heating equipment at the center of the building footprint rather than at one end of the building helps minimize the pipe length. If a water-heating system serves several building sections, the water-heating equipment would preferably nest between these sections. **«»**

(b) Compliance demonstration requirements for performance standards.

1. Certificate of Compliance and Application for a Building Permit. The application for a building permit shall include documentation pursuant to Sections 10-103(a)1 and 10-103(a)2 that demonstrates, using an approved calculation method, that the building has been designed so that its source energy and LSC energy consumption do not exceed the standard design energy budgets for the applicable climate zone.
2. Field verification of individual dwelling unit systems. When performance of installed features, materials, components, manufactured devices or systems above the minimum specified in Section 170.2 is necessary for the building to comply with Section 170.1, or is necessary to achieve a more stringent local ordinance, field verification shall be performed in accordance with the applicable requirements in the following subsections, and the results of the verification(s) shall be documented on applicable Certificates of Installation pursuant to Section 10-103(a)3 and applicable Certificates of Verification pursuant to Section 10-103(a)5.

   D. Thermal Balancing Valve. When performance compliance requires installation of thermal balancing valves with variable speed circulation pump(s), the installation shall meet the procedures specified in Reference Residential Appendix RA4.4.3.

«» Commentary for Section 170.1(b)1.D:

RA4.4.3 provides qualification requirements for thermostatic balancing valves (TBV) installed in multi-riser systems. Qualifying multi-riser hot water distribution systems benefit from a performance credit and also benefit from lower first costs and better hot water delivery performance than systems with manual balancing valves, which are often not balanced at all or poorly balanced. Poorly balanced multi-riser systems are less efficient than well balanced systems, while un-balanced multi-riser systems suffer from additional problems with hot water system performance due to significant variance of temperatures within the distribution system which cause complaints, health and safety risks.

A key qualification requirement is that the total length of each section of return piping cannot exceed 160 feet. This qualification requirement is related to the construction of certain TBV which cannot close fully and have high minimum flow values. The valve flow coefficient (Cv) characterizes this aspect of the valve performance and relates valve pressure drop to flow rate. Several product manufacturers report minimum and maximum Cv values for their valves. Although the code language does not limit qualifying TBV products based on their Cv values, designers should consider these reported Cv values when selecting TBV.

The qualification requirements also specify a circulator pump control method and hot water system startup procedure that is required to claim the performance credit. The control method and procedures are required to ensure that the actual temperatures achieved by the thermostatic balancing valves do not exceed 120 °F as verified at the last riser, resulting in energy savings. «»

SECTION 170.2 – PRESCRIPTIVE APPROACH

Multifamily buildings, including both dwelling units and common use areas, that comply with the prescriptive standards shall be designed, constructed and equipped to meet all of the requirements for the appropriate climate zone shown in Table 170.2-A. In Table 170.2-A, NA (not allowed) means that feature is not permitted in a particular climate zone and NR (no requirement) means that there is no prescriptive requirement for that feature in a particular climate zone. Installed components shall meet the following requirements:

TABLE 170.2-K MECHANICAL COMPONENT PACKAGE – Multifamily Standard Building Design

Component	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Water Heating - All Buildings System Shall meet Section 170.2(d)	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ

(d) Domestic Hot Water Systems Water-heating systems shall meet the applicable requirements of 1 or 2 below:

1. **Individual Systems.** For systems serving individual dwelling units, the water-heating system shall meet the requirement of either A, or B, or shall meet the performance compliance requirements of Section 170.1. For recirculation distribution systems serving individual dwelling units, only demand recirculation systems with manual on/off control as specified in the Reference Appendix RA4.4.9 shall be used.

«» Commentary for Section 170.2(d)1:

Installation of a demand recirculation control to minimize pump operation and heat loss from pipes is a prescriptive requirement when a recirculation distribution system is used to serve individual dwelling units. This requirement is applicable regardless of fuel source.

A demand-control recirculation system uses brief pump operation in response to a hot water demand signal (manual push button) to circulate hot water through the recirculation loop. The system must have a temperature sensor to turn off the pump when the sensed temperature rises. This sensor is typically located at the most remote point of the recirculation loop, but some water heaters have internal temperature sensors. «»

A. A single 240 volt heat pump water heater. In addition, meet the following:

   i. A compact hot water distribution system as specified in Reference Appendix RA4.4.6 in climate zones 1 and 16; and

   ii. A drain water heat recovery system that is field verified as specified in the Reference Appendix RA3.6.9 in Climate Zone 16.

«» Commentary for Section 170.2(d)1A:

There are several types of water heaters for multifamily buildings, as described below. The most common water heaters serving individual dwelling units are consumer gas storage, instantaneous gas water heaters, and heat pump water heaters. To comply with the Energy Code using either the prescriptive or performance approach, the water heater must meet the federal or the California Appliance Efficiency Regulations (Title 20) or both. Central gas or propane water heaters must also meet the electric-ready requirements of section 160.9(f), and individual gas or propane water heaters must also meet the electric-ready requirements of 160.9(e). Approved water heaters can be found in the Modernized Appliance Efficiency Database Systems (MAEDBS) found here, https://cacertappliances.energy.ca.gov/Pages/Search/AdvancedSearch.aspx.

An HPWH is an electric water heater that works like an air conditioner cycle in reverse. It uses a compressor to transfer heat from the surrounding air to the water tank. It includes all necessary auxiliary equipment such as fans, storage tanks, pumps, or controls. Typically, HPWHs include backup electric resistance elements to ensure hot water delivery when the air temperature is too cold, or the hot water demand is too high. A few models use larger compressors to avoid the need for resistance elements.

The performance of HPWHs depends heavily on air temperature because they rely on extracting heat from the air. Climate conditions and different installation locations, such as a garage or a vented outdoor closet, affect performance. In addition to air temperature sensitivity, HPWH performance is affected by cold water inlet temperatures, as introducing and mixing of inlet water during larger draws may trigger second stage electric resistance heating in the tank.

There are two basic configurations of the storage tank and heat pump of an HPWH system.

1. Unitary heat pump with integrated storage (commonly used for individual systems): A simple and readily available solution is unitary heat pump with integrated storage. These units are single-package and resemble the size and form of traditional residential tank-type gas water heaters. Most integrated heat pumps are sized for individual or multiple dwelling unit applications.
2. Split heat pump with separate storage tank(s): Split heat pumps with separate storage tanks are larger capacity products suitable for multifamily central HPWH applications. These heat pumps range in heating capacity from 15,000 Btu/hr to 250,000 Btu/hr.

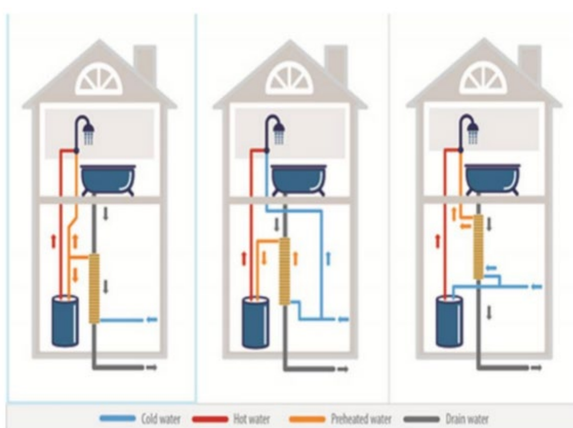
The intent of a compact hot water distribution system design is to reduce the size of the plumbing layout by bringing the water heater closer to hot water use points than in typical trunk-and-branch systems. Qualification for both credits is based on using a plan view, straight-line measurement to calculate a weighted distance to key hot water use points including the master bath, kitchen, and remaining farthest hot water fixture from the water heater, such as clothes washing. (In some multifamily situations, there may not be another use point beyond the master bath and kitchen, resulting in the third term being ignored). If this resulting weighted distance is less than a qualification distance (dependent on floor area, number of stories in the dwelling unit, and number of water heaters), the plan is eligible for the Basic Credit. The Basic Credit does not require any further verification steps to secure the compliance credit.

Drain water heat recovery (DWHR) is a technology that captures shower waste heat from the drain line. DWHR devices are counter flow heat exchangers, with cold water entering the building on one side of the device and hot drain water exiting the building on the other.

A DHWR device uses the reclaimed heat to preheat potable cold water that is then delivered either to the shower or the water heater. The device can be installed in either an equal flow configuration (with preheated water being routed to the water heater and the shower) or an unequal flow configuration (preheated water directed to either the water heater or shower). Figure 5-9: The Three Plumbing Configurations of DWHR Installation (From Left to Right: Equal Flow, Unequal Flow - Water Heater, Unequal Flow - Fixture) schematically shows the three installation configurations. The energy harvested from a DWHR device is maximized in an equal-flow configuration. They are available in both vertical design configurations, as shown in Figure 5-9: The Three Plumbing Configurations of DWHR Installation (From Left to Right: Equal Flow, Unequal Flow - Water Heater, Unequal Flow - Fixture), and in horizontal configurations. The two forms each have advantages and disadvantages, which should be evaluated for each potential installation.

To use these systems to comply with Energy Code, the design and installation must be HERS-verified and meet the Reference Appendix RA4.4.21 requirements for buildings with three stories or fewer and be field verified for buildings with four stories or more.

Figure 5-9: The Three Plumbing Configurations of DWHR Installation (From Left to Right: Equal Flow, Unequal Flow - Water Heater, Unequal Flow - Fixture)



Source: Frontier Energy

«»

B. A single heat pump water heater that meets the requirements of NEEA Advanced Water Heater Specification Tier 3 or higher. In addition, for climate zone 16, a drain water heat recovery system that is field verified as specified in Reference Appendix RA3.6.9.

«» Commentary for Section 170.2(d)1B:

The Northwest Energy Efficiency Alliance (NEEA) Advanced Water Heater Specification (AWHS) was developed to address critical performance and comfort issues of individual HPWH in colder climates. The NEEA AWHS incorporates tiers of various product performances and configurations. A NEEA Tier 3 or higher HPWH can be used to meet the prescriptive requirements. «»

Exception 1 to Section 170.2(d)1: Multifamily buildings four habitable stories or greater may install a gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank.

«» Commentary for Section 170.2(d)1 Exception 1: Instantaneous water heaters, commonly referred to as tankless or on-demand, heat water using natural gas, electricity, or propane. These units do not have a tank for storing heated water, but instead use a sensor that detects the flow of water over the heat exchanger that initiates the heating element (typical volumes around 0.5 gallons). Instantaneous units can deliver water at a controlled temperature of less than 180ºF. The input rating for gas instantaneous water heaters ranges between 50,000 and 200,000 BTU per hour (at least 4,000 BTU per hour per gallon of stored water) with a storage capacity of less than two gallons.

To comply prescriptively with the Energy Code, a user can choose to install a gas or propane instantaneous water heater serving individual dwelling units in multifamily buildings with four or more habitable stories that meets the minimum efficiency requirements of California's Title 20 Appliance Efficiency Regulations. The equipment is limited to a maximum input of 200,000 BTU per hour and no storage tank. Approved water heaters can be found in the MAEDBS found here, https://cacertappliances.energy.ca.gov/Pages/Search/AdvancedSearch.aspx. «»

Exception 2 to Section 170.2(d)1: A 120V HPWH may be installed in place of a 240V HPWH for new dwelling units with one bedroom or less.

2. **Central Systems.** For systems serving multiple dwelling units, the water-heating system shall meet the applicable requirement of A through F, or shall meet the performance compliance requirements of Section 170.1:

   A. For heat pump water-heating systems serving multiple dwelling units, the water-heating system shall be installed according to the manufacturer's design and installation guidelines and meet the following requirements, or meet the requirements of NEEA Advanced Water Heater Specification for commercial heat pump water heater Tier 2 or higher:

«» Commentary for Section 170.2(d)2A:

A central system is any one water heater serving two or more dwelling units. The Northwest Energy Efficiency Alliance (NEEA) Advanced Water Heater Specification (AWHS) was developed to address critical performance and comfort issues of individual HPWH in colder climates. The NEEA AWHS incorporates tiers of various product performances and configurations. A NEEA AWHS for commercial HPWHs Tier 2 or higher can be used to meet the prescriptive requirements. HPWHs configured as multi-pass systems can either comply prescriptively, if meeting the requirements of NEEA Tier 2 or higher, or using the performance approach.«»

i. The primary heat pump water heater shall be a single-pass heat pump water heater.

«» Commentary for Section 170.2(d)2Ai:

Heat pump water heaters can be configured into either single-pass or multi-pass systems, with single-pass systems heating water once to the desired storage temperature and multi-pass systems heating water multiple times until the target temperature is achieved. Single-pass configurations, typically drawing cold water from the bottom of the storage tank and delivering hot water at the desired temperature to the top of the storage tank, result in highly stratified tanks and are usually more efficient than multi-pass configurations. Single-pass is required for CO2-based HPWHs due to refrigerant characteristics. In multi-pass piping configuration, the HPWH draws water from the bottom third of the tank, incrementally heating the hot water, typically 5 -10°F at each pass, resulting in less tank stratification. Equipment using refrigerants such as R513a, R134s and R410a can accommodate either single-pass or multi-pass configurations due to their ability to handle a wide range of temperature rise. Designers must carefully configure plumbing systems to maintain optimal HPWH operation depending on the selected model, ensuring efficiency and performance in diverse applications.

To use the prescriptive approach, the primary HPWH must be configured as a single-pass system. «»

ii. The hot water return from the recirculation loop shall connect to a recirculation loop tank and shall not directly connect to the primary heat pump water heater inlet or the primary thermal storage tanks.

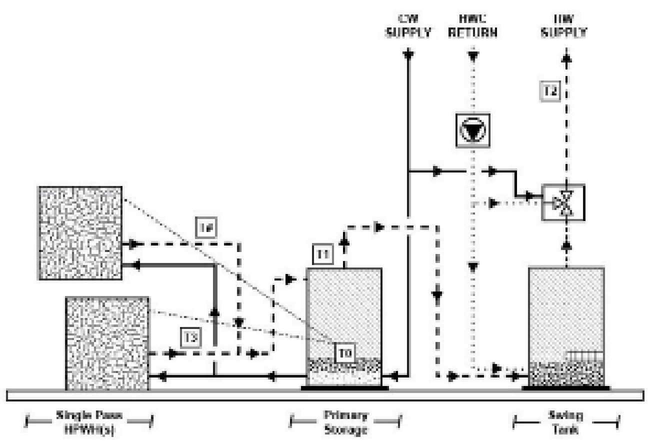
«» Commentary for Section 170.2(d)2Aii:

To use this prescriptive approach, the central HPWH system design must use a temperature maintenance system that is decoupled from the primary system to meet the DHW temperature maintenance load. A temperature maintenance system consists of a recirculation pump, a storage tank (the loop tank), and a temperature maintenance heat source. The hot water return from the recirculation loop must connect to the loop tank and cannot connect directly to the primary storage tanks or the inlet of the primary HPWH equipment. This design approach can prioritize delivering cool water to the HPWHs for peak performance while maintaining thermal stratification in the primary tanks.

For HPWHs, most single-pass heat pumps do not operate well with warm incoming water temperatures (above approximately 110°F). A critical design feature of central HPWH systems with hot water circulation systems is separation of the two distinct building DHW loads. The first load is primary water heating. The second is temperature maintenance of recirculating hot water due to heat loss in the distribution loop. The HPWHs in the primary loop is referred to as the primary HPWH. In separating the loads, the DHW system design can prioritize delivering cool water to the primary HPWHs for peak performance while maintaining thermal stratification in the primary tanks. Separating primary heating load and temperature maintenance load can improve equipment efficiency, lessen heating equipment cycling, and yield better system reliability.

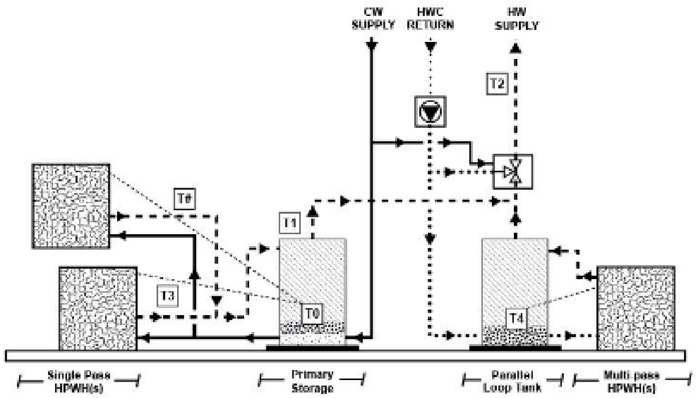
To separate the two loads, a key design practice is to use a temperature maintenance system separated from the thermally stratified primary storage volume. The NEEA AWHS specifies two different types of temperature maintenance systems. First, a swing tank design which uses a loop tank piped in series with the primary storage, illustrated in Figure 5-10: Single-Pass HPWH (s) With Swing Tank. Second, a parallel loop tank design which uses a loop tank piped in parallel with the primary storage, illustrated in Figure 5-11: Single-Pass HPWH (s) with Parallel Loop Tank.

Figure 5-10: Single-Pass HPWH (s) With Swing Tank



Source: Ecotope

Figure 5-11: Single-Pass HPWH (s) with Parallel Loop Tank



Source: Ecotope

For system design without a recirculation system, the hot water heater(s) must be located close to each hot water point-of-use such that a recirculation loop is not needed. This strategy is most easily applicable to buildings with up to three stories where the designer can locate the system on the roof and feed hot water to the dwelling units below with straight hot water piping. «»

iii. The fuel source for the recirculation loop tank shall be electricity.

iv. The primary storage tank temperature setpoint shall be at least 135°F.

v. The recirculation loop tank temperature setpoint shall be at least 10°F lower than the primary thermal storage tank temperature setpoint.

«» Commentary for Section 170.2(d)2Aiv and v:

To effectively increase storage capacity and leverage the load shifting capability of hot water storage, the prescriptive approach requires the primary hot water storage temperature must be at least 135°F. In addition, the loop tank temperature setpoint must be controlled to be at least 10°F lower than the primary thermal storage tank setpoint. Since the loop tank heater, which could be an electric resistance heater or a multi-pass HPWH, operates less efficiently than the primary HPWH, lowered loop tank setpoint can ensure that the loop heater is engaged only when additional heat is needed for temperature maintenance purposes. «»

vi. The minimum heat pump water heater compressor cut-off temperature shall be equal to or lower than 40°F ambient air temperature.

«» Commentary for Section 170.2(d)2vi:

Operation of an HPWH compressor must be able to meet all control requirements stated above when the ambient air temperature is equal to or higher than 40°F. «»

vii. Design documentation shall be provided in accordance with JA14.4.

«» Commentary for Section 170.2(d)2Avii:

In addition to the plumbing configuration and control requirements, the prescriptive approach requires presentation of specified information in the design documentation. JA 14.4 specifies the following information must be included.

1. Minimum and maximum ambient air temperature designed for the HPWH to operate. HPWH performance is impacted by the ambient air conditions. Designers must consider the climate conditions and where to locate the HPWHs for equipment selection.
2. Minimum and maximum cold-water temperature.
3. Minimum and maximum building demand at design draw and recovery conditions and duration. Designers must consider these parameters to properly size for HPWH and storage tank, regardless of if load shifting is considered.
4. Recirculation loop heat loss: designers must determine the recirculation loop heat loss to properly size the loop tank and determine whether a heater is needed. **«»**

B. For gas or propane systems serving multiple dwelling units, the water-heating system that includes the following components shall be installed:

i. For Climate Zones 1 through 9, gas service water-heating systems with a total installed gas water-heating input capacity of 1 MMBtu/h or greater shall have gas service water-heating equipment with a minimum thermal efficiency of 90 percent. Multiple units are allowed to meet this requirement with an input capacity-weighted average of at least 90 percent.

Exception 1 to Section 170.2(d)Bi: Individual gas water heaters with input capacity at or below 100,000 Btu/h shall not be included in the calculations of the total system input or total system efficiency.

Exception 2 to Section 170.2(d)Bi: If 25 percent of the annual water-heating requirement is provided by site-solar energy or site-recovered energy.

«» Commentary for Section 170.2(d)Bi:

To use the prescriptive path with gas or propane central water-heating systems, water heaters with input capacity at or greater than 1 MMBtu/h must have a minimum thermal efficiency of 90 percent. When multiple water heaters are used in the system, a capacity weighted average is used to determine the minimum thermal efficiency. Water heaters with a lower capacity rate are exempt from the thermal efficiency requirement. Additional exemption is allowed when 25 percent or more of the annual water-heating load is met by an on-site solar system or site-recovered energy. **«»**

ii. A solar water-heating system meeting the installation criteria specified in Reference Residential Appendix RA4 and with a minimum solar savings fraction of either a. or b. below:

a. 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; or

b. A minimum solar savings fraction of 0.15 in Climate Zones 1 through 9 or a minimum solar savings fraction of 0.30 in Climate Zones 10 through 16. In addition, a drain water heat recovery system that is field verified as specified in the Reference Appendix RA3.6.9.

«» Commentary for Section 170.2(d)2Bii:

When a central gas or propane water-heating system is installed, a solar water-heating system with a minimum solar fraction is also required. A central system is any one water heater serving two or more units. The minimum solar savings fraction requirement is climate zone-dependent; the minimum is 0.2 for climate zones 1 – 9 and 0.35 in Climate Zones 10 through 16. If a drain water heat recovery (DWHR) device meeting the requirements specified in the Reference Appendix RA 3.6.9 is installed, moderately lower solar savings fraction levels are required instead. The minimums become 0.15 for climate zones 1 – 9 and 0.30 for climate zones 10 through 16.

Table 5-3: Minimum Solar Fraction Requirements for Solar Water-Heating Systems

	Climate Zones 1 – 9	Climate Zones 10 – 16
Minimum Solar Fraction	0.2	0.35
Minimum Solar Fraction if meeting RA 3.6.9	0.15	0.30

Source: California Energy Commission

The water-heating calculation method allows water-heating credits for solar water heaters. Solar thermal systems save energy by using renewable resources to offset the use of conventional energy sources. For detailed instructions on installation of solar water heaters, refer to Reference Appendix RA4.4.20. The database of SRCC-certified equipment is on SRCC website at the following link: https://solar-rating.org/.

The database of IAPMO R&T-certified equipment is on the IAPMO R&T website at the following link: www.iapmort.org/Pages/SolarCertification.aspx. «»

C. All hot water piping shall be sized in accordance with the California Plumbing Code Appendix M.

«» Commentary for Section 170.2(d)2C:

This section prescriptively requires that all hot water distribution piping be sized following the guidelines set forth in the California Plumbing Code (CPC) Appendix M. CPC Appendix M introduces an alternative methodology for pipe sizing, known as the Water Demand Calculator

(WDC), which is designed to reflect the lower water usage rates of contemporary high-efficiency fixtures.

The California Plumbing Code Appendix M replaces the outdated sizing methods from Appendix A, which were based on the Hunter's Curve—a model developed in the 1940s when water flow rates were significantly higher. This older methodology often resulted in oversized pipes, sometimes by a factor of 10 to 20 times the necessary size. Such oversizing led to unnecessary material costs, higher energy consumption, stagnant water, higher water consumption from increased hot water wait times and inefficiencies in water delivery systems.

In contrast, Appendix M employs updated probability curves and flow rate data, resulting in more accurate and efficient pipe sizing. By recognizing that modern fixtures use less water, Appendix M typically leads to smaller pipe diameters, often only 2-3 times larger than required for peak demands, compared to the much larger sizes recommended by the older methods. This approach not only reduces initial installation costs due to reduced pipe diameters of piping and plumbing appurtenances, it also reduces water age and improves hot water delivery performance. Using CPC Appendix M may reduce water and sewer costs related to meter size reduction depending on if the provider bases their monthly fixed charges on water meter size. While CPC Appendix M is an alternative pipe sizing methodology in the plumbing code, it is a prescriptive requirement in the Energy Code since there are significant energy efficiency benefits by lowering the energy required to overcome pipe heat losses at the heating plant and recirculation loop. For more detailed information on the CPC Appendix M Peak Water Demand Calculator, refer to Title 24, Part 5. **«»**

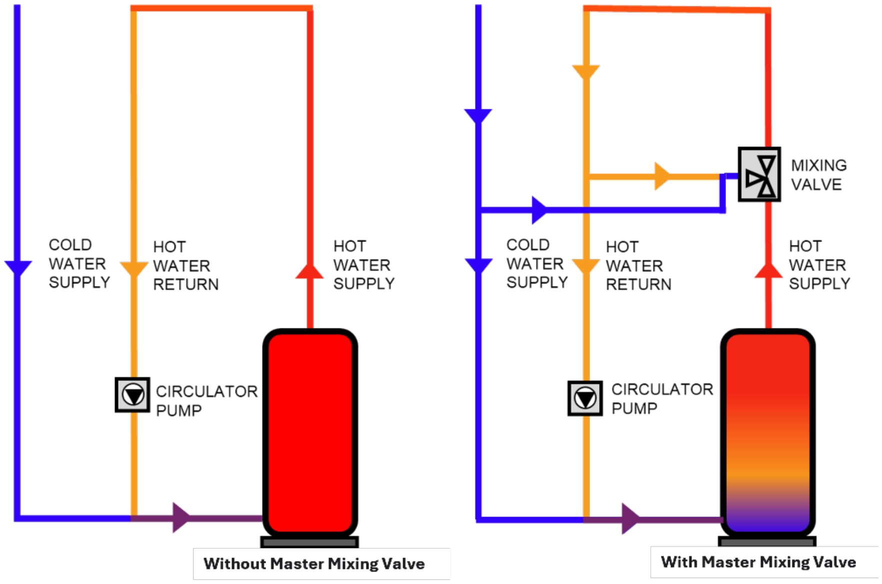
D. The central system shall have a recirculation system with a mechanical or digital thermostatic master mixing valve on each distribution supply and return loop, and meet the requirements specified in the Residential Reference Appendix RA4.4.19.

   Exception to Section 170.2(d)2D: Buildings with eight or fewer dwelling units.

«» Commentary for Section 170.2(d)2D:

This section prescriptively requires that a central domestic hot water system incorporates a recirculation system equipped with a mechanical or digital master mixing valve on each distribution supply and return loop. These valves are crucial for maintaining consistent water temperatures and ensuring the efficiency of the hot water system. Figure 5-12: Domestic Hot water System with and without a Master Mixing Valve shows a system without a master mixing valve (left) and a system with a master mixing valve (right).

Figure 5-12: Domestic Hot water System with and without a Master Mixing Valve



Source: California Energy Commission, TRC Companies, Inc.

Mechanical mixing valves, also known as thermostatic mixing valves (TMVs), are mainly designed for use in high volume distribution systems with mostly static flow conditions. These valves mix hot and cold water to a predetermined temperature and maintain this temperature regardless of fluctuations in pressure and flow. This is difficult to achieve with one large master mixing valve to meet the theoretical peak flow design condition. While physically larger and more costly, a two-valve High/Low (1 large and 1 small) combination TMV, shown in Figure 5-13: Image of a Two-Valve High Low Combination Thermostatic Mixing Valve is more effective. These valves are more complex to install and commission compared to simpler single valve systems. The complexity arises from the need to precisely adjust the mixing parameters to ensure optimal performance and safety. Other concerns with TMVs are they are commonly oversized in the specification, which impacts their performance, and it is critical to follow manufacturers' installation, commissioning and maintenance instructions comprehensively.

Figure 5-13: Image of a Two-Valve High Low Combination Thermostatic Mixing Valve

Source: California Energy Commission, TRC Companies, Inc.

Digital master mixing valves offer a more advanced solution by providing precise electronic control over the mixing process with much faster response to dynamic flow conditions. The desired temperature is selected and the valve does the rest of the work based on the pre-programmed algorithm. These valves can be programmed for pathogen mitigation and monitored more easily than their mechanical counterparts, allowing for greater flexibility and accuracy in maintaining desired water temperatures. Many digital valves have a daily descaling feature that exercises the valve over the full open and closed range to remove scale before it can build up.

Reference Appendix RA4.4.20 provides detailed installation and commissioning requirements for these thermostatic valves, particularly mechanical ones. These requirements ensure that the valves are properly set up to function effectively within the system. Key installation and commissioning considerations include:

1. Ensuring the valves are correctly calibrated to maintain the desired water temperature.
2. Verifying that the valves respond appropriately to changes in flow and pressure conditions.
3. Regularly testing and maintaining the valves to ensure long-term reliability and performance.

By adhering to the guidelines in RA4.4.20, installers can ensure that the thermostatic valves operate efficiently and safely, providing consistent hot water temperatures throughout the distribution system.

This requirement aims to enhance the performance and energy efficiency of central hot water systems in residential buildings. Properly installed and commissioned thermostatic valves help minimize heat loss, reduce energy consumption, and improve the overall reliability of the hot water supply. «»

E. Insulation for hot water pipes and plumbing appurtenances shall be field verified as specified in Residential Reference Appendix RA3.6.3.

«» Commentary for Section 170.2(d)2E

A key new pipe insulation requirement has been added for the 2025 Standards. This section outlines the requirement for field verification of insulation quality for hot water pipes and plumbing appurtenances. Refer to Residential Reference Appendix RA3.6.3 for detailed instructions on compliance.

As a prescriptive requirement, third party field verification allows flexibility for performance-based approaches and adjustments, accommodating any potential energy offsets needed if pipe insulation verification is not performed. It is crucial to ensure that this verification is not overlooked during the design and construction phases to maintain energy efficiency and system performance. **«»**

SECTION 180.0 – GENERAL

Additions, alterations and repairs to existing attached dwelling units and common use areas in multifamily buildings, existing outdoor lighting for these occupancies, and internally and externally illuminated signs shall meet the requirements specified in Sections 100.0 through 110.10, 160.1, and 160.3 through 170.2 that are applicable to the building project, and either the performance compliance approach (energy budgets) in Section 180.1(b) (for additions) or 180.2(c) (for alterations), or the prescriptive compliance approach in Section 180.1(a) (for additions) or 180.2(b) (for alterations), for the climate zone in which the building is located. Climate zones are shown in Figure 100.1-A.

Covered process requirements for additions, alterations and repairs to existing multifamily buildings are specified in Section 141.1.

Nonresidential occupancies in mixed occupancy buildings shall comply with nonresidential requirements in Sections 120.0 through 141.1.

NOTE: For alterations that change the occupancy classification of the building, the requirements specified in Section 180.2 apply to the occupancy after the alterations.

«» Commentary for Section 180.0:

Additions and alterations to existing individual water-heating systems are subject to mandatory requirements and select prescriptive requirements. These requirements apply to systems serving multiple dwelling units. Examples of instances that trigger requirements include:

1. Increasing the number of water heaters serving individual dwelling units (as part of an addition).
2. Replacing the existing water-heating or adding water heaters or adding hot water piping or both.
3. Replacing a heating element in a water heater but not replacing the entire water heater.

«»

SECTION 180.1 – ADDITIONS

Additions to existing multifamily buildings shall meet the applicable requirements of Sections 110.0 through 110.9; Sections 160.0, 160.1, and 160.2(c) and (d); Sections 160.3 through 160.7; and either Section 180.1(a) or 180.1(b).

Exception 3 to Section 180.1: Existing inaccessible piping shall not require insulation as defined under Section **160.4(f)2**Aiii.

«» Commentary for Section 180.1:

Water heater systems that serve one or more dwelling units as part of an addition will meet the prescriptive requirements specified in Section 170.2(d) on both water heater and distribution system. **«»**

(a) Prescriptive approach. The envelope and lighting of the addition; any newly installed space-conditioning or ventilation system, electrical power distribution system, or water-heating system; any addition to an outdoor lighting system; and any new sign installed in conjunction with an indoor or outdoor addition shall meet the applicable requirements of Sections 110.0 through 110.12**;** 160.0, 160.1, and 160.2(c) and (d); and 160.3 through 170.2.

«» Commentary for Section 180.1(a):

Altered or replaced water-heating systems or components serving dwelling units must meet mandatory pipe insulation and insulation protection requirements. For a replacement water heater, there are separate requirements for the distribution system and the water heater. The requirements for pipe insulation are mandatory and cannot be traded off. For the distribution system and the water heater, if the prescriptive requirements cannot be met, then the performance approach can be used to comply. **«»**

3. **Water heater.** When additional water-heating equipment is installed to serve a dwelling unit as part of the addition, one of the following types of water heaters shall be installed:

   A. A water-heating system that meets the requirements of Section 170.2(d); or

   B. A water-heating system determined by the Executive Director to use no more energy than the one specified in Item A above.

(b) Performance approach. Performance calculations shall meet the requirements of Sections 170.0 through 170.2(a), pursuant to the applicable requirements in Items 1, 2 and 3 below.

1. **For additions alone.** The addition complies if the addition alone meets the energy budgets expressed in terms of Long-Term System Cost (LSC) energy.

«» Commentary for Section 180.1(b)1:

Modeling an addition alone requires meeting the same requirements as newly constructed buildings. The prescriptive requirements apply only to the space that is added, not the entire building. **«»**

2. **Existing plus alteration plus addition.** The standard design for existing plus alteration plus addition energy use is the combination of the existing building's unaltered components to remain; existing building altered components that are the more efficient, in LSC energy, of either the existing conditions or the requirements of Section 180.2(c); plus the proposed addition's energy use meeting the requirements of Section 180.1(a). The proposed design energy use is the combination of the existing building's unaltered components to remain and the altered components' energy features, plus the proposed energy features of the addition.

«» Commentary for Section 180.1(b)2:

For altered or replaced water-heating systems, the calculated energy use of the proposed design is compared to the standard design energy budget. The standard design system is described in the 2025 Nonresidential and Multifamily Alternative Calculation Method Reference Manual.**«»**

SECTION 180.2 – ALTERATIONS

Alterations to components of existing multifamily buildings, including alterations made in conjunction with a change in building occupancy to a multifamily occupancy, shall meet Item (a), and either Item (b) or (c) below:

Exception 1 to Section 180.2: When heating, cooling or service water heating for an alteration is provided by expanding existing systems, the existing systems and equipment need not comply with Sections 110.0 through 110.10; Sections 160.0 through 160.7; and Section 170.2(c) or 170.2(d).

Exception 2 to Section 180.2: When existing heating, cooling or service water-heating systems or components are moved within a building, the existing systems or components need not comply with Sections 110.0 through 110.10; Sections 160.0 through 160.7; and Section 170.2(c) or 170.2(d).

(b) Prescriptive approach. The altered component and any newly installed equipment serving the alteration shall meet the applicable requirements of Sections 110.0 through 110.9 and all applicable requirements of Sections 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c) and 160.5; and

3. **Hot water systems**. Altered or replacement water-heating systems or components serving individual dwelling units shall meet the applicable requirements below:

   A. **Pipe insulation.** For newly installed piping and existing accessible piping, the insulation requirements of Section 160.4(e) shall be met.

«» Commentary for Section 180.2(b)3A:

Altered or replaced water-heating systems or components serving dwelling units must meet mandatory pipe insulation and insulation protection requirements. For a replacement water heater, there are separate requirements for the distribution system and the water heater. The requirements for pipe insulation are mandatory and cannot be traded off. For the distribution system and the water heater, if the prescriptive requirements cannot be met, then the performance approach can be used to comply. «»

   B. **Distribution system.** For recirculation distribution system serving individual dwelling units, only demand recirculation systems with manual on/off control as specified in Reference Appendix RA4.4.9 shall be installed.

   C. **Water-heating system.** The water-heating system shall meet one of the following:

      i. A natural gas or propane water-heating system; or

ii. A single heat pump water heater. The storage tank shall not be located outdoors and shall be placed on an incompressible, rigid insulated surface with a minimum thermal resistance of R-10. The water heater shall be installed with a communication interface that either meets the requirements of Section 110.12(a) or has an ANSI/CTA-2045-B communication port; or

iii. A single heat pump water heater that meets the requirements of NEEA Advanced Water Heater Specification Tier 3 or higher; or

iv. If the existing water heater is an electric resistance water heater, a consumer electric water heater.

v. A water-heating system determined by the Executive Director to use no more energy than the one specified in Sections 180.2(b)3Ci through iii above; or if no natural gas is connected to the existing water heater location, a water-heating system determined by the Executive Director to use no more energy than the one specified in Section 180.2(b)3Civ above.

(c) Performance approach. The altered component(s) and any newly installed equipment serving the alteration shall meet the applicable requirements of Subsections 1, 2 and 3 below. The energy budget for alterations is expressed in terms of Long-Term System Cost (LSC) energy.

1. The altered components shall meet the applicable requirements of Sections 110.0 through 110.9, 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c), and 160.5. Entirely new or complete replacement mechanical ventilation systems as these terms are used in Section 180.2(b)5A shall comply with the requirements in Section 180.2(b)5A. Altered mechanical ventilation systems shall comply with the requirements of Sections 180.2(b)5B. Entirely new or complete replacement space-conditioning systems, and entirely new or complete replacement duct systems, as these terms are used in Sections 180.2(b)2Ai and 180.2(b)2Aiia, shall comply with the requirements of Sections 160.2(a)1 and 160.3(b)5L.
2. The standard design for an altered component shall be the higher efficiency of existing conditions or the requirements of Section 180.2(b). For components not being altered, the standard design shall be based on the unaltered existing conditions such that the standard and proposed designs for these components are identical. When the third-party verification option is specified, all components proposed for alteration for which the additional credit is taken, must be verified by a certified ECC-rater.
3. The proposed design shall be based on the actual values of the altered components.

NOTES TO SECTION 180.2(c):

1. If an existing component must be replaced with a new component, that component is considered an altered component for the purpose of determining the standard design altered component energy budget and must meet the requirements of Section 180.2(c)2.
2. The standard design shall assume the same geometry and orientation as the proposed design.
3. The "existing efficiency level" modeling rules, including situations where nameplate data is not available, are described in Section 10-109(c) and Section 10-116.

«» Commentary for Section 180.2(c):

For altered or replaced water-heating systems, the calculated energy use of the proposed design is compared to the standard design energy budget. For system serving individual dwelling units, the standard design is based on either a single gas instantaneous water heater for gas water heaters or an HPWH system with a standard distribution system. For systems serving multiple dwelling units, the standard design is based on the existing efficiency level. «»

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INTRODUCTION

Chapter 6 Introduction

This chapter covers electrical and lighting system requirements for all dwelling units and common use areas in multifamily buildings for newly constructed buildings and additions or alterations to existing buildings.

Guidance on general requirements is included in the Multifamily Compliance Manual Chapter 1: General Requirements. Guidance on administrative requirements is included in the Multifamily Compliance Manual Chapter 2: Compliance and Enforcement. This chapter includes guidance on electrical and lighting system requirements.

Table 6-1: Excerpt from Table 100.0-A Application of Standards provides an overview of the location of the electrical and lighting system requirements that apply to multifamily occupancies in the Energy Code.

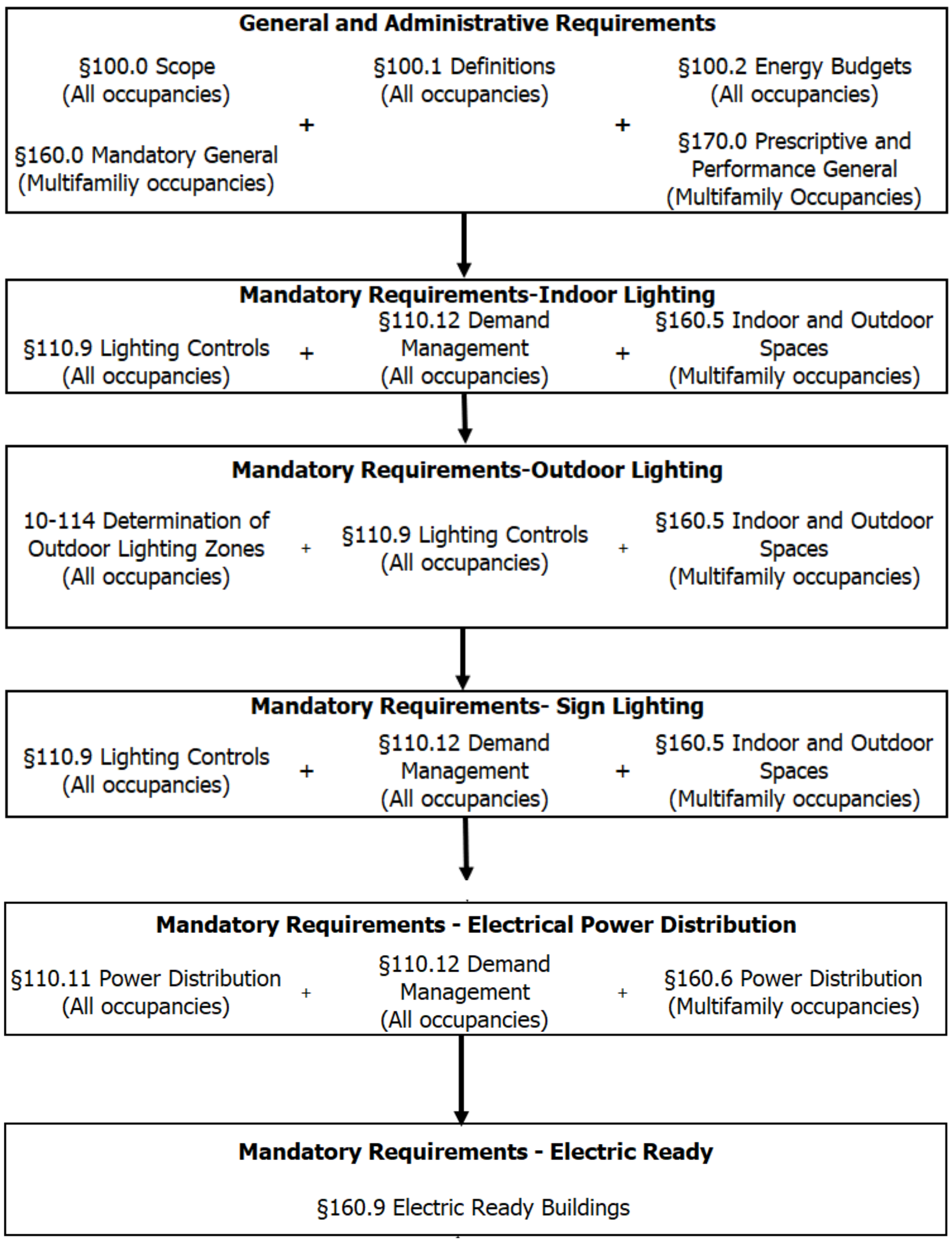
Table 6-1: Excerpt from Table 100.0-A Application of Standards

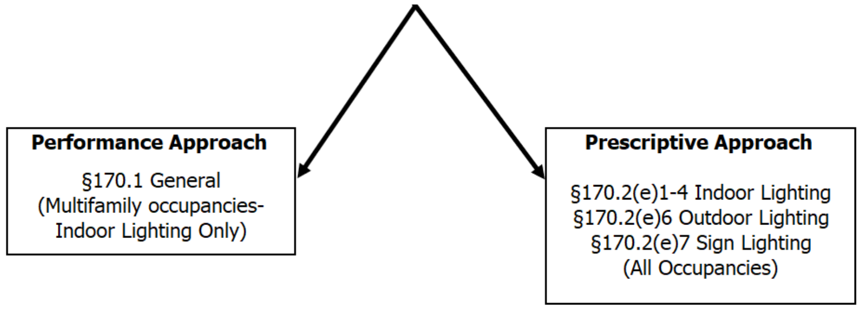
Application	Mandatory	Prescriptive	Performance	Additions/Alterations
General[1]	160.0	170.0	170.0	180.0
Indoor Lighting	110.9, 110.12 and 110.12(c), 160.5	170.2(e)1-4	170.1	180.1 (Additions) 180.2, 180.2(b)4, 180.2(c) (Alterations)
Outdoor Lighting	10-114, 110.9, 160.5	170.2(e)6	N/A	180.1 (Additions) 180.2, 180.2(b)4 (Alterations)
Sign Lighting	110.9, 110.12 and 110.12(d), 160.5	170.2(e)7	N/A	180.1 (Additions) 180.2, 180.2(b)4 (Alterations)
Electrical Power Distribution	110.11, 110.12 and 110.12(e), 160.6	N/A	N/A	180.1 (Additions) 180.2, 180.2(b)4 (Alterations)
Electric Ready	160.9	N/A	N/A	N/A

1. Guidance on General Requirements from Sections 160.0, 170.0 and 180.0 are included in the Multifamily Compliance Manual Chapter 1 General Requirements. Guidance specific to multifamily electrical and lighting is included in this chapter.

Figure 6-1: Flowchart Guidance for Application of New Construction Multifamily Electrical and Lighting Requirements and Figure 6-2: Flowchart Guidance for Application of Addition or Alteration Multifamily Electrical and Lighting Requirements below illustrate the applicable sections for newly constructed buildings and additions or alterations to existing buildings.

Figure 6-1: Flowchart Guidance for Application of New Construction Multifamily Electrical and Lighting Requirements

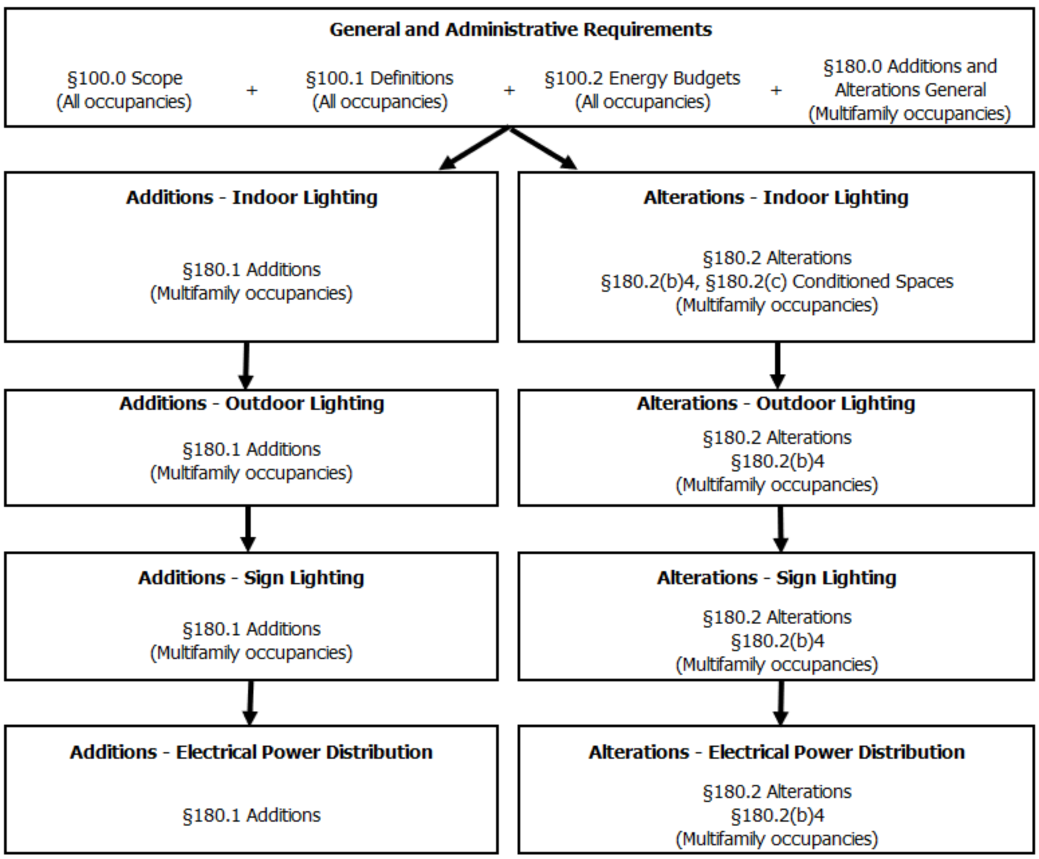




Newly Constructed Buildings Compliance Approaches

Source: California Energy Commission

Figure 6-2: Flowchart Guidance for Application of Addition or Alteration Multifamily Electrical and Lighting Requirements



Addition, Alteration Compliance Approaches

Source: California Energy Commission

10-114 – DETERMINATION OF OUTDOOR LIGHTING ZONES AND ADMINISTRATIVE RULES FOR USE

This section establishes rules for implementing outdoor lighting zones to show compliance with Section 140.7 of Title 24, California Code of Regulations, Part 6.

(a) Lighting Zones. Exterior lighting allowances in California vary by Lighting Zones (LZ).

(b) Lighting Zone Characteristics. TABLE 10-114-A specifies the relative ambient illumination level and the statewide default location for each lighting zone.

(c) Amending the Lighting Zone Designation. A local jurisdiction may officially adopt changes to the lighting zone designation of an area by following a public process that allows for formal public notification, review, and comment about the proposed change. The local jurisdiction may determine areas where Lighting Zone 4 is applicable and may increase or decrease the lighting zones for areas that are in State Default Lighting Zones 1, 2 and 3, as specified in TABLE 10-114-A.

TABLE 10-114-A LIGHTING ZONE CHARACTERISTICS AND RULES FOR AMENDMENTS BY LOCAL JURISDICTIONS

Zone	Ambient Illumination	Statewide Default Location	Moving Up to Higher Zones	Moving Down to Lower Zones
LZ0	Very Low	Undeveloped areas of government designated parks, recreation areas, and wildlife preserves.	Undeveloped areas of government designated parks, recreation areas, and wildlife preserves can be designated as LZ1 or LZ2 if they are contained within such a zone.	Not applicable
LZ1	Low	Rural areas, as defined by the 2020 U.S. Census. These areas include: single or dual family residential areas, parks, and agricultural zone districts,developed portion of government designated parks, recreation areas,	Developed portion of a government designated park, recreation area, or wildlife preserve, can be designated as LZ2 or LZ3 if they are cRetail stores, located in a residential neighborhood, and rural town centers can be	Not applicable.

		and wildlife preserves. Those that are wholly contained within a higher lighting zone may be considered by the local government as part of that lighting zone.	designated as LZ2 if the business operates during hours of darkness.	
LZ2	Moderate	Urban areas, as defined by the 2020 U.S. Census. The following building types may occur here: multifamily housing, mixed use residential neighborhoods, religious facilities, schools, and light commercial business districts or industrial zoning districts.	Special districts within a default LZ2 zone may be designated as LZ3 or LZ4 by a local jurisdiction. Examples include special commercial districts or areas with special security considerations located within a mixed-use residential area or city center.	Special districts may be designated as LZ1 by the local jurisdiction, without any size limits.
LZ3	Moderately High	Urban areas, as defined by the 2020 U.S. Census. The following building types may occur here: high intensity commercial corridors, entertainment centers, and heavy industrial or manufacturing zone districts.	Special districts within a default LZ3 may be designated as a LZ4 by local jurisdiction for high intensity nighttime use, such as entertainment or commercial districts or areas with special security considerations requiring very high light levels.	Special districts may be designated as LZ1 or LZ2 by the local jurisdiction, without any size limits.
LZ4	High	None.	Not applicable.	Not applicable.

«»Commentary for Section 10-114(c):

The Energy Code allows outdoor lighting power on the amount of light and subsequent surface brightness of the surrounding conditions. The Energy Code contains lighting power allowances for new lighting installations and specific alterations that depend on the lighting zone (LZ) where the project is located.

Five categories of outdoor lighting zones are defined: LZ0, LZ1, LZ2, LZ3, and LZ4. Lighting zones with lower numbers are less illuminated, starting at LZ0, such as national parks and other areas intended to be very dark at night, through to LZ4 for high-intensity nighttime use, such as entertainment or commercial districts or areas with special security considerations requiring very illuminated levels.

Over a period of time, human vision will adapt to darker surrounding conditions and less light is required to see properly. Providing more light than is needed can potentially create debilitating glare and a need for higher light levels to counteract the reduced vision. As future projects are built, they must also compete with the light levels and glare that has been established in previous nearby projects, leading to unnecessarily greater wasted energy as the properties rachet up the light levels.

The least amount of lighting is allowed in LZ1, and increasingly more amount of lighting is allowed in LZ2, LZ3, and LZ4. LZ0 is intended for undeveloped spaces in parks and wildlife preserves and is of very low ambient illumination.

The default lighting zone for undeveloped portions of government designated parks, recreation areas, and wildlife preserves is Lighting Zone 0.

The default lighting zone for developed portions of government designated parks, recreation areas, and wildlife preserves is Lighting Zone 1.

The default for rural areas as defined by the U.S. Census Bureau is Lighting Zone 1.

The default lighting zone for urban areas as defined by the U.S. Census Bureau is Lighting Zone 2.

Lighting Zone 3 is the default for urban areas, as defined by the U.S. Census Bureau. However, local jurisdictions may designate specific areas as higher or lower than the default lighting zone if deemed appropriate. Examples include using a higher level lighting zone in areas with commercial activities, or using lower level lighting zones in residential areas or environmentally sensitive areas. When a local jurisdiction adopts changes to the lighting zone boundaries, it must follow a public process that allows for formal public notification, review, and comment about the proposed change.

Permit applicants may determine the lighting zone for a particular property using the following steps.

For government-designated parks, recreation areas, and wildlife preserves:

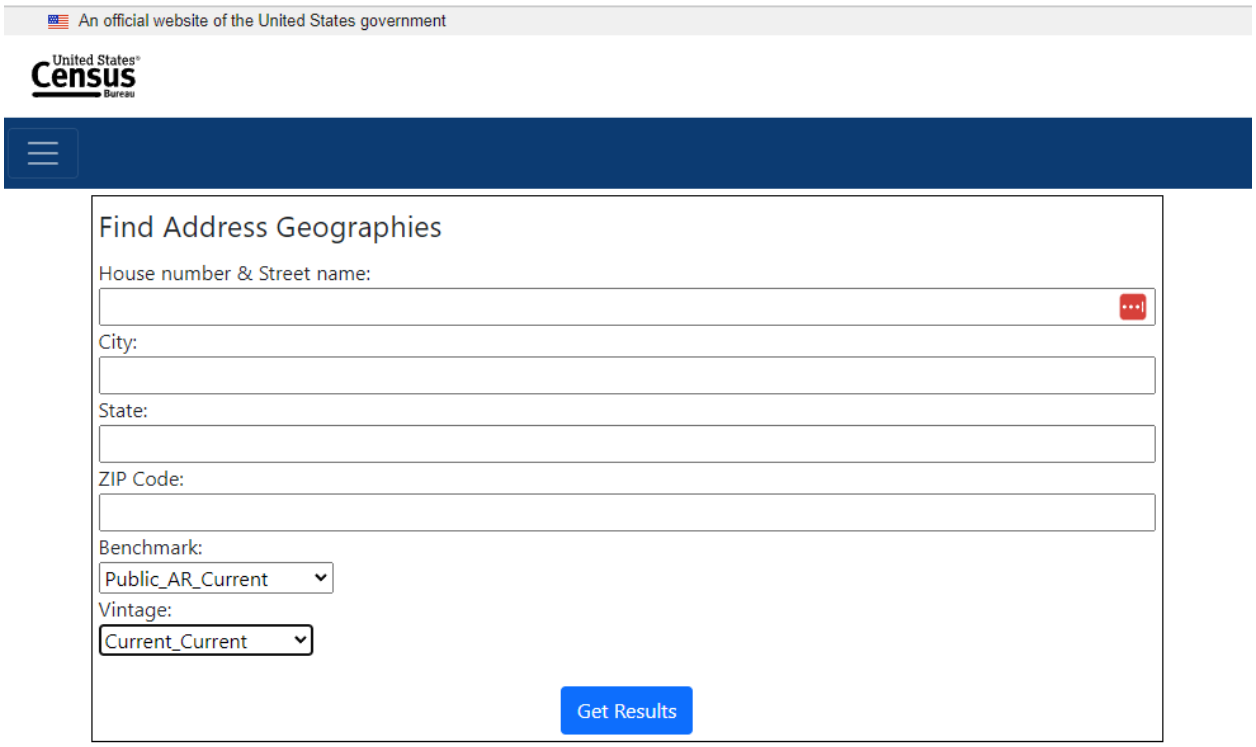
1. Check with the local jurisdiction having authority over permitting of the property. The local jurisdiction will know if the property is a government-designated park, recreation area, or wildlife preserve, and therefore in default Lighting Zone 0 or 1. The local jurisdiction also may know if the property is contained within the physical boundaries of a lighting zone for which a locally adopted change has been made.

For urban areas and rural areas:

1. The lighting zones for urban areas and rural areas as well as the legal boundaries of wilderness and park areas are based on the 2020 U.S. Census Bureau boundaries.

2. The U.S. Census Bureau website can be used to determine if the property is within Lighting Zone 1 (rural areas), Lighting Zone 2 (urban areas), or Lighting Zone 3 (urban areas).
3. Using an online map overlay tool provided by the U.S. Census Bureau on https://geocoding.geo.census.gov/geocoder/geographies/address?form the property address can be entered to look up geography results indicating whether the address is within an urban area or rural area once the "vintage" is changed to "Census2020_Current".

Figure 6-3 U.S. Census Bureau Website: https://geocoding.geo.census.gov/geocoder/geographies/address?form



Source: California Energy Commission

«»

SECTION 110.9 – MANDATORY REQUIREMENTS FOR LIGHTING CONTROLS

(a) All lighting control devices and systems and all light sources subject to the requirements of Section 110.9 shall meet the following requirements:

1. Shall be installed only if the lighting control or light source complies with all of the applicable requirements of Section 110.9.
2. Lighting controls may be individual devices or systems consisting of two or more components.

(b) All lighting controls. Lighting controls listed in Section 110.9(b) shall comply with the requirements listed below; and all components of the system considered together as installed shall meet all applicable requirements for the application for which they are installed as required in Sections 130.0 through 130.5, Sections 140.6 through 140.8, Section 141.0, and Section 150.0(k).

1. **Time-switch lighting controls.** All controls that provide time-switch functionality, including all automatic and astronomical time-switch controls, shall have program backup capabilities that prevent the loss of the device's schedule for at least 7 days, and the device's date and time for at least 72 hours if power is interrupted. In addition:

   A. Time-switch controls installed in nonresidential buildings shall:

      i. For each connected load, be capable of providing manual override to each connected load and of resuming normally scheduled operation after a manual override is initiated within 2 hours; and

      ii. Provide an automatic holiday shutoff feature that turns off all connected loads for at least 24 hours and then resumes normally scheduled operation.

   B. Astronomical time-switch controls shall:

      i. Have sunrise and sunset prediction accuracy within plus-or-minus 15 minutes and timekeeping accuracy within 5 minutes per year;

      ii. Be capable of displaying date, current time, sunrise time, sunset time, and switching times for each step during programming;

      iii. Be capable of automatically adjusting for daylight savings time; and

      iv. Have the ability to independently offset the on and off for each channel by at least 90 minutes before and after sunrise or sunset.

C. Multilevel time-switch controls shall include at least two separately programmable steps per zone.

D. Time-switch controls installed outdoors shall have setback functions that allow the lighting on each controlled channel to be switched or dimmed to lower levels. The setback functions shall be capable of being programmed by the user for at least one specific time of day.

2. **Daylight responsive controls.** Controls that provide daylight responsive controls functionality shall:

A. Automatically return to its most recent time delay settings within 60 minutes of the last received input when left in calibration mode;

B. Have a set point control that easily distinguishes settings to within 10 percent of full-scale adjustment;

C. Provide a linear response within 5 percent accuracy over the range of illuminance measured by the light sensor; and

D. Be capable of being calibrated in a manner that the person initiating the calibration is remote from the sensor during calibration to avoid influencing calibration accuracy, for example by having a light sensor that is physically separated from where the calibration adjustments are made.

3. **Dimmers.** Controls that provide dimming functionality shall:

A. Be capable of reducing lighting power consumption by a minimum of 65 percent when at its lowest setting;

B. Provide reduced flicker operation, meaning that directly controlled light sources shall be provided electrical power such that the light output has an amplitude modulation of less than 30 percent for frequencies less than 200 Hz without causing premature lamp failure;

C. Provide an offsetting that produces a zero lumen output; and

D. For wall box dimmers and associated switches designed for use in three way circuits, be capable of turning lights off, and on to the level set by the dimmer if the lights are off.

4. **Occupant sensing controls.** Occupant sensing controls include occupant sensors, motion sensors, and vacancy sensors, including those with a partial-ON or partial-OFF function. Occupant sensing controls shall:

A. Be capable of automatically turning the controlled lights in the area either off or down no more than 20 minutes after the area has been vacated;

B. For manual-on controls, have a grace period of no less than 15 seconds and no more than 30 seconds to turn on lighting automatically after the sensor has timed out; and

C. Provide a visible status signal that indicates that the device is operating properly, or that it has failed or malfunctioned. The visible status signal may have an override that turns off the signal**.**

Exception to Section 110.9(b)4: Occupant sensing control systems may consist of a combination of single or multilevel occupant, motion or vacancy sensor controls, provided that components installed to comply with manual-on requirements shall not be capable of conversion by occupants from manual-on to automatic-on functionality.

5. Reserved**.**
6. **Sensors used to detect occupants.** Sensors that are used by occupant sensing controls to detect occupants shall meet all of the following requirements:
   A. Sensors shall not incorporate switches or mechanical devices that allow the sensor to be disabled without changing the settings of the control.
   B. Sensors that utilize ultrasonic radiation for detection of occupants shall:
      i. comply with 21 C.F.R. part 1002.12;
      ii. not emit audible sound; and
      iii. not emit ultrasound in excess of the decibel levels shown in Table 110.9-A measured no more than 5 feet from the source, on axis.
   C. Sensors that utilize microwave radiation for detection of occupants shall:
      i. comply with 47 C.F.R. parts 2 and 15; and
      ii. not emit radiation in excess of 1 milliwatt per square centimeter measured at no more than 5 centimeters from the emission surface of the device.
7. **Indicator lights.** Indicator lights integral to lighting controls shall consume no more than 1 watt of power per indicator light.

«» Commentary for Section 110.9(b):

All installed lighting control devices and systems for multifamily indoor lighting (i.e. lighting installed in common areas and dwellings), parking lot lighting, and outdoor lighting must meet the functionality requirements in Section 110.9(b).

These lighting controls requirements are used to ensure that the controlled lighting is not operating unnecessarily with the automatic controls enabled – for example, the controlled lighting are switched off (with time switch controls or astronomical time-switch controls) during the daytime when there is daylight available or the controlled lighting is switched off (through occupancy or motion sensors) when there is nobody in the nearby area that will benefit from the lighting.

Additionally, there is a dimming requirement that is intended to allow for several different strategies. This includes matching the output of the lighting system to the design criteria to avoid over-lighting and using occupancy sensor or time switch driven "high-low" operation that will provide minimal lighting in low occupancy periods but still be able to operate at the proper level when an occupant is detected.

This section stipulates minimum performance requirements for installed lighting control devices and systems for the types specified in Section 110.9. The devices or the systems must be able to turn off or dim the lighting in a manner that ensures normal operation of the lighting system with the controls as an effective and reliable method to ensure energy conservation. For this reason, the section stipulates capabilities that may be minimum or maximum values, depending on the circumstances, and also details certain functional or process requirements in the devices to help avoid users in the building overriding or disabling the controls. «»

(c) Track lighting integral current limiter. An integral current limiter for line-voltage track lighting shall be recognized for compliance with Part 6 only if it meets all of the following requirements:

1. Shall have the identical volt-ampere (VA) rating of the current limiter as installed and rated for compliance with Part 6 clearly marked as follows:
    A. So that it is visible for the enforcement agency's field inspection without opening coverplates, fixtures or panels; and
    B. Permanently marked on the circuit breaker; and
    C. On a factory-printed label that is permanently affixed to a nonremovable base-plate inside the wiring compartment.
2. Shall have a conspicuous factory installed label permanently affixed to the inside of the wiring compartment warning against removing, tampering with, rewiring or bypassing the device; and
3. Each electrical panel from which track lighting integral current limiters are energized shall have a factory printed label permanently affixed and prominently located, stating the following: "NOTICE: Current limiting devices installed in track lighting integral current limiters connected to this panel shall only be replaced with the same or lower amperage. Adding track or replacement of existing current limiters with higher continuous ampere rating will void the track lighting integral current limiter certification, and will require resubmittal of compliance documentation to the enforcement agency responsible for compliance with the California Title 24, Part 6 Building Energy Efficiency Standards."

«» Commentary for Section 110.9(c)3:

A track lighting current limiter limits the power that can go through a section of track lighting. Without the current limiter, the "installed" wattage of a long section of track could be excessive and use up the allotted lighting power for a space. With track lighting and a current limiter, the track heads can be placed anywhere along the run of the track as long as the total wattage of all heads on the track stays below the rated wattage of the current limiter. If the wattage exceeds the rated wattage of the current limiter, the limiter turns off current to the controlled lighting.

The current limiter requirement addresses two possible issues.

1. A track with too many heads that produce over lighting and likelihood of a dangerous overload, and
2. A long track with very few heads. **«»**

(d) Track lighting supplementary overcurrent protection panel. A Track Lighting Supplementary Overcurrent Protection Panel shall be used only for line-voltage track lighting and shall be recognized for compliance with Part 6 only if it meets all of the following requirements:

1. Shall be listed as defined in Section 100.1; and
2. Shall have a permanently installed label that is prominently located stating the following: "NOTICE: This Panel for Track Lighting Energy Code Compliance Only." The overcurrent protection devices in this panel shall only be replaced with the same or lower amperage. No other overcurrent protective device shall be added to this panel. Adding to, or replacement of, existing overcurrent protective device(s) with higher continuous ampere rating will void the panel listing and require resubmittal of compliance documentation to the enforcement agency responsible for compliance with the California Title 24, Part 6 Building Energy Efficiency Standards.

«» Commentary for Section 110.9(d)2:

A track lighting supplementary overcurrent protection panel is a subpanel that contains current limiters for use with multiple track lighting circuits only. A track lighting supplementary overcurrent protection panel shall be used only for line-voltage track lighting.

This requirement addresses the same issues as above, but from a remote location.**«»**

TABLE 110.9-A - ULTRASOUND MAXIMUM DECIBEL VALUES

MID-FREQUENCY OF SOUND PRESSURE THIRD-OCTAVE BAND (IN kHz)	**MAXIMUM DB LEVEL WITHIN THIRD-OCTAVE BAND (IN dB REFERENCE 20 MICROPASCALS)**
Less than 20	80
20 or more to less than 25	105
25 or more to less than 31.5	110
31.5 or more	115

SECTION 110.11 – MANDATORY REQUIREMENTS FOR ELECTRICAL POWER DISTRIBUTION SYSTEM

Certification by Manufacturers. Any electrical power distribution system equipment listed in this section may be installed only if the manufacture has certified to the Commission that the equipment complies with all the applicable requirements of this section.

(a) Low-voltage dry-type distribution transformer shall be certified by the Manufacturer as required by the Title 20 Appliance Efficiency Regulations.

EXCEPTION to Section 110.11(a):

1. autotransformer;
2. drive (isolation) transformer;
3. grounding transformer;
4. machine-tool (control) transformer;
5. nonventilated transformer;
6. rectifier transformer;
7. regulating transformer;
8. sealed transformer;
9. special-impedance transformer;
10. testing transformer;
11. transformer with tap range of 20 percent or more;
12. uninterruptible power supply transformer; or
13. welding transformer.

SECTION 110.12 – MANDATORY REQUIREMENTS FOR DEMAND MANAGEMENT

Buildings, other than healthcare facilities, that install or are required to install demand responsive controls shall comply with the applicable demand responsive control requirements of Sections 110.12(a) through 110.12(e).

(a) Demand responsive controls.

1. All demand responsive controls shall be either:
   A. A certified OpenADR 2.0a or OpenADR 2.0b Virtual End Node (VEN), as specified under Clause 11, Conformance, in the applicable OpenADR 2.0 Specification; or a certified Baseline Profile OpenADR 3.0 Virtual End Node; or

   B. Certified to the Energy Commission as being capable of responding to a demand response signal from a certified OpenADR 2.0b or a certified Baseline Profile OpenADR 3.0 Virtual End Node by automatically implementing the control functions requested by the Virtual End Node for the equipment it controls.
2. All demand responsive controls shall be capable of communicating with the VEN using a wired or wireless bidirectional communication protocol.
3. RESERVED
4. When the demand response signal is disabled or unavailable, all demand responsive controls shall continue to perform all other control functions provided by the control.

«» Commentary for Section 110.12(a)4:

Demand response is an increasingly important function of buildings as distributed energy resources become more common and customers have access to time of use electricity rates and incentive programs designed to encourage demand side optimization. Demand response occurs on a range of timescales, from seconds to seasons, and represents any demand change in response to grid or economic needs. In addition to existing time of use electricity rates, utilities in the future will likely connect electricity costs to high frequency fluctuations in both the supply and demand for electricity. Appropriate demand responsive controls allow building operators to maintain the quality of services a building provides and reduce the total cost of energy by automating a building’s response to changes in electricity rates.

Communication with Entity that Initiates DR Signal

The demand responsive (DR) control system must be able to communicate with the entity that initiates a DR signal by way of an OpenADR certified virtual end node (VEN).

The OpenADR 2.0 protocol is the primary open-standard protocol used in the California market. It implements a profile within the Organization of Structured Information Standards (OASIS) Energy Interoperation information and communication model that defines two types of communications entities – virtual top nodes (VTNs) and virtual end nodes (VENs). VTNs are either physical or cloud based information exchange servers, typically operated by utilities or third-party providers, that transmit events or price information. VENs are the hardware that receive the data transmitted by a VTN, and are typically the gateway or end-use devices installed at customer facilities. See OpenADR Alliance's website (http://www.openadr.org/) for more information about OpenADR certified VENs.

Certification Requirements for Demand Response Controls

The Energy Code has certification requirements for demand responsive controls in Section 110.12(a).

Option A:

Install an OpenADR 2.0a or 2.0b certified VEN or a certified Baseline Profile OpenADR 3.0 VEN physically within the building as part of the DR control system (Section 110.12(a)1A)

For demand-responsive controls that comply according to Section 110.12(a)1A, the certified OpenADR 2.0 Virtual End Node (VEN) or certified Baseline Profile OpeADR 3.0 VEN can be incorporated into a networked system of devices allowing the VEN to communicate with multiple devices in the network. Alternatively, each demand-responsive control device in the building could be a certified VEN. Devices downstream of the certified OpenADR VEN do not need to be certified to Section 110.12(a)1. The OpenADR VEN must be installed on-site as part of the demand-responsive control system and at time of inspection.

Option B:

Install a demand response (DR) control system that has been certified to the Energy Commission as being capable of communicating with an OpenADR 2.0b certified VEN (Section 110.12(a)1B)

For demand-responsive controls that comply according to Section 110.12(a)1B, the demand responsive control system must be certified to the CEC as being capable of automatically responding to a certified OpenADR 2.0b VEN or a certified Baseline Profile OpenADR 3.0 VEN. The VEN may be separately located on-site, off-site, or in the cloud, and is not required to be in operation at the time of permitting. The demand-responsive control must be programmed or configured so any test control strategy defined in the building code can be deployed at the time of permitting.

The 2025 Energy Code Section 110.12(a)2 requires that all demand-responsive controls must be capable of communicating with the VEN using a wired or wireless bidirectional communication pathway. The communication pathway to the VEN must be installed or established to comply.

A list of demand-responsive controls certified to the Energy Commission can be found at the Energy Commission website, https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment/dr-controls-lighting. «»

(c) Demand Responsive Lighting Controls. Buildings with nonresidential lighting systems having a total installed lighting power of 4,000 watts or greater that are subject to the requirements of Section 130.1(b) or 160.5(b)4B shall install controls that are capable of automatically reducing lighting power in response to a demand response signal.

1. For compliance testing, the lighting controls shall demonstrate a 15-percent or greater reduction in lighting power as described in NA7.6.3. The controls may provide additional demand responsive functions or abilities.
2. For buildings where demand response controls are required, demand responsive controls shall control the general lighting in the spaces required to meet Section 130.1(b) or 160.5(b)4B.
3. General lighting shall be reduced in a manner consistent with the requirements of Section 130.1(b) or 160.5(b)4B.

Exception to Section 110.12(c): Spaces where a health or life safety statute, ordinance, or regulation does not permit the general lighting to be reduced are not required to install demand responsive controls and do not count toward the 4,000-watt threshold.

«» Commentary for Section 110.12(c)3:

Multifamily buildings with general lighting systems in the common use areas having a total installed lighting power of 4,000 watts or greater that are subject to the multilevel requirements in Section 160.5(b)4B must meet demand-responsive lighting control requirements. Lighting in the dwelling units or controlled through the dwelling units (e.g. outdoor porch or deck lighting) is excluded from the calculation of total building lighting power.

The demand-responsive control must be capable of reducing the total lighting power by 15 percent or greater. The lighting power reduction must meet the uniformity requirements of Section 160.5(b)4B.

Note that these requirements are focused on a temporary light level reduction and not on the long-term reduction of lighting. Only the general lighting is required to be connected to the DR controls, however any additional lighting (accent, decorative, etc.) can be connected to the controls as well. The general lighting in the common use areas is the basis for the reduction.

This DR capability must be applied in habitable spaces only; other spaces are less likely to have the lights turned 'On' at any given time due to the occupancy sensors and the DR benefit comes from the lighting systems that are normally operating when a DR event occurs. «»

(d) Demand Responsive Electronic Message Center Control. Controls for electronic message centers greater than 15 kW shall be capable of reducing the lighting power by a minimum of 30 percent when receiving a demand response signal.

Exception to Section 110.12(d): Electronic message centers that are not permitted by a health or life safety statute, ordinance, or regulation to be reduced.

(e) Demand Responsive Controlled Receptacles. In spaces required to have controlled receptacles per Section 130.5(d) or 160.6(d) and where demand responsive lighting controls are installed, the controlled receptacles shall be capable of automatically turning off all connected loads in response to a demand response signal.

Exception to Section 110.12(e): Spaces where a health or life safety statute, ordinance or regulation does not permit the receptacles to be automatically controlled.

«» Commentary for Section 110.12(e):

The common use areas in a multifamily building that are required to have demand responsive receptacles per Section 160.6(d) will have a circuit or circuits that are connected to a relay that is driven by the DR responsive lighting control system. This requirement is intended to be used for discretionary plug loads that can be turned 'Off' when a DR event occurs and should not be used for other devices that would have problems when turned 'Off' without following a shutdown procedure.

This DR receptacles requirement follows with the controlled receptacles requirement in Section 160.6(d) and adds an additional stipulation that if the building must have DR capability, then any of the controlled receptacles must also be connected to take the DR signal to temporarily turn 'Off' the outlets. «»

SECTION 160.5 – MANDATORY LIGHTING REQUIREMENTS FOR INDOOR AND OUTDOOR SPACES

The design and installation of all lighting systems and equipment in multifamily buildings within the scope of Section 100.0(a) shall comply with the applicable provisions of Section 160.5. All functional areas except dwelling units and common living areas shall comply with the applicable requirements of Sections 160.5(b) through 160.5(e).

(a) Dwelling unit lighting.

The design and installation of all lighting systems and equipment in multifamily dwelling units shall comply with Section 160.5(a). Multifamily dwelling units include dormitory and senior housing dwelling accommodations. Outdoor lighting attached to multifamily buildings and controlled from the inside of a dwelling unit shall comply with the lighting requirements of Section 160.5(a).

1. Luminaire requirements

A**. Luminaire efficacy**. All installed luminaires and light sources shall comply with Reference Joint Appendix JA8 and shall be certified and marked as required by JA8.

Exception 1 to Section 160.5(a)1A: **Integrated device lighting:** Lighting integral to exhaust fans, kitchen range hoods, bath vanity mirrors, garage door openers, and ceiling fan kits that are subject to DOE's Appliance and Equipment Standards Program.

Exception 2 to Section 160.5(a)1A: Navigation lighting rated less than five watts, such as night lights, step lights, and path lights.

Exception 3 to Section 160.5(a)1A: Lighting with an efficacy of 45 lumens per watt or greater and located internal to drawers, cabinetry, and linen closets.

Exception 4 to Section 160.5(a)1A: Light sources as follows:

i. LED light sources installed outdoors;

ii. inseparable solid state lighting (SSL) luminaires containing colored light sources that are installed to provide decorative lighting;

iii. High intensity discharge (HID) light sources including pulse start metal halide and high pressure sodium light sources; and

iv. Luminaires with hardwired high frequency generator and induction lamp.

B. Reserved.

«» Commentary for Section 160.5(a)1:

For dwelling unit lighting, the Energy Code requires all permanently installed luminaires to be high luminous efficacy, as specified in Reference Joint Appendix JA8. Permanently installed lighting is defined in Section 100.1 and includes:

1. Lighting attached to walls, ceilings, or columns
2. Track and flexible lighting systems
3. Lighting inside permanently installed cabinets
4. Lighting attached to the top or bottom of permanently installed cabinets.
5. Lighting attached to ceiling fans
6. Lighting integral to exhaust fans
7. Lighting integral to garage door openers if it is switched independently from the garage door opener and does not automatically turn off after a pre-determined amount of time

Note that even if a luminaire is connected to power through a receptacle, if it is mounted on permanently installed cabinets or other objects, it must meet the high efficacy requirements in JA8.

The following are examples of non-permanently installed lighting:

1. Portable lighting as defined by Section 100.1 (including, but not limited to, table and freestanding floor lamps with plug-in connections)
2. Lighting installed by the manufacturer in appliances, or kitchen exhaust hoods in the dwelling unit

Luminaires not listed as exceptions to Section 160.5(a)1A must have an integral light source or removable lamp that meets the performance requirements of JA8. In addition to setting minimum efficacy requirements (lumens/Watt), JA8 establishes performance requirements that ensure accurate color rendition, dimmability, and reduced noise and flicker during operation.

Luminaires with integral sources, such as LED luminaires, must be certified to the Energy Commission as meeting the JA8 requirements. Luminaires that have changeable lamps (such as screw-base luminaires) must be installed with JA8-certified lamps.

Luminaires and lamps that are certified to the Energy Commission must be marked on the product as described in JA8. Lamps that will be installed in elevated temperature applications such as in enclosed luminaires must have a JA8-2025-E marking to indicate that the product has passed the more stringent federal test conducted at elevated temperature.

Luminaires that can be classified as high luminous efficacy by meeting the requirements of JA8 include:

1. LED luminaires with integral light sources that are certified to the Energy Commission.
2. Ceiling recessed downlight luminaires with JA8 certified light sources (the luminaire must not contain screw-based lamp sockets).
3. Screw-based luminaires with JA8-certified lamps.
4. Low-voltage pin-based luminaires with JA8-certified lamps.

Almost any luminaire can be classified as high luminous efficacy, as long as the luminaire is installed with a JA8 certified lamp or light source. The exception is recessed downlight luminaires in ceilings, which must meet additional requirements as detailed in the commentary below.

The Energy Commission maintains a database of certified JA8 certified luminaires, lamps, and light sources https://www.energy.ca.gov/programs-and-topics/programs/appliance-efficiency-program-outreach-and-education/modernized. The database can be accessed using a Quick Search Tool or an Advanced Search. **«»**

C. **Recessed downlight luminaires**. In addition to complying with Section 160.5(a)1A, luminaires recessed into ceilings shall meet all of the following requirements:

i. Shall not contain screw base lamp sockets; and

ii. Have a label that certifies the luminaire is airtight with air leakage less than 2.0 cfm at 75 Pascals when tested in accordance with ASTM E283. An exhaust fan housing with integral light shall not be required to be certified airtight; and

iii. Be sealed with a gasket or caulk between the luminaire housing and ceiling, and have all air leak paths between conditioned and unconditioned spaces sealed with a gasket or caulk, or be installed per manufacturer's instructions to maintain airtightness between the luminaire housing and ceiling; and

iv. Meet the clearance and installation requirements of California Electrical Code Article 410.116 for recessed luminaires.

Exception to Section 160.5(a)1Cii and Iii: Recessed luminaires marked for use in fire-rated installations, and recessed luminaires installed in noninsulated ceilings.

«» Commentary for Section 160.5(a)1C:

All recessed downlight luminaires must contain a light source or lamp that is JA8-certified, such as an integral LED source or LED lamp. Screw-based lamps such as LED A-lamps or LED PAR lamps are not allowed. Pin-based lamps such as LED MR-16 lamps are allowed in recessed luminaires as long as they are JA8-certified.

In addition to the light source and lamp requirements listed, recessed downlight luminaires in ceilings must meet all the following requirements.

1. Have a label that certifies the luminaire is airtight with air leakage less than 2.0 cubic ft. per minute at 75 Pascals when tested in accordance with ASTM E283 (exhaust fan housings with integral lighting are not required to be certified airtight).
2. Be sealed with a gasket or caulk between the luminaire housing and ceiling, and have all air leak paths between conditioned and unconditioned spaces sealed with a gasket or caulk, or be installed per manufacturer's instructions to maintain airtightness between the luminaire housing and ceiling.
3. Meet the clearance and installation requirements of California Electrical Code Article 410.116 for recessed luminaires which requires the following.
4. A recessed luminaire that is not identified for contact with insulation (non-Type IC), must have all recessed parts spaced not less than 1/2 inch from combustible

materials. The points of support and the trim finishing off the openings in the ceiling must be permitted to be in contact with combustible materials.

5. A recessed luminaire that is identified for contact with insulation (Type IC), must be permitted to be in contact with combustible materials at recessed parts, points of support, and portions passing through or finishing off the opening in the building structure.
6. Thermal insulation must not be installed above a recessed luminaire or within 3 inches of the recessed luminaire's enclosure, wiring compartment, ballast, transformer, LED driver, or power supply unless the luminaire is identified as Type IC for insulation contact.

Luminaires that meet the air leakage requirement or luminaires that are Type IC rated will have this information listed on luminaire cut sheets or packaging. Contractors are responsible for ensuring that luminaires are properly sealed to prevent air leakage between the luminaire housing and ceiling.

The air leakage requirements are to ensure there isn't substantial energy loss through the ceiling penetration, resulting in higher energy consumption throughout the life of the luminaire. Most other luminaires in a dwelling unit do not penetrate the conditioned/unconditioned boundary, so there is much less attention to the conditions of manufacture and installation in the energy code.

Recessed luminaires that are marked for use in fire-rated installations and recessed luminaires installed in non-insulated ceilings are exempt from the air leakage requirement and sealing requirement. However, these luminaires must meet all other requirements for recessed luminaires. «»

D. **Light sources in enclosed or recessed luminaires**. Lamps and other separable light sources in enclosed or recessed luminaires shall be in compliance with the JA8 elevated temperature requirements, including marking requirements.

E. **Blank electrical boxes**. The number of electrical boxes that are more than five feet above the finished floor and do not contain a luminaire or other device shall be no greater than the number of bedrooms. These electrical boxes shall be served by a dimmer, vacancy sensor control, low voltage wiring, or fan speed control.

2. **Indoor lighting controls**.

A. Lighting shall have readily accessible wall-mounted controls that allow the lighting to be manually turned ON and OFF.

Exception to Section 160.5(a)2A: Ceiling fans may provide control of integrated lighting via a remote control.

«» Commentary for Section 160.5(a)2A:

Per Section 100.1 Definitions, readily accessible is defined as "capable of being reached quickly for operation, repair, or inspection without requiring climbing or removing obstacles, or resorting to access equipment". Note that ceiling fans with pull chains do not meet the definition of "readily accessible". **«»**

B. Reserved.

C. **All lighting controls**. Lighting controls shall comply with the applicable requirements of Section 110.9.

D. **Controls permitted**. An energy management control system (EMCS) or a multi-scene programmable controller may be used to comply with dimming, occupancy and lighting control requirements in Section 160.5(a)2 if it provides the functionality of the specified controls in accordance with Section 110.9 and the physical controls specified in Section 160.5(a)2A. No controls shall bypass control functions of a dimmer, occupant sensor, or vacancy sensor where the dimmer or sensor has been installed to comply with Sectt«» Commentary for Section 160.5(a)2D:tA lighting circuit can be controlled by more than one switch, such as by three-way or four-way switches. For a lighting circuit with multiple switches, and where a dimmer or vacancy sensor has been installed to comply with Section 160.5(a), the following requirements must be met:tNo controls must bypass the dimmer or vacancy sensor function.

1. The dimmer or vacancy sensor must comply with the applicable requirements of Section 110.9(b). **«»**

E. **Automatic-off controls**.

   i. In bathrooms, garages, laundry rooms, utility rooms and walk-in closets, at least one installed luminaire shall be controlled by an occupancy or vacancy sensor providing automatic-off functionality.

   ii. For lighting internal to drawers and cabinetry with opaque fronts or doors, controls that turn the lighting off when the drawer or door is closed shall be provided.

F. **Dimming controls**. Lighting in habitable spaces, including living rooms, dining rooms, kitchens and bedrooms, shall have readily accessible wall-mounted dimming controls that allow the lighting to be manually adjusted up and down. Forward phase cut dimmers controlling LED light sources shall comply with NEMA SSL 7A.

Exception 1 to Section 160.5(a)2F: Ceiling fans may provide control of integrated lighting via a remote control. Lighting integral to kitchen range hoods and bathroom exhaust fans.

Exception 2 to Section 160.5(a)2F: Luminaires controlled by an occupancy or vacancy sensor providing automatic-off functionality.

Exception 3 to Section 160.5(a)2F: Navigation lighting rated less than five watts**,** such as night lights, step lights and path lights. Lighting controlled by automatic-off controls and located internal to drawers, cabinetry with opaque fronts, or cabinetry with doors.

«» Commentary for Section 160.5(a)2F:

Forward phase cut dimmers controlling LED light sources in these spaces must comply with NEMA SSL 7A. The combined use of a NEMA SSL-7A-compliant dimmer with LED luminaires can ensure flicker free operation when the luminaire is dimmed. This dimmer/light source compatibility information is included in dimmer cut sheets or dimmer product packaging.

Lighting integral to appliances including kitchen range hoods and exhaust fans are not required to be provided with dimming controls. **«»**

G. **Independent controls**. Lighting integrated with the exhaust fans shall be controlled independently from the fans. The following shall be controlled separately from ceiling-installed lighting such that one can be turned on without turning on the other:

   i. Undercabinet lighting

   ii. Undershelf lighting

   iii. Interior lighting of display cabinets

   iv. Switched outlets

3. **Outdoor lighting controls.** In addition to meeting the requirements of Section 160.5(a)1, luminaires providing residential outdoor lighting shall meet the following requirements, as applicable:

   A. Outdoor lighting attached to a building and separately controlled from the inside of a dwelling unit shall meet the following requirements:

      i. Controlled by a manual ON and OFF control switch that permits the automatic actions of Item ii or iii below; and

      ii. Controlled by one of the following controls:

         a. a photocell and a motion sensor; or

         b. a photocell and an automatic time switch control; or

      iii. Controlled by an astronomical time clock control.

B. Controls that override to ON shall not be allowed unless the override automatically returns the automatic control to its normal operation within six hours.

C. An energy management control system (EMCS) or other controls that provides the specified lighting control functionality and complies with all requirements applicable to the specified controls may be used to meet these requirements.

«» Commentary for Section 160.5(a)3C:

All lighting permanently attached to the building or to other buildings on the same lot are subject to the dwelling unit outdoor lighting requirements if controlled from within a dwelling unit. This includes lighting for patios, entrances, balconies, and porches. Any outdoor lighting attached to a building that is not controlled from within a dwelling unit must meet the common use outdoor lighting requirements.

Decorative landscape lighting that is controlled from within a dwelling unit is not regulated by the multifamily lighting requirements. **«»**

(b) Common services area lighting. Lighting systems and equipment in multifamily common services areas shall comply with the applicable provisions of Sections 160.5(b)1 through 160.5(b)4.

Exception to Section 160.5(b): Lighting systems in common use areas providing shared provisions for living, eating, cooking or sanitation to dwelling units that would otherwise lack these provisions may instead comply with Section 160.5(a).

Note: The requirements of Section 160.5(b) apply to newly constructed buildings. Sections 180.1 and 180.2 specify which requirements of Sections 160.5(b)1 through 160.5(e) also apply to additions and alterations to existing buildings.

«» Commentary for Section 160.5(b):

The Energy Code requires that common service area lighting power is within a specified wattage budget, and that lighting controls are installed for the efficient operation of installed lighting.

In addition to meeting all mandatory requirements, design teams can choose between prescriptive and performance compliance approaches. **«»**

1. **Luminaire classification and power**. Luminaires shall be classified, and their wattage determined as follows:

   A. Luminaire wattage shall be labeled as follows:

      i. The maximum rated wattage or relamping rated wattage of a luminaire shall be listed on a permanent, preprinted, factory-installed label, as specified by UL 1574, 1598, 2108 or 8750, as applicable; and

ii. The factory-installed maximum rated wattage or relamping rated wattage label shall not consist of peel-off or peel-down layers or other methods that allow the rated wattage to be changed after the luminaire has been shipped from the manufacturer.

Exception to Section 160.5(b)1Aii: Luminaires with a single lamp and an integrated ballast or transformer may use a peel-down label provided that they are layered such that the rated wattage reduces as successive layers are removed.

a. Low-voltage luminaires (except low voltage track systems), ≤ 24 volts, with a maximum relamping rated wattage of 50 watts.

b. Compact fluorescent luminaires, having an integral electronic ballast, with a maximum relamping rated wattage of 42 watts.

c. High intensity discharge luminaires, having an integral electronic ballast, with a maximum relamping rated wattage of 150 watts.

B. For luminaires with line voltage lamps not served by drivers, ballasts or transformers, the wattage of such luminaires shall be determined as the maximum rated wattage as labeled in accordance with Section 160.5(b)1A.

«» Commentary for Section 160.5(b)1B:

Figure 6-4: Examples of Luminaires With Line-Voltage Lamp Holders

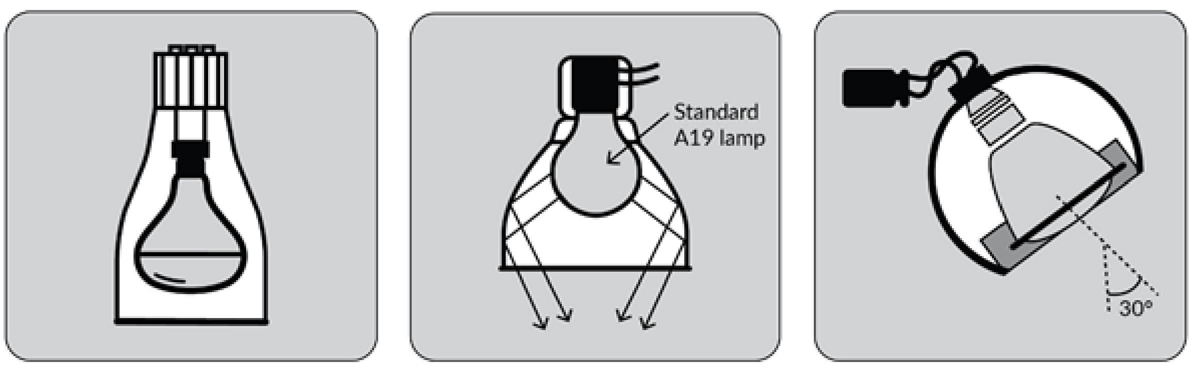


Image Source: Energy Solutions

In common use areas, luminaires with line voltage lamp holders may be acceptable, but the wattage of the luminaires is based on the maximum rated wattage as labeled, not on the wattage of the lamp installed in the luminaire. The maximum rated wattage will determine how many luminaires can be used based on the lighting power allowances for the type of space. «»

C. For luminaires with permanently installed or remotely installed ballasts, the wattage of such luminaires shall be the operating input wattage of the rated lamp/ballast combination published in the ballast manufacturer's catalogs based on independent testing lab reports as specified by UL 1598.

D. For inseparable SSL luminaires and SSL luminaires with remotely mounted drivers, the maximum rated wattage shall be the maximum rated input wattage of the SSL luminaire as specified in Section 160.5(b)1A when tested in accordance with UL 1598, 2108 or 8750, or IES LM-79.

«» Commentary for Section 160.5(b)1D:

Figure 6-5: Examples of SSL Luminaires: Recessed Downlight Luminaires

Image Source: Lutron Electronics Co., Inc.

«»

E. For LED tape lighting and LED linear lighting with LED tape lighting components, the maximum rated wattage shall be the sum of the installed length of the tape lighting times its rated linear power density in watts per linear foot, or the maximum rated input wattage of the driver or power supply providing power to the lighting system, with tape lighting tested in accordance with UL 2108 or 8750, or IES LM-79.

«» Commentary for Section 160.5(b)1E:

Figure 6-6 Examples of LED Tape Lighting

Source: NORA Lighting

The LED tape light products are not specifically matched to an LED driver but the driver does have a maximum wattage rating that will limit the length of LED tape light installed upon it. Section 160.5(b)1E indicates that the LED driver full wattage does not have to be the wattage used in the lighting power density (LPD) calculations because the actual energy consumption for the strip lights will be dependent on how long the tape light segments are and how many watts per foot the tape light product consumes at full output.

In many cases, designers will use a larger driver than the total LED tape light requires to ensure the driver isn't being operated too close to full output all the time, or because there is no driver that perfectly matches the wattage requirements of the tape light. In this circumstance, the designer is permitted to use the wattage per foot of the tape light multiplied by the total length of the tape light instead of the full LED driver rating. **«»**

F. For modular lighting systems that allow the addition or relocation of luminaires without altering the wiring of the system, wattage shall be determined as follows:

   i. The wattage shall be the greater of:

      a. 30 watts per linear foot of track or plug-in busway; or

      b. the rated wattage of all of the luminaires included in the system, where the luminaire wattage is determined as specified in Section 160.5(b)1A; or

   ii. For line-voltage lighting track and plug-in busway served by a track lighting integral current limiter or a dedicated track lighting supplementary overcurrent protection panel, the wattage shall be determined as follows:

      a. The volt-ampere rating of current limiter as specified by UL 1077; or

      b. The sum of the ampere (A) rating of all of the current protection devices times the branch circuit voltages for track lighting supplementary overcurrent protection panel.

   iii. For other modular lighting systems with power supplied by a driver, power supply or transformer, including but not limited to low-voltage lighting systems, the wattage of the system shall be the maximum rated input wattage of the driver, power supply or transformer published in the manufacturer's catalogs, as specified by UL 2108 or 8750.

   Exception to Section 160.5(b)1F: For power-over-Ethernet lighting systems, power provided to installed nonlighting devices may be subtracted from the total power rating of the power-over-Ethernet system.

«» Commentary for Section 160.5(b)1F:

Track lighting is a highly-configurable lighting design approach and accounting for it in lighting power calculations can be complex. The lighting power calculations allow the wattage calculation to be based on the sum of the wattages of all the track heads included for the system or for line-voltage track, by using the track current limiter rating. A PoE (power-over-Ethernet) lighting system provides low-voltage direct current and communications over Ethernet cabling. By contrast, most conventional lighting systems use alternating current to power luminaires.

Figure 6-7 A Track Lighting System

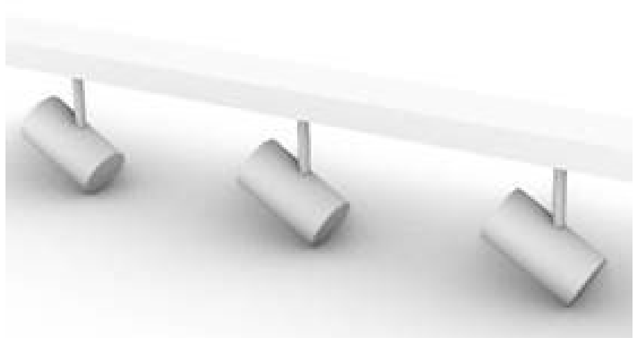


Image Source: California Energy Commission

Figure 6-8 A Track Lighting Installation

Image Source: Acuity Brands Lighting, Inc.

A PoE lighting system usually contains three main components — a powered device (PD), Ethernet cabling, and power sourcing equipment (PSE) such as Ethernet switches. PSE is a general term used for a PoE power supply.

PSEs supply power via Ethernet cabling to PDs, such as PoE luminaires.

Note that PoE lighting is different from the tape light application discussed above in that the wattage of this system must be based on the output of the PSE and not the actual lighting equipment connected to that power source. The exception is that any loads on the PSE that are not lighting equipment can be subtracted from the PSE rated wattage. «»

G. For all other lighting equipment not addressed by Sections 160.5(b)1B through F, the wattage of the lighting equipment shall be the maximum rated wattage of the lighting equipment, or operating input wattage of the system, labeled in accordance with Section 160.5(b)1A, or published in manufacturer's catalogs, based on independent testing lab reports as specified by UL 1574, 1598, 2108, 8750, or IES LM-79.

2. **Lighting controls**. All lighting controls and equipment shall comply with the applicable requirements in Sections 110.9, 160.5(b) and 160.5(c), and shall be installed in accordance with any applicable manufacturer instructions.

3. **Energy Management Control System (EMCS)**. An EMCS may be installed to comply with the requirements of one or more lighting controls if it meets the following minimum requirements:

   A. Provides all applicable functionality for each specific lighting control or system for which it is installed in accordance with Sections 110.9, 160.5(b) and 160.5(c); and

   B. Complies with all applicable lighting control installation requirements in accordance with Section 160.5(e) for each specific lighting control or system for which it is installed; and

   C. Complies with all applicable application requirements for each specific lighting control or system for which it is installed, in accordance with Part 6.

4. **Mandatory indoor lighting controls**. Multifamily common use areas shall comply with the applicable requirements of Sections 160.5(b)4A through 160.5(b)4F, in addition to the applicable requirements of Section 110.9.

   A. **Manual controls.** Each space shall be provided with lighting controls that allow the lighting in that space to be manually turned on and off. The manual control shall:

      i. Be readily accessible; and

      Exception to Section 160.5(b)4Ai: Restrooms having two or more stalls, parking areas, stairwells, corridors and spaces of the building intended for access or use by the public may use a manual control not accessible to unauthorized personnel.

ii. Be located in the same space, or be located such that the controlled lighting or the status of the controlled lighting can be seen when operating the controls; and

iii. Provide separate control of general, floor display, wall display, window display, case display, ornamental, and special effects lighting, such that each type of lighting can be turned on or off without turning on or off other types of lighting. Scene controllers may comply with this requirement provided that at least one scene turns on general lighting only, and the control provides a means to manually turn off all lighting.

«» Commentary for Section 160.5(b)4A:

Each multifamily common use area space shall have lighting controls that allow lighting in that area to be manually turned on and off. Manual area controls allow occupants to control the light while they are in the space.

General lighting (also known as ambient lighting) is electric lighting that provides a uniform level of illumination throughout an area exclusive of any provision for special visual tasks or decorative effect, or exclusive of daylighting. General lighting is the primary lighting resource for basic tasks in general office spaces, etc. and is intended to be supplemented by task lights for visually intensive tasks.

Typical luminaires used for general lighting are troffers (prismatic, parabolic, or indirect diffusers), pendants (direct, indirect, or direct/indirect), high bay, low bay, and "aisle-lighter" fixtures. General lighting does not include display lighting (typically using directional MR, PAR, flood, spot, or wall washers) or decorative lighting (such as drum fixtures, chandeliers, or projection lighting.)

Section 100.1 also defines decorative, display, task, and special effects lighting as follows:

1. Decorative lighting or luminaires are installed only for aesthetic purposes that do not serve as display lighting or general lighting. Decorative luminaires are chandeliers, sconces, lanterns, cove lighting, neon or cold cathode, theatrical projectors, moving lights, and light color panels, not providing general lighting or task lighting.
2. Display lighting is supplementary lighting that provides a higher level of illuminance to a specific area than the level of surrounding ambient illuminance required to highlight features, such as merchandise, sculpture, or artwork.
3. Task lighting is lighting directed to a specific surface or area providing illumination for visual tasks. Task lighting is not general lighting.
4. Special effects lighting is lighting installed to give off luminance instead of providing illuminance, which does not serve as general, task, or display lighting.

When there is only one lighting system type in a space, that system type will be treated as general lighting. Thus, light fixtures that might ordinarily be considered decorative or display luminaires are considered general lighting luminaires if they are the only system type in a given enclosed space. Note that the allowances for lighting cannot be combined; if a lighting system is deemed to be a general lighting system, it cannot also include the lighting allowance for decorative lighting or other supplementary lighting systems in the calculation. General lighting must also be circuited independent of decorative and display lighting. «»

Exception to Section 160.5(b)4A: Up to 0.1 watts per square foot of indoor lighting may be continuously illuminated to allow for means of egress illumination consistent with California Building Code Section 1008. Egress lighting complying with this wattage limitation is not required to comply with manual area control requirements if:

i. The space is designated for means of egress on the plans and specifications submitted to the enforcement agency under Section 10-103(a)2 of Part 1; and

ii. The egress lighting controls shall not be controllable by unauthorized personnel during a normal power failure.

B. **Multilevel lighting controls.** The general lighting of any space with a size of 100 square feet or larger and with a connected lighting load greater than 0.5 watts per square foot shall be provided with multilevel lighting controls. The multilevel lighting controls shall provide and enable continuous dimming from 100 percent to 10 percent or lower of lighting power.

Exception 1 to Section 160.5(b)4B: An indoor space that has only one luminaire.

Exception 2 to Section 160.5(b)4B: Restrooms.

Exception 3 to Section 160.5(b)4B: The general lighting with light source of HID and induction shall have a minimum of one control step between 30 and 70 percent of full rated power.

«» Commentary for Section 160.5(b)4B:

Multilevel lighting controls allow the lighting level to be adjusted to accommodate how a room is being used. «»

C. **Shut-OFF controls.** All installed indoor lighting shall be equipped with controls able to automatically reduce lighting power when the space is typically unoccupied.

Exception to Section 160.5(b)4C: Continuous illumination of up to 0.1 watts per square foot of lighting is allowed to be in any area designated for egress within a building, provided that the area is indicated on the plans and specifications submitted to the enforcement agency under Section 10-103(a)2 of Part 1. Lighting providing means of egress illumination, as defined in the

California Building Code, shall be configured to provide no less than the illumination required by California Building Code Section 1008 while in the partial-off mode.

i. All installed indoor lighting shall be equipped with controls that meet the following requirements:

   a. Shall be controlled with an occupant sensing control set at no more than a 20-minute time delay, automatic time-switch control, or other control capable of automatically shutting OFF all of the lighting when the space is typically unoccupied; and

   b. Separate controls for the lighting on each floor, other than lighting in stairwells; and

   c. Separate control zones for a space enclosed by ceiling height partitions not exceeding 5,000 square feet;

   Exception 1 to Section 160.5(b)4Ci: Where the lighting is serving an area that is in continuous use, 24 hours per day/365 days per year.

   Exception 2 to Section 160.5(b)4Ci: Lighting complying with Section 160.5(b)4Cv or Section 160.5(b)4Cvic.

   Exception 3 to Section 160.5(b)4Ci: Electrical equipment rooms subject to Article 110.26(D) of the California Electrical Code.

   Exception 4 to Section 160.5(b)4Ci: Illumination provided by lighting equipment that is designated for emergency lighting, and intended to function in emergency mode only when normal power is absent.

ii. Countdown timer switches may be used to comply with the automatic shut-OFF control requirements in Section 160.5(b)4Ci only in closets less than 70 square feet. The maximum timer setting shall be 10 minutes for closets.

iii. If an automatic time-switch control is installed to comply with Section 160.5(b)4Ci, it shall incorporate a manual override lighting control that allows the lighting to remain on for no more than 2 hours when an override is initiated.

   Exception to Section 160.5(b)4Ciii: Areas where occupant sensing controls are installed.

iv. If an automatic time-switch control is installed to comply with Section 160.5(b)4Ci, it shall incorporate an automatic holiday "shut-OFF" feature that turns OFF all loads for at least 24 hours, and then resumes the normally scheduled operation.

Exception 1 to Section 160.5(b)4Civ: Automatic holiday shut-OFF features are not required in restaurants.

Exception 2 to Section 160.5(b)4Civ: Areas where occupant sensing controls are installed.

v. **Occupant sensing controls.** In offices 250 square feet or smaller, multipurpose rooms of less than 1,000 square feet, conference rooms, and restrooms, lighting shall be controlled with occupant sensing controls to automatically shut OFF all of the lighting in 20 minutes or less after the control zone is unoccupied.

In areas required by Section 160.5(b)4B to have multi-level lighting controls, the occupant sensing controls shall function either as:

a. a partial-ON occupant sensing control capable of automatically activating between 50 and 70 percent of controlled lighting power, or

b. a vacancy sensing control, where all lighting responds to a manual ON input only.

In areas not required by Section 160.5(b)4B to have multi-level lighting controls the occupant sensing controls shall function either as:

a. an automatic full-on occupant sensing control; or

b. a partial-ON occupant sensing control, or

c. a vacancy sensing control, where all lighting responds to a manual ON input only.

In addition, controls shall be provided that allow the lights to be manually shut OFF in accordance with Section 160.5(b)4A regardless of the sensor status.

«» Commentary for Section 160.5(b)4C:

Figure 6-9: Functional Diagram for Partial-ON Occupant Sensor

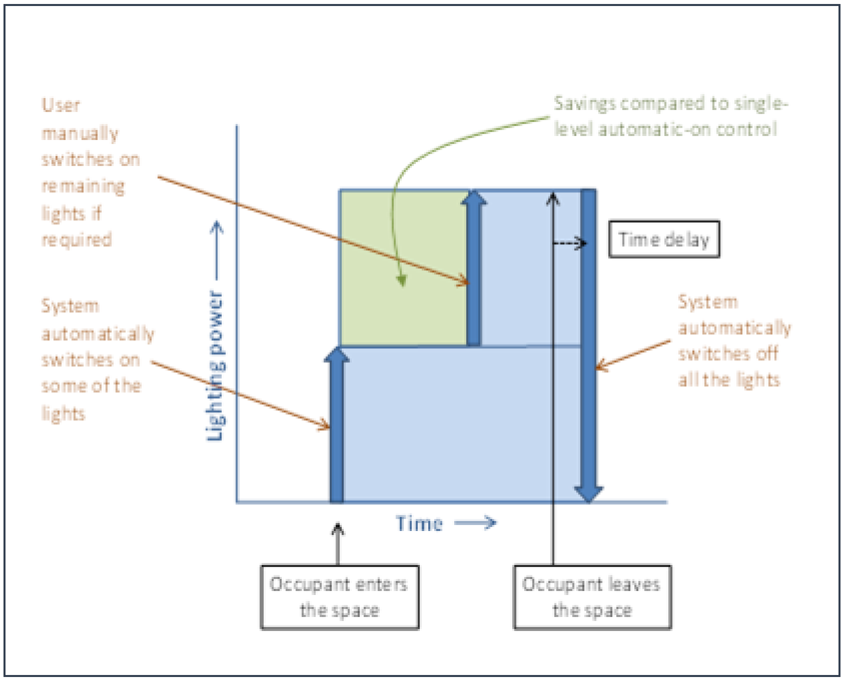


Image Source: California Energy Commission

Figure 6-9: Functional Diagram for Partial-ON Occupant Sensor illustrates the typical operation of a Partial-ON occupant sensor. A portion of the lighting automatically turns on when an occupant enters the space (illustrated by the lower blue rectangle), the occupant can manually turn on the rest of the lighting in the space when needed (the upper blue rectangle), and all of the lighting in the space automatically turns off when the space is no longer occupied. «»

vi. **Full or partial OFF occupant sensing controls.** For corridors, stairwells, and offices greater than 250 square feet, parking garages, parking areas, loading areas, and unloading areas, the installed lighting shall meet the following requirements:

a. In corridors and stairwells, lighting shall be controlled by occupant sensing controls that separately reduce the lighting power in each space by at least 50 percent when the space is unoccupied. The occupant sensing controls shall be capable of automatically turning the lighting fully ON only in the separately controlled space and shall be automatically activated from all designed paths of egress.

b. In office spaces greater than 250 square feet, general lighting shall be controlled by occupancy sensing controls that meet all of the following:

I. The occupancy sensing controls shall be configured so that lighting shall be controlled separately in control zones not greater than 600 square feet. All control zones in offices greater than 250 square feet shall be shown on the plans; and

II. In 20 minutes or less after the control zone is unoccupied, the occupancy sensing controls shall uniformly reduce lighting power in the control zone to no more than 20 percent of full power. Control functions that switch control zone lights completely off when the zone is vacant meet this requirement; and

III. In 20 minutes or less after the entire office space is unoccupied, the occupancy sensing controls shall automatically turn off lighting in all control zones in the space; and

IV. In each control zone, lighting shall be allowed to automatically turn on to any level up to full power upon occupancy within the control zone. When occupancy is detected in any control zone in the space, the lighting in other control zones that are unoccupied shall operate at no more than 20 percent of full power.

Exception to Section 160.5(b)4Cvib: Under-shelf or furniture-mounted task lighting controlled by a local switch and either a time switch or an occupancy sensor.

«» Commentary for Section 160.5(b)4Cvi:

All installed indoor lighting in multifamily common use areas shall be equipped with controls that are able to automatically reduce lighting power when the space is typically unoccupied.

Shut off controls can be used to automatically turn off or reduce lighting when the spaces are not occupied.

Offices larger than 250 sq. ft. are required to be equipped with an occupant sensing control that manages the general lighting and may also control HVAC thermostat setback and air flow (Section 160.5(b)4Cvib, Section 160.3(a)2D, Section 160.2(c)3, and Section 160.2(c)5E). The occupant sensing control for the space must be capable of signaling to the HVAC system the occupancy status of the space independent of the lighting load status.

Using the same occupancy sensors for the lighting and the HVAC system immediately alerts occupants if the occupancy sensors have failed, as the lights would turn off when the space is occupied. An occupancy sensor failure might not be as readily apparent if it controlled the HVAC system only. However, it is not a requirement that the lighting and HVAC systems be controlled by the same occupancy sensor. This method of controlling cooling, ventilation, and lighting satisfies the requirements of Section 160.3(a)2D, Section 160.2(c)5E, and Section 160.5(b)4Cvib, so no additional shut off controls are required in these spaces (except for lighting associated with the egress path, which may remain energized when the building is unoccupied).

Figure 6-10 (for Example 6-1): Occupant Sensing Control Zones for Office Spaces Greater Than 250 Square Feet

In office spaces greater than 250 sq. ft., the occupant sensing controls must be configured such that general lighting in the space is divided into separate control zones, and the size of each control zone must be 600 sq. ft. or less.

Figure 6-10 (for Example 6-1) An Office Plan With Occupant Sensing Control Zone Layout below provides an example of a 2,584 square foot office that meets this requirement. Display lighting and wall wash are omitted as they do not need to comply with this requirement. In this case, the office is divided into eight occupant sensing control zones, each controlled by an occupant sensor. The occupant sensors in this example have a circular coverage pattern with a radius of 13.5 feet, resulting in a coverage area of 573 square feet, which meets the 600 square feet or less per control zone requirement. Each circle in the image represents the coverage area of the occupant sensor located at the center of the circle. The evenly spaced purple rectangles represent 2’x4’ luminaires that provide general lighting in the office, and the luminaires within each circle are controlled by the occupant sensor at the center of the circle. If a luminaire is in two or more circles, it is controlled by the closest occupant sensor.

The size of each control zone is at the discretion of the practitioner, as long as it is not larger than 600 square feet. The control zones within the office space do not need to be equal in size. If each occupant sensing control zone in an office is 250 square feet or less and the prescriptive compliance path is used, consider taking advantage of the power adjustment factor (PAF) provided in Section 170.2(e)2B for occupant sensing controls in offices larger than 250 square feet. Refer to Table 170.2-L for more information on the PAF.

Figure 6-10 (for Example 6-1) An Office Plan With Occupant Sensing Control Zone Layout

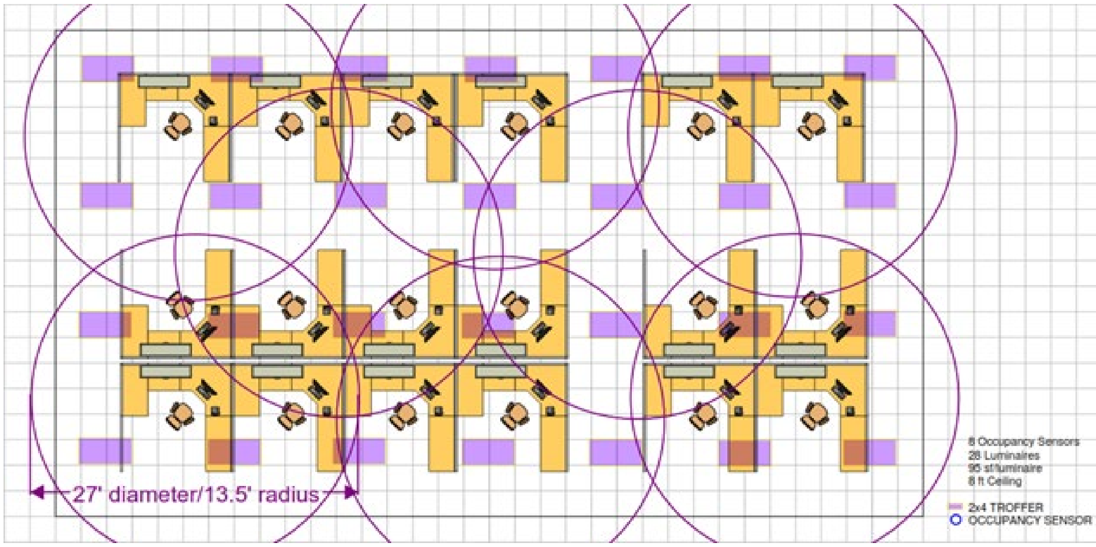


Image Source: Energy Solutions

Figure 6-11 (for Example 6-2): Occupant Sensing Control Zone in a Large Office Using Power Adjustment Factor

Figure 6-11 (for Example 6-2) An Office Plan With Occupant Sensing Control Zone Layout below shows another occupant sensing control zone design for the same 2,584 sq. ft. office. In this design, 15 occupant sensors are used to meet the requirement, and each sensor has a circular coverage pattern with a radius of 8.5 feet, resulting in a coverage area of 227 sq. ft. Because each sensor controls 227 sq. ft., which is less than 250 sq. ft. but more than 126 sq. ft., a PAF of 0.20 can be used per Table 170.2-L. Refer to Section 170.2(e)2B for detailed requirements on using the PAF for occupant sensing controls in offices larger than 250 square feet.

Note that using PAFs for occupant sensing controls is dependent on the square footage that each occupant sensor covers and not the number of occupant sensors used. For example, if each of the 15 occupant sensors in Figure 6-11 (for Example 6-2) An Office Plan With Occupant Sensing Control Zone Layout below had a coverage area greater than 250 sq. ft., the design would not qualify to use the PAF.

Figure 6-11 (for Example 6-2) An Office Plan With Occupant Sensing Control Zone Layout

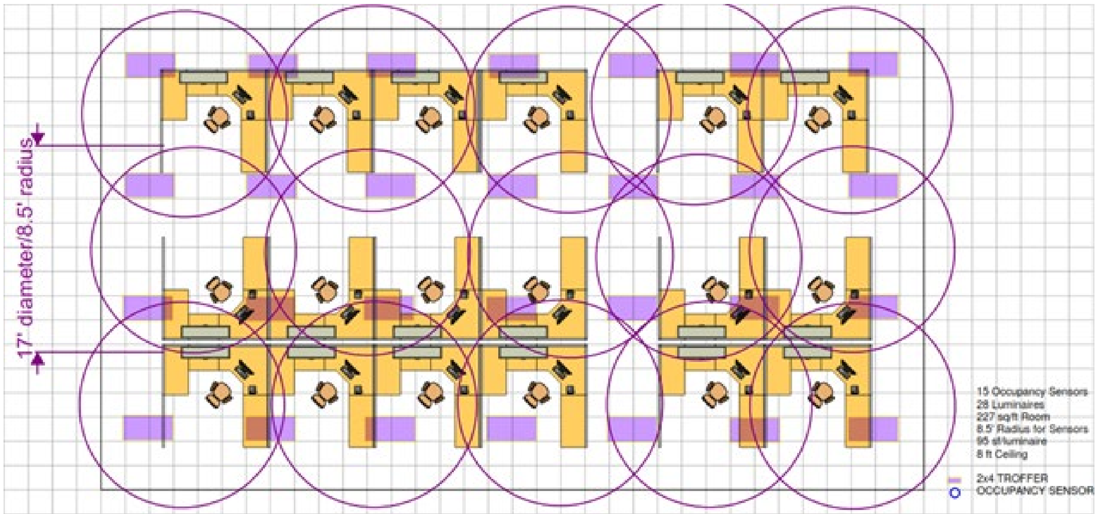


Image Source: Energy Solutions

Figure 6-12 (for Example 6-3): Occupant Sensing Control Zones for Luminaires With Integral Occupant Sensors

For luminaires with an integral occupant sensor that are capable of reducing power independently from other luminaires, each luminaire can be considered as its own control zone, and the size of the control zone equals the coverage area of the luminaire-integrated occupant sensor. This configuration is likely to result in occupant sensing control zones 250 sq. ft. or smaller. So, if using the prescriptive compliance path, consider taking advantage of the PAF provided in Section 170.2(e)2B for occupant sensing controls in offices larger than 250 square feet. Refer to Table 170.2-L for more about using the PAF.

Note that each luminaire with an integral occupant sensor can be considered as its own control zone only if they are commissioned to reduce power independently from other luminaires. Several lighting systems allow "grouping" luminaires with an integral occupant sensor. In such a grouping configuration, all luminaires within the group will operate to provide the designed task light level as long as one luminaire-integrated sensor detects occupancy. Similarly, all luminaires will reduce power to 20 percent or less only after no occupant is detected by any of the luminaire-integrated sensors within the group for 20 minutes. In this case, the total area covered by a group of luminaire-integrated occupant sensors is considered as a single occupant sensing control zone and shall be 600 square feet or less.

Figure 6-12 (for Example 6-3): An Office Plan With Occupant Sensing Control Zone Layout below provides an example of the same 2,584 sq. ft. office using luminaires with an integral occupant sensor, with each luminaire commissioned to reduce power independently from the other luminaires. In this case, there are 28 luminaires; therefore, there are 28 occupant sensing control zones. The coverage area of each sensor (and therefore the size of each control zone) is 100 sq. ft. This occupant sensing control zone design not only meets the control requirements but is eligible for a PAF of

0.30 since each occupant sensing control zone is less than 125 sq. ft. (see Table 170.2-L).

Figure 6-12 (for Example 6-3): An Office Plan With Occupant Sensing Control Zone Layout

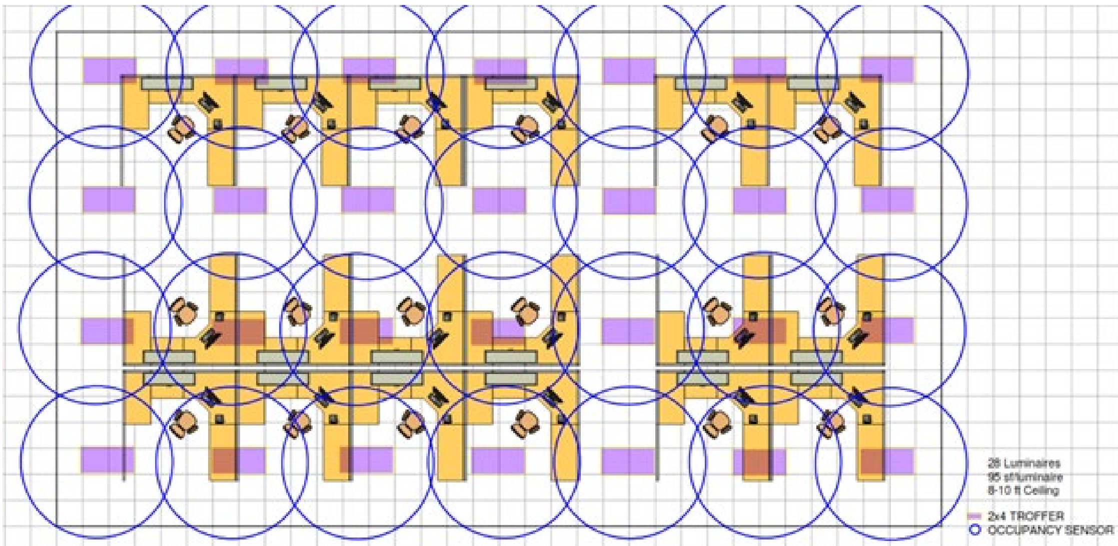


Image Source: Energy Solutions

Figure 6-13 (for Example 6-4): Occupant Sensing Controls for an Office Greater Than 250 Square Feet With a Single Control Zone

An office space larger than 250 sq. ft. but smaller than or equal to 600 sq. ft. may have a single control zone for the entire office as long as the field of view of the occupant sensor is able to cover the entire office. Figure 6-13 (for Example 6-4) An Office Plan With Occupant Sensing Control Zone Layout below shows a shared office space of 400 square feet as an example. In this case, a single occupant sensor is able to cover the entire office and, therefore, meets the requirement.

Figure 6-13 (for Example 6-4) An Office Plan With Occupant Sensing Control Zone Layout

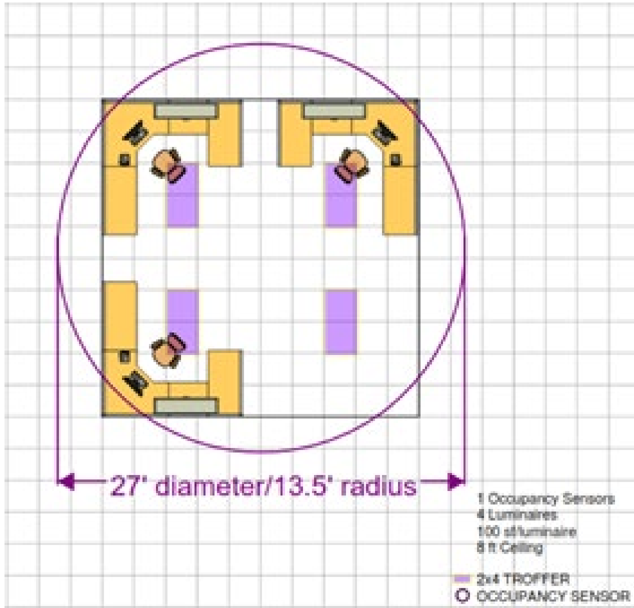


Image Source: Energy Solutions

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c. In parking garages, parking areas, and loading and unloading areas, general lighting shall be controlled by occupant sensing controls that meet the requirements below instead of complying with Section 160.5(b)4Ci:

   i. The occupant sensing controls shall uniformly reduce lighting power in the control zone to between 20 percent and 50 percent of full power and with at least one control step; and

   ii. No more than 500 watts of rated lighting power shall be controlled together as a single zone; and

   iii. The occupant sensing controls shall be capable of automatically turning the lighting fully ON only in the separately controlled zone and shall be automatically activated from all designed paths of egress.

   Interior areas of parking garages are under the classification of indoor lighting and shall comply with Section 160.5(b)4Cvic. Parking areas on the roof of a parking structure are under the classification of outdoor hardscape and shall comply with Section 160.5(c).

«» Commentary for Section 160.5(b)4Cvic:

For the spaces described in Section 160.5(b)4Cvic, lighting power must be reduced by at least 50 percent of the design lighting power, and the lighting must be reduced while maintaining similar levels of uniformity to the full power conditions. The zoning of the controls requires careful consideration of paths of egress to ensure that the sensor coverage in the zone is adequate. The wattage limits per zone will typically not permit entire floors of a garage to be on a single zone.

Regardless of the wattage limits, the sensors must cover the full area of the controlled lighting to ensure there are no dead zones in the sensors that will cause the system to not respond appropriately.

Interior areas of parking garages are classified as indoor lighting for compliance with Section 160.5(b)4Cvic.

The parking areas on the roof of a parking structure are classified as outdoor hardscape and shall comply with the applicable provisions in Section 160.5(c). Controls requirements in Section 160.5(b)4Cvic do not apply to open rooftop parking.

A partial off lighting control system as shown in Figure 6-14 Functional Diagram for Partial Off Occupant Sensor commonly employed in spaces in a building that are public and not 'owned' by an individual or several people such that they would have manual override controls.

This design approach is often used for corridors and lobbies inside the building and in parking garages. After normal hours, the lighting will be 'Off' but will respond to an occupancy event, but during normal hours, it will operate in a 'Partial-on' level until an occupancy event, where it will rise up to the 'occupied' level, which may be fully 'On'.

Figure 6-14 Functional Diagram for Partial Off Occupant Sensor

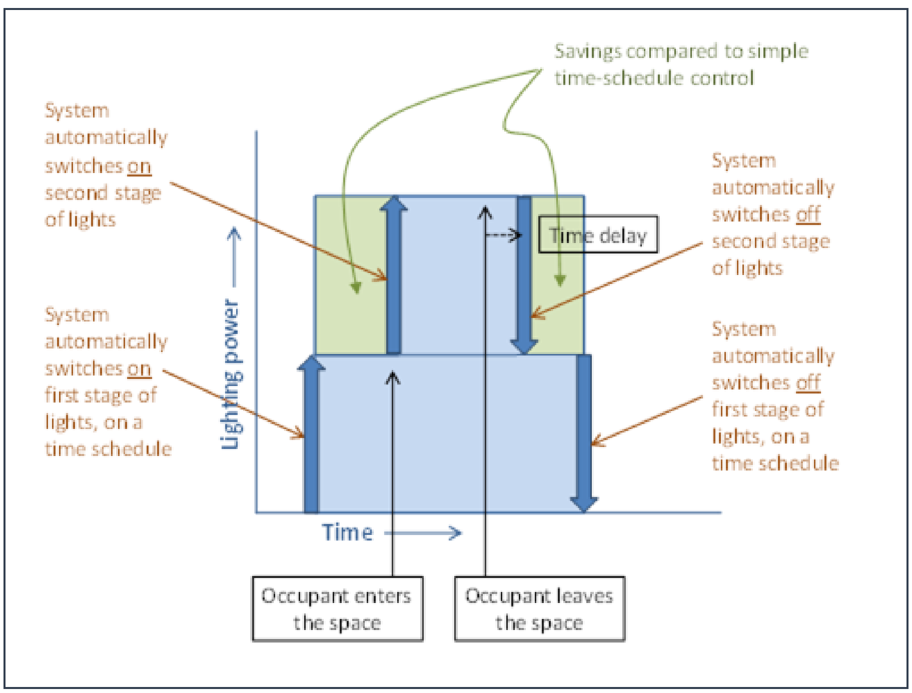

Image Source: California Energy Commission

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D. **Daylight Responsive Controls.**

Daylight responsive controls shall be installed in the following locations, as applicable:

i. In any enclosed space where the total installed wattage of general lighting luminaires completely or partially within skylit daylit zones is 75 watts or greater, the general lighting in the skylit daylit zones shall be controlled by daylight responsive controls.

ii. In any enclosed space where the total installed wattage of general lighting luminaires completely or partially within primary sidelit daylit zones is 75 watts or greater, the general lighting in the primary sidelit daylit zones shall be controlled by daylight responsive controls. In any enclosed space where the total wattage of general lighting luminaires in the secondary zones is 75 watts or greater, the general lighting in the secondary sidelit daylit zones shall be controlled by daylight responsive controls. General lighting in the secondary sidelit daylit zones shall be controlled independently of general lighting in the primary sidelit daylit zones. For skylights located in an atrium, the skylit daylit zones shall apply to the floor area directly under the atrium and the top floor area directly adjacent to the atrium. Parking garage areas where the total installed wattage of the general lighting in the primary and the secondary sidelit daylit zones is 60 watts or greater, the general lighting in the primary and secondary sidelit daylit zones shall be controlled by daylight responsive controls.

All daylight responsive controls shall meet the following requirements:

iii. All skylit daylit zones, primary sidelit daylit zones, secondary sidelit daylit zones and the combined primary and secondary sidelit daylit zones in parking garages shall be shown on the plans; and

Note: Parking areas on the roof of a parking structure are outdoor hardscape, not skylit daylit areas.

iv. The daylight responsive controls shall provide separate control for general lighting in each type of daylit zone. The daylight responsive controls shall meet the following:

. General lighting in overlapping skylit daylit zone and sidelit daylit zone shall be controlled as part of the skylit daylit zone.

a. General lighting in overlapping primary and secondary sidelit daylit zone shall be controlled as part of the primary sidelit daylit zone.

b. General lighting luminaires longer than 8 feet shall be controlled as segments of 8 feet or less according to the type of the daylit zone the segment is primarily located; and

Exception to Section 160.5(b)4Dviic: Where a luminaire contains a factory assembled housing and light source as an integral unit in segments longer than 8 feet, the luminaire is allowed to be controlled according to the type of the daylit zone in which the segment is primarily located.

v. The daylight responsive controls shall meet the following:

   a. For spaces where the installation of multilevel lighting controls is required under Section 160.5(b)4B, allow the multilevel lighting controls to adjust the light level with continuous dimming;

   b. For each space, ensure the combined illuminance from the controlled lighting and daylight is not less than the illuminance from controlled lighting when no daylight is available;

   c. For areas other than parking garages, ensure that when the daylight illuminance is greater than 150 percent of the illuminance provided by the controlled lighting system when no daylight is available, the controlled lighting power in that daylight zone shall be reduced by a minimum of 90 percent; and

   d. For parking garages, ensure that when daylight illuminance levels measured at the farthest edge of the secondary sidelit zone away from the glazing or opening are greater than 150 percent of the illuminance provided by the controlled lighting when no daylight is available, the controlled lighting power in the combined primary and secondary sidelit daylight zones shall be reduced by 100 percent; and

vi. Photosensor shall be located so that they are not readily accessible to unauthorized personnel; and

vii. The location where calibration adjustments are made to the daylight responsive controls shall be readily accessible to authorized personnel but may be inside a locked case or under a cover that requires a tool for access; and

viii. Interaction with other lighting controls in a space where manual controls are required, the manual controls shall be capable of turning off or decreasing light levels below the light level set by the daylight responsive controls.

Exception 1 to Section 160.5(b)4D: Areas under skylights where it is documented that existing adjacent structures or natural objects block direct sunlight for more than 1,500 daytime hours per year between 8 a.m. and 4 p.m.

Exception 2 to Section 160.5(b)4D: Areas adjacent to vertical glazing below an overhang, where the overhang covers the entire width of the vertical glazing, no vertical glazing is above the overhang, and the ratio of the overhang projection to the overhang rise is greater than 1.5 for south, east and west orientations or greater than 1 for north orientations.

Exception 3 to Section 160.5(b)4D: Where daylight responsive controls are not required for the primary sidelit daylit zones, and where the total wattage of general lighting luminaires in the secondary sidelit daylit zones is less than 85 watts, daylight responsive controls are not required for the secondary sidelit zone.

Exception 4 to Section 160.5(b)4D: Reserved.

Exception 5 to Section 160.5(b)4D: Rooms that have a total glazing area of less than 24 square feet, or parking garage areas with a combined total of less than 36 square feet of glazing or opening.

Exception 6 to Section 160.5(b)4D: For parking garages, luminaires located in the daylight adaptation zone.

Exception 7 to Section 160.5(b)4D: Luminaires in sidelit daylit zones in retail merchandise sales and wholesale showroom areas.

«» Commentary for Section 160.5(b)4D:

Daylit zone is the floor area under skylights or next to windows. Types of daylit zones include primary sidelit daylit zone, secondary sidelit daylit zone, and skylit daylit zone.

Window Head Height is the vertical distance from the finished floor level to the top of a window or vertical fenestration.

There are three types of daylit zones, skylit daylit zone, primary sidelit daylit zone, and secondary sidelit daylit zone.

Skylit Daylit Zone

Skylit daylit zone is the rough area in plan view under each skylight, *plus* 0.7 times the average ceiling height in each direction from the edge of the rough opening of the skylight, *minus* any area on a plan beyond a permanent obstruction that is taller than one-half the distance from the floor to the bottom of the skylight.

Note: Modular furniture walls should not be considered a permanent obstruction.

The bottom of the skylight is measured from the bottom of the skylight well (for skylights having wells), or the bottom of the skylight if no skylight well exists.

For determining the skylit daylit zone, the geometric shape of the skylit daylit zone shall be identical to the plan view geometric shape of the rough opening of the skylight; for example, the skylit daylit zone for a rectangular skylight must be rectangular. For a circular skylight, the skylit daylit zone must be circular.

Figure 6-15: Example of Skylit Daylit Zone Layout in Overhead View

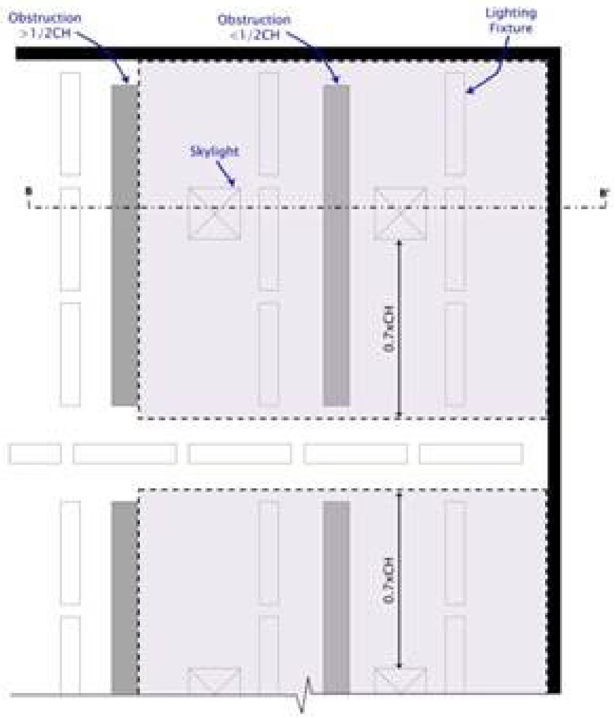

Image Source: California Energy Commission

Figure 6-16: Example of Skylit Daylit Zone Layout in Side View

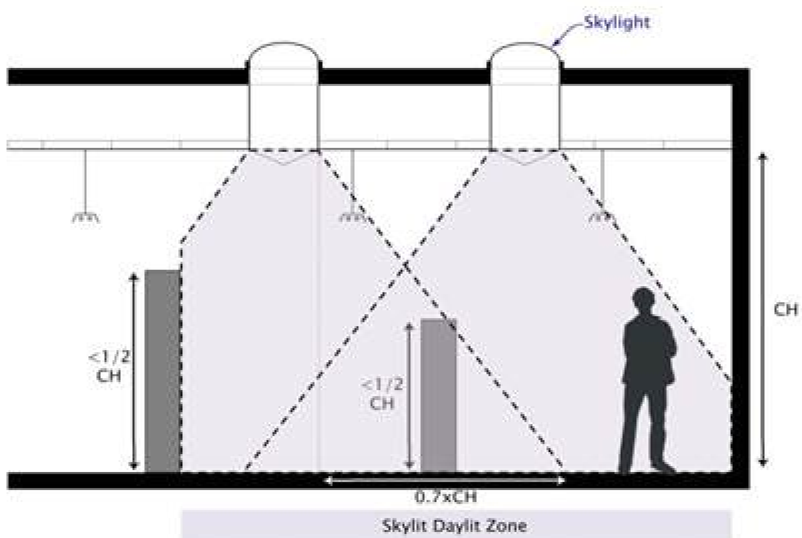

Image Source: California Energy Commission

PRIMARY SIDELIT DAYLIT ZONE

Primary sidelit daylit zone is the area in plan view directly adjacent to each vertical glazing, one window head height deep into the area, and window width *plus* 0.5 times window head height wide on each side of the rough opening of the window, *minus* any area on a plan beyond a permanent obstruction that is 6 feet or taller as measured from the floor.

Note: Modular furniture walls should not be considered a permanent obstruction.

Figure 6-17: Example of Primary Sidelit Daylit Zone Layout in Overhead View

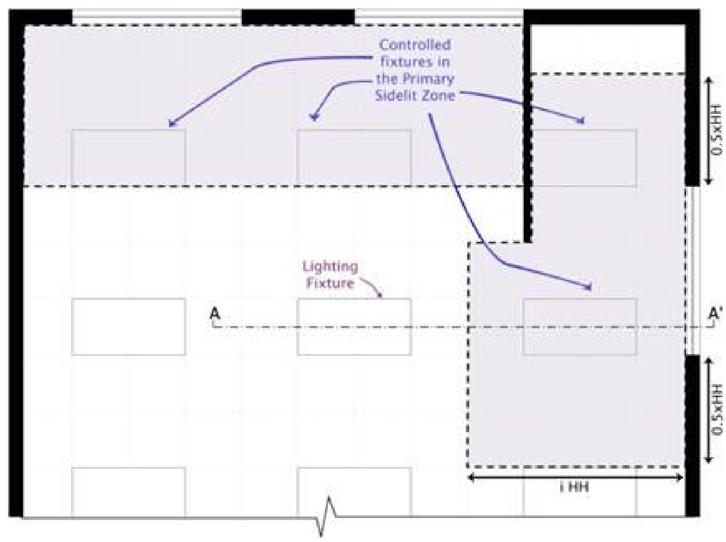

Image Source: California Energy Commission

Figure 6-18: Example of Primary Sidelit Daylit Zone Layout in Side View

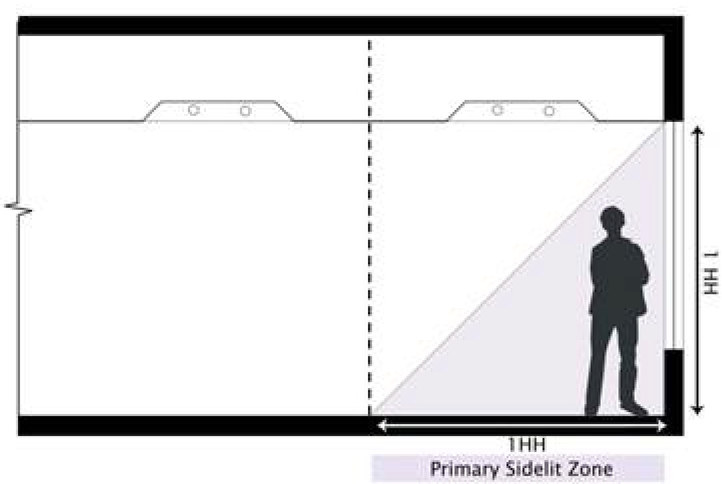

Image Source: California Energy Commission

SECONDARY SIDELIT DAYLIT ZONE

Secondary sidelit daylit zone is the area in plan view directly adjacent to each vertical glazing, two window head heights deep into the area, and window width *plus* 0.5 times window head height wide on each side of the rough opening of the window, *minus* any area on a plan beyond a permanent obstruction that is 6 feet or taller as measured from the floor.

Note: Modular furniture walls should not be considered a permanent obstruction.

Figure 6-19: Example of Secondary Sidelit Daylit Zone in Side View

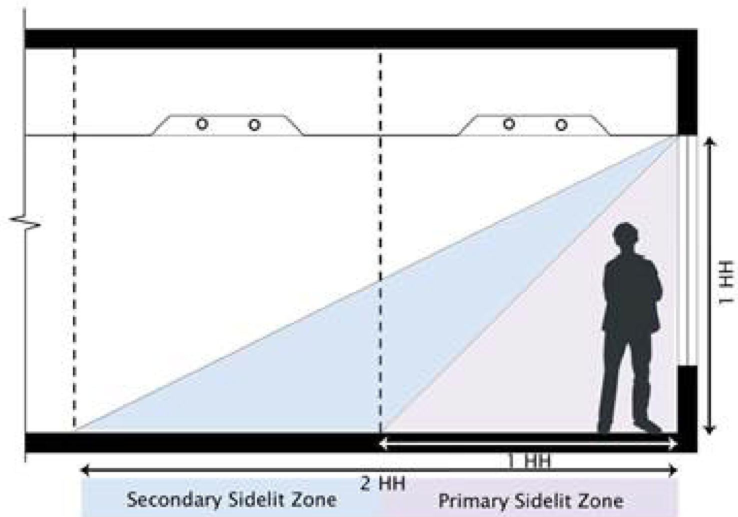

Image Source: California Energy Commission

Figure 6-20: Example of Secondary Sidelit Daylit Zone in Overhead View

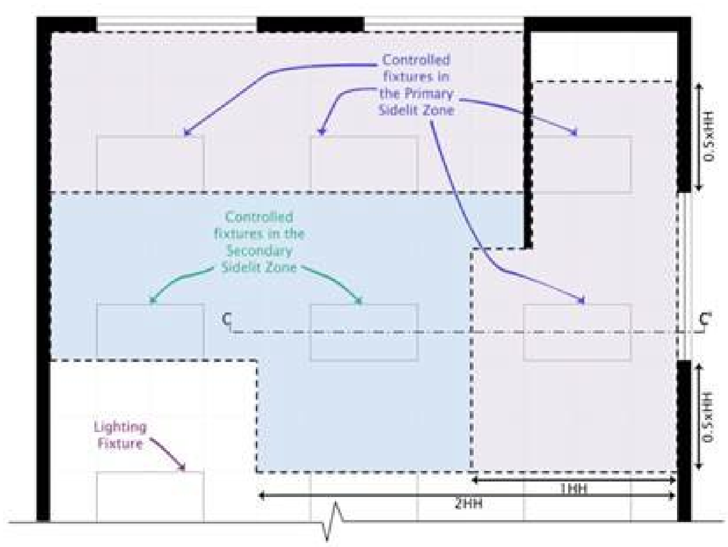

Image Source: California Energy Commission

Figure 6-21: Sidelit Daylit Zone Layout for a Bay Window

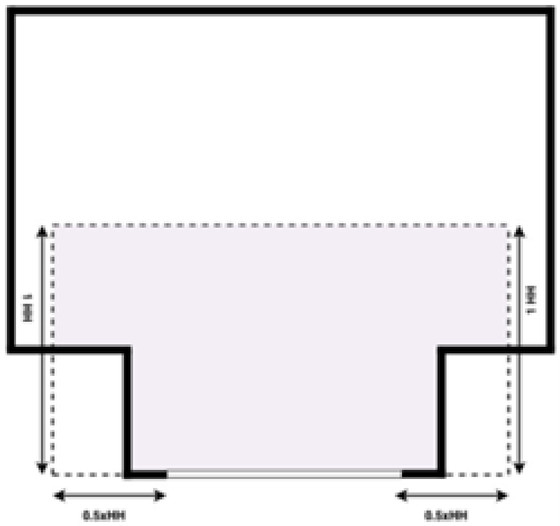

Image Source: California Energy Commission

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E. **Demand Responsive Controls.** See Section 110.12 for requirements for demand responsive lighting controls.

F. **Occupancy Sensing Controls interactions with Space-conditioning Systems.** For space-conditioning system zones serving only spaces that are required to have occupancy sensing controls as specified in Sections 160.5(b)4Cv and vi, and where Table 120.1-A allows the ventilation air to be reduced to zero when the space is in occupied-standby mode, the space conditioning system shall be permitted to be controlled by occupancy sensing controls as specified in Section 120.2(e)3.

(c) Outdoor lighting and control equipment. Multifamily buildings shall comply with the applicable requirements of Sections 160.5(c)1 through 160.5(c)2.

1. **Luminaire shielding requirements.** All outdoor luminaires of 6,200 initial luminaire lumens or greater shall comply with Backlight, Uplight, and Glare (BUG) (in accordance with ANSI/IES TM-15-20, Annex A) requirements in accordance with Title 24, Part 11, Section 5.106.8.

   Exception 1 to Section 160.5(c)1: Signs.

   Exception 2 to Section 160.5(c)1: Lighting for building facades, public monuments, public art, statues and vertical surfaces of bridges.

   Exception 3 to Section 160.5(c)1: Lighting not permitted by a health or life safety statute, ordinance or regulation to be a cutoff luminaire.

   Exception 4 to Section 160.5(c)1: Temporary outdoor lighting**.**

Exception 5 to Section 160.5(c)1: Replacement of existing pole mounted luminaires in hardscape areas meeting all of the following conditions:

A. Where the existing luminaire does not meet the luminaire BUG requirements in Section 160.5(c)1; and

B. Spacing between existing poles is greater than six times the mounting height of the existing luminaires; and

C. Where no additional poles are being added to the site; and

D. Where new wiring to the luminaires is not being installed; and

E. Provided that the connected lighting power wattage is not increased.

Exception 6 to Section 160.5(c)1: Luminaires that illuminate the public right of way, including publicly maintained or utility-maintained roadways, sidewalks and bikeways.

Exception 7 to Section 160.5(c)1: Outdoor lighting attached to a multifamily building and separately controlled from the inside of a dwelling unit.

Exception 8 to Section 160.5(c)1: Luminaires that qualify as exceptions in Sections 5.106.8 of Part 11 of Title 24 and in Section 170.2(e)6A.

«» Commentary for Section 160.5(c)1:

The 2025 Energy Code includes outdoor luminaire shielding requirements based on the luminaire's initial lumen rating. See Figure 6-22: The Three Primary Solid Angles of the Luminaire Classification System for Outdoor Luminaires below for an illustration of BUG rating zones.

The BUG ratings assume that the light emitted from the luminaire is providing useful illuminance on the task surfaces rather than scattering the light in areas where the light is not needed or intended, such as toward the sky. These BUG ratings also increase visibility because high amounts of light shining directly into observer's eyes are reduced, thus decreasing glare. Additionally, light pollution into neighboring properties is reduced. The BUG requirements vary by outdoor lighting zones which are described in Section 10-114 of Title 24, Part 1.

Luminaire manufacturers typically provide the BUG ratings for their luminaires in product specifications or cutsheets. In the rare occasions where the luminaire manufacturer does not provide a BUG rating, it can be calculated with outdoor lighting software if the luminaire photometric data is available.

There are exceptions to the luminaire shielding and the BUG rating requirements in the Energy Code.

In addition, a local ordinance may have more stringent outdoor lighting BUG requirements than the CALGreen Code — the local ordinance would govern the outdoor lighting BUG requirements in that scenario.

Figure 6-22: The Three Primary Solid Angles of the Luminaire Classification System for Outdoor Luminaires

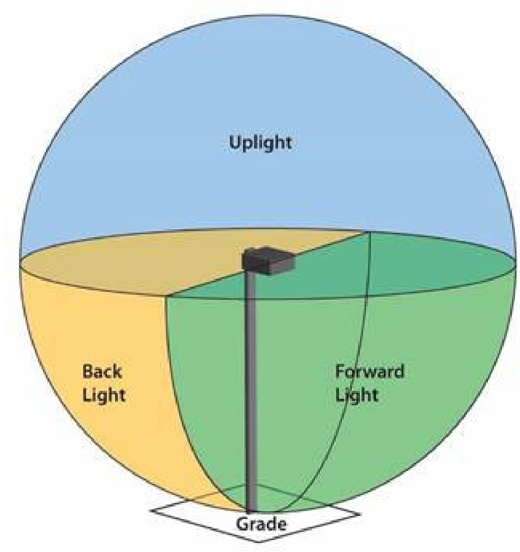


Image Source: Illuminating Engineering Society (image from ANSI/IES TM-15-20)

«»

2. **Controls for outdoor lighting.** Outdoor lighting shall be independently controlled from other electrical loads, and the controls for outdoor lighting shall meet the following functional requirements:

   Exception 1 to Section 160.5(c)2: Outdoor lighting not permitted by a health or life safety statute, ordinance or regulation to be turned OFF or reduced.

   Exception 2 to Section 160.5(c)2: Lighting in tunnels required to be illuminated 24 hours per day and 365 days per year.

   A. **Daylight availability.** All installed outdoor lighting shall be controlled by a photo control, astronomical time-switch control or other control capable of automatically shutting OFF the outdoor lighting when daylight is available.

«» Commentary for Section 160.5(c)2A:

All installed outdoor lighting that is not controlled from within a dwelling unit must be controlled by a photocontrol, astronomical time-switch control, or other controls that automatically turn off the outdoor lighting when daylight is available.

1. A photocontrol measures the amount of ambient light outdoors. When the light level outside is high enough to indicate that it is daytime, the control turns lighting off.
2. Astronomical time-switch controls require an initial setup of the time clock device, which may include the entry of the current date, time, time zone, site location by longitude and latitude, and whether daylight saving time is applicable. The clock

calculates sunrise and sunset times, which vary by location and day of the year, and turns lighting off at sunrise and on at sunset.

Astronomical time switches are time-based controls that can be used to meet the daylight availability and automatic scheduling control requirements. **«»**

B. **Automatic scheduling controls.**

   i. Automatic scheduling controls shall be installed for all outdoor lighting. Automatic scheduling controls may be installed in combination with motion sensing controls or other outdoor lighting controls.

   ii. Automatic scheduling controls shall be capable of reducing the outdoor lighting power by 50 to 90 percent, and separately capable of turning the lighting OFF, during scheduled unoccupied periods.

   iii. Automatic scheduling controls shall allow scheduling of a minimum of two nighttime periods with independent lighting levels, and may include an override function that turns lighting ON during its scheduled dim or OFF state for no more than two hours when an override is initiated.

«» Commentary for Section 160.5(c)2B:

All installed outdoor lighting that is not controlled from within a dwelling unit shall be controlled by an automatic scheduling control capable of reducing lighting power by 50 to 90 percent and separately capable of turning lighting off when not needed according to a schedule.

Further, automatic scheduling controls are required to have the capability of programming at least two nighttime periods (a scheduled occupied period and a scheduled unoccupied period) with different light levels, if desirable by the building design and operation.

Automatic scheduling controls provide flexibility to accommodate changes in building operation. If different operating schedules or different lighting levels are desired, the settings of the automatic scheduling controls can be adjusted. **«»**

C. **Motion sensing controls**.

   i. Motion sensing controls shall be installed for outdoor luminaires providing lighting for general hardscape, parking lots, and outdoor canopies, where the bottom of the luminaire is mounted 24 feet above grade or lower.

   ii. Motion sensing controls shall be capable of reducing the outdoor lighting power of each controlled luminaire by 50 to 90 percent, and separately capable of turning the luminaire OFF, during unoccupied periods.

   iii. Motion sensing controls shall be capable of reducing the lighting to its dim or OFF state no longer than 15 minutes after the area has been vacated, and of returning the lighting to its ON state when the area becomes occupied.

iv. No more than 1,500 watts of lighting power shall be controlled by a single sensor or as a single zone.

Exception 1 to Section 160.5(c)2C: Luminaires with a maximum rated wattage of 40 watts each are not required to have motion sensing controls.

Exception 2 to Section 160.5(c)2C: Applications listed as exceptions to Section 170.2(e)2A and luminaires providing lighting for building façade, ornamental hardscape or outdoor dining are not required to have motion sensing controls.

Exception 3 to Section 160.5(c)2C: Lighting subject to a health or life safety statute, ordinance or regulation may have a minimum time-out period longer than 15 minutes or a minimum dimming level above 50 percent when necessary to comply with the applicable law.

«» Commentary for Section 160.5(c)2C:

Some applications require the installation of motion-sensing controls. For these applications, automatic scheduling controls are required in addition to motion-sensing controls. During the scheduled occupied period, motion-sensing controls can detect occupancy of an outdoor space and turn on or reduce lighting based on the occupancy of the space. During the scheduled unoccupied period, the automatic scheduling control can turn off all lighting when no occupancy is detected.

The requirements for motion sensing is limited to luminaire mounting heights below 24 feet for two reasons. First, motion sensors may not be capable of reliably detecting motion in the necessary coverage area from heights of more than 24 feet. Second, as the luminaire mounting height increases, the area of coverage for a single luminaire becomes very large, which may result in undesirable or non-uniform lighting conditions that are not suitably matched for the activity. «»

(d) Sign lighting controls. All sign lighting shall meet the requirements below as applicable:

1. **Indoor signs.** All indoor sign lighting other than exit sign lighting shall be controlled with an automatic time-switch control or astronomical time-switch control.
2. **Outdoor signs.** Outdoor sign lighting shall meet the following requirements as applicable:

   A. All outdoor sign lighting shall be controlled with a photocontrol in addition to an automatic time-switch control, or an astronomical time-switch control.

Exception to Section 160.5(d)2A: Outdoor signs in tunnels, and signs in large permanently covered outdoor areas that are intended to be continuously lit, 24 hours per day and 365 days per year.

B. All outdoor sign lighting that is ON both day and night shall be controlled with a dimmer that provides the ability to automatically reduce sign lighting power by a minimum of 65 percent during nighttime hours. Signs that are illuminated at night and for more than 1 hour during daylight hours shall be considered ON both day and night.

Exception to Section 160.5(d)2B: Outdoor signs in tunnels and large covered areas that are intended to be illuminated both day and night.

3. **Demand Responsive Electronic Message Center (EMC) control.** See Section 110.12 for requirements for demand responsive EMC controls.

(e) Lighting control acceptance and installation certificate requirement. Multifamily common use areas shall comply with the applicable requirements of Sections 160.5(e)1 through 160.5(e)3.

1. **Lighting control acceptance requirements.** Before an occupancy permit is granted, indoor and outdoor lighting controls serving the building, area or site and installed to comply with Section 160.5(b)4D, 160.5(b)4C, 160.5(b)4E, 160.5(c)2 or 170.2(e)1Aiij shall be certified as meeting the Acceptance Requirements for Code Compliance as specified by Reference Nonresidential Appendix NA7.6 and NA7.8. A Certificate of Acceptance shall be submitted to the enforcement agency under Section 10-103(a) of Part 1 that the equipment and systems meet the acceptance requirements:

A. Reserved;

B. Reserved;

C. Daylight responsive controls shall be tested in accordance with Reference Nonresidential Appendix NA7.6.1;

«» Commentary for Section 160.5(e)1C:

Automatic daylighting controls in multifamily common areas must be tested according to NA7.6.1 to verify that they are properly installed and that they automatically adjust electric lighting power in response to available daylighting in the space. **«»**

D. Lighting shut-OFF controls shall be tested in accordance with Reference Nonresidential Appendix NA7.6.2;

«» Commentary for Section 160.5(e)1D:

Automatic shutoff controls must be tested according to NA7.6.2 to verify that occupant sensing controls and automatic time switch controls are functioning properly to achieve the desired lighting controls.

Occupant sensing control acceptance testing verifies that the controls are installed per manufacturer's instructions and that the occupant sensing control dims or turns lighting on or off according to occupancy in the space.

The automatic time switch controls acceptance testing verifies that indoor lighting controlled by an automatic time switch control turns lighting on and off according to a programmed schedule and that manual override controls turn lighting on during scheduled off periods. «»

E. Demand responsive lighting controls shall be tested in accordance with Reference Nonresidential Appendix NA7.6.3; and

«» Commentary for Section 160.5(e)1E:

Demand responsive lighting controls in multifamily common areas must be tested according to NA7.6.3 to verify that they can reduce lighting power of the building to at least 85 percent of full power. The test confirms that the lighting system produces a uniform level of illumination during a demand response event. «»

F. Outdoor lighting controls shall be tested in accordance with Reference Nonresidential Appendix NA7.8; and

«» Commentary for Section 160.5(e)1F:

This test applies to outdoor lighting controls which include photocontrols, motion sensors, astronomical time-switch controls, and scheduling controls for outdoor lighting systems per the requirements of Section 160.5(c). These controls are required for outdoor lighting in multifamily buildings, other than outdoor lighting controlled from inside a dwelling unit.

Outdoor lighting controls must be tested according to NA7.8 to verify that all outdoor lighting regulated by Section 160.5(c) is controlled by a motion sensor, photocontrol, astronomical time-switch control, and automatic scheduling control, as required. «»

G. Lighting systems receiving the Institutional Tuning Power Adjustment Factor shall be tested in accordance with Reference Nonresidential Appendix NA7.6.4.

«» Commentary for Section 160.5(e)1G:

Institutional tuning is the process of adjusting the maximum light output of lighting systems to support visual needs or save energy. Institutional tuning differs from personal tuning in that the control strategy is implemented by the building operator rather than the individual user level, and maximum light level adjustments are available only to authorized personnel.

Institutional tuning in multifamily common areas must be tested according to NA7.6.4 to verify that the institutional tuning controls limit the maximum light output or power draw of the controlled lighting to 85 percent or less of full light output or full power draw. This 85% requirement only applies if the building is using the institutional tuning

PAF to gain additional lighting watts. If not, the lighting system should be tested to confirm the institutional tuning is working as intended by the designer or engineer. «»

H. Demand responsive controls required to control controlled receptacles shall be tested in accordance with Reference Nonresidential Appendix NA7.6.5.

«» Commentary for Section 160.5(e)1H:

Demand responsive controls for controlled receptacles in multifamily common areas must be tested according to NA7.6.5 to verify that demand responsive controls can turn off all loads connected to controlled receptacles when a demand response signal is received. «»

2. **Lighting control installation certificate requirements.** To be recognized for compliance with Part 6, an Installation Certificate shall be submitted in accordance with Section 10-103(a) for any lighting control system, energy management control system, interlocked lighting system, lighting power adjustment factor, or additional wattage available for a videoconference studio, in accordance with the following requirements, as applicable:

   A. Certification that when a lighting control system is installed to comply with lighting control requirements in Part 6, it complies with the applicable requirements of Section 110.9 and complies with Reference Nonresidential Appendix NA7.7.1.

   B. Certification that when an energy management control system is installed to function as a lighting control required by Part 6, it functionally meets all applicable requirements for each application for which it is installed, in accordance with Sections 110.9, 160, 170 and 180, and complies with Reference Nonresidential Appendix NA7.7.2.

   C. Certification that interlocked lighting systems used to serve an approved area comply with Section 170.2(e)2A and comply with Reference Nonresidential Appendix NA7.7.4.

   D. Certification that lighting controls installed to earn a lighting Power Adjustment Factor (PAF) comply with Section 170.2(e)2B and comply with Reference Nonresidential Appendix NA7.7.5.

   E. Reserved.

«» Commentary for Section 160.5(e)2D:

The certificate of installation is used primarily as a declaration that the installed lighting and controls matches what is claimed on the certificate of compliance. The certificate of installation is signed by the licensed person that completed the installation.

The required multifamily common use area indoor lighting certificates of installation include the following:

1. For multifamily buildings four habitable stories or more: NRCI-LTI-E — must be submitted for all buildings. This is the general certificate of installation used to declare that what was proposed in the certificates of compliance is what was installed.
2. For multifamily buildings up to three habitable stories: LMCI-LTI-E — must be submitted for all buildings. This is the general certificate of installation used to declare that what was proposed in the certificates of compliance is what was installed. «»
3. When certification is required by Title 24, Part 1, Section 10-103.1, the acceptance testing specified by Section 160.5(e) shall be performed by a Certified Lighting Controls Acceptance Test Technician (CLCATT). If the CLCATT is operating as an employee, the CLCATT shall be employed by a Certified Lighting Controls Acceptance Test Employer. The CLCATT shall disclose on the Certificate of Acceptance a valid CLCATT certification identification number issued by an approved Acceptance Test Technician Certification Provider. The CLCATT shall complete all Certificate of Acceptance documentation in accordance with the applicable requirements in Section 10-103(a)4.

«» Commentary for Section 160.5(e)3:

Acceptance requirements ensure that equipment, controls, and systems operate as required by the Energy Code. Acceptance testing consists of:

1. Visual inspection of the equipment and installation.
2. Functional testing of the systems and controls.

Individual acceptance tests may be performed by one or more field technicians under the responsible charge of a licensed contractor or design professional, (responsible person) eligible under Division 3 of the Business and Professions Code, in the applicable classification, to accept responsibility for the scope of work specified by the certificate of acceptance document. The responsible person must review the information on the certificate of acceptance form and sign the form to certify compliance with the acceptance requirements:

Typically, the individuals who perform the field testing/verification work and provide the information required for completion of the acceptance form (field technicians) are contractors, engineers, or commissioning agents. Field technicians do not need to be a third-party and are not required to be licensed contractors or licensed design professionals. Only the responsible person who signs the certificate of acceptance form certifying compliance must be licensed.

When certification is required by Title 24, Part 1, Section 10-103.1, acceptance testing must be performed by a certified lighting controls acceptance test technician. Acceptance test technicians receive hands-on and classroom training on the testing procedures and must pass an exam to become certified. Acceptance test technicians are trained and certified by an Energy Commission approved Acceptance Test Technician Certification Provider. «»

SECTION 160.6 – MANDATORY REQUIREMENTS FOR ELECTRICAL POWER DISTRIBUTION SYSTEMS

Multifamily buildings shall comply with the applicable requirements of Sections 160.6(a) through 160.6(e).

(a) Service electrical metering. Each electrical service or feeder that provides power to the common use areas (interior and exterior) shall have a permanently installed metering system that measures electrical energy use in accordance with Table 160.6-A.

Exception to **Section 160.6(a)**: Service or feeder for which the utility company provides a metering system for the multifamily building that indicates instantaneous kW demand and kWh for a utility-defined period.

TABLE 160.6-A MINIMUM REQUIREMENTS FOR METERING OR SUBMETERING OF ELECTRICAL LOAD

Metering Functionality	Electrical Services[1] rated 50 kVA or less	Electrical Services[1] rated more than 50kVA and less than or equal to 250 kVA	Electrical Services[1] rated more than 250 kVA and less than or equal to 1000kVA	Electrical Services[1] rated more than 1000kVA
Instantaneous (at the time) kW demand	Required	Required	Required	Required
Historical peak demand (kW)	Not required	Not required	Required	Required
Tracking kWh for a user-definable period.	Required	Required	Required	Required
kWh per rate period	Not required	Not required	Not required	Required

1 "Electrical Services" applies to the building service-entrance rating or to the submetering service. For a building with submetering, this applies to the submetering service size to the common use areas.

«» Commentary for Section 160.6(a):

This is not a requirement to install meters at the service and at each feeder. Rather, this requirement simply prevents unmetered service or feeder circuits from being installed within a building by requiring that a meter be installed at either the service level or, if not at the service level, at the feeder level. «»

(b) Separation of electrical circuits for electrical energy monitoring. Electrical power distribution systems shall be designed so that measurement devices can monitor the electrical energy usage of load types according to Table 160.6-B.

Exception 1 to Section 160.6(b): For each separate load type, up to 10 percent of the connected load may be of any type.

Exception 2 to Section 160.6(b): Submetered electrical power distribution systems that provide power to dwelling units.

TABLE 160.6-B MINIMUM REQUIREMENTS FOR SEPARATION OF ELECTRICAL LOAD

Electrical Load Type	Electrical Services1 rated 50 kVA or less	Electrical Services1 rated more than 50kVA and less than or equal to 250 kVA	Electrical Services1 rated more than 250 kVA and less than or equal to 1000kVA	Electrical Services1 rated more than 1000kVA
Lighting including exit and egress lighting and exterior lighting	Not required	All lighting in aggregate	All lighting disaggregated by floor, type or area	All lighting disaggregated by floor, type or area
HVAC systems and components including chillers, fans, heaters, furnaces, package units, cooling towers, and circulation pumps associated with HVAC	Not required	All HVAC in aggregate	All HVAC in aggregate and each HVAC load rated at least 50 kVA	All HVAC in aggregate and each HVAC load rated at least 50kVA
Domestic and service water system pumps and related systems and components	Not required	All loads in aggregate	All loads in aggregate	All loads in aggregate

Plug load including appliances rated less than 25 kVA	Not required	All plug load in aggregate Groups of plug loads exceeding 25 kVA connected load in an area less than 5000 sf	All plug load separated by floor, type or area Groups of plug loads exceeding 25 kVA connected load in an area less than 5000 sf	All plug load separated by floor, type or area All groups of plug loads exceeding 25 kVA connected load in an area less than 5000 sf
Elevators, escalators, moving walks, and transit systems	Not required	All loads in aggregate	All loads in aggregate	All loads in aggregate
Renewable power source (net or total)	Each group	Each group	Each group	Each group
Loads associated with renewable power source	Not required	All loads in aggregate	All loads in aggregate	All loads in aggregate
Charging stations for electric vehicles	All loads in aggregate	All loads in aggregate	All loads in aggregate	All loads in aggregate

1 "Electrical Services" applies to the building service-entrance rating or to the submetering service. For a building with submetering, this applies to the submetering service size to the common use area.

«» Commentary for Section 160.6(b):

The separation of electrical circuits requirement allows monitoring the specific contributions of separate loads to the overall energy use of a building. By designing the electrical distribution system with separation of electrical loads in mind, energy monitoring can be readily set up and implemented without significant physical changes to the electrical installations.

The goal of this requirement is to be able to monitor the electrical energy usage of each load type specified in Table 160.6-B of the Energy Code. Building owners, facility management, and others can make use of such energy usage information to better understand how much energy has been used by each building system during a certain period. Further analysis of such energy information can help facilitate energy efficiency and related measures to improve building energy performance for building owners and operators.

The Energy Code allows the use of conventional panelboards, motor control centers, and other standard wiring methods for meeting the separation requirement. The requirement may also be met by a well-planned wiring approach, such as connecting all HVAC units to a single feeder from the service using a combination of through feeds and taps. The regulations are intentionally written to specify the "what" without prescribing the "how," providing flexibility.

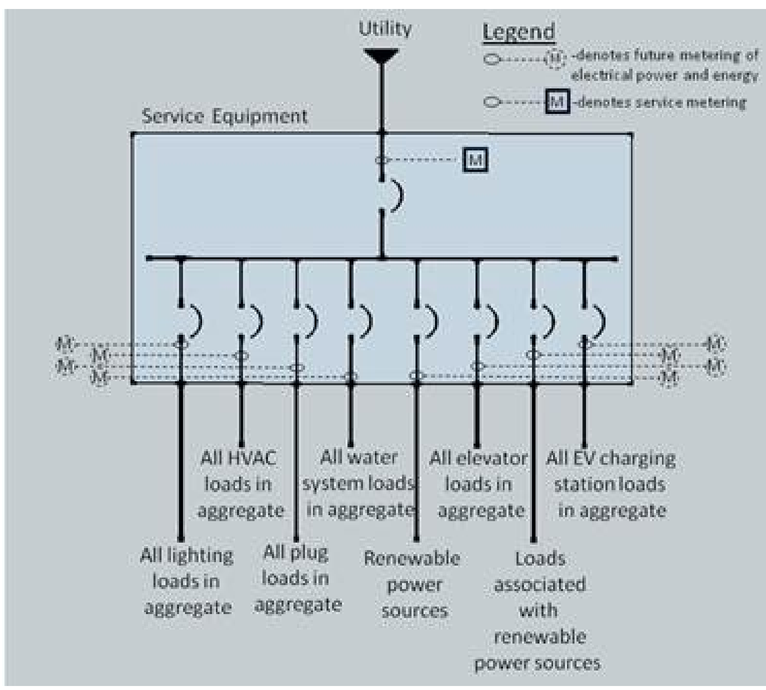
The separation of electrical circuits requirement may be satisfied by any method that accomplishes this goal, including any of the following example methods:

Example Method 1

Switchboards, motor control centers, or panelboards may be separated by load type, allowing energy measurement of each load type independently and readily. This method must allow measurement and determination of the actual interval demand load value for each disaggregated load in the system.

This is a straightforward approach for measurement of each load type, as each switchboard, motor control center, or panelboard serves a single load type. Summation of the load measurement of the distribution equipment in accordance with the respective load type can result in the energy usage of each load type. This method is simple and straightforward in terms of the effort required in compiling the measurement data.

Figure 6-23: Separation of Electrical Circuits by Panelboard



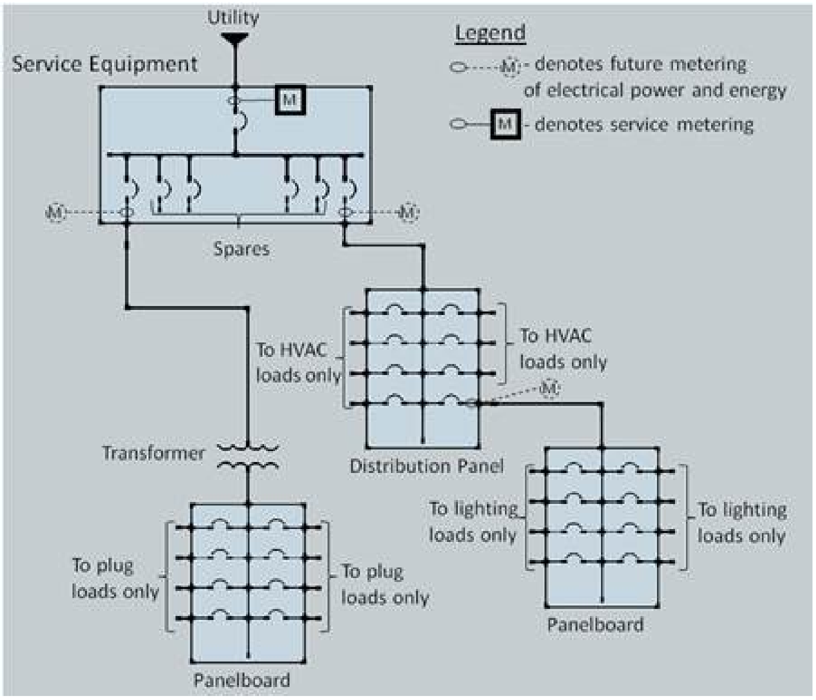
Source: California Energy Commission

Example Method 2

Switchboards, motor control centers, or panelboards may supply other distribution equipment with the associated loads separated for each load type. The measured load for each piece of distribution equipment must be able to be added or subtracted from other distribution equipment supplying them. This method must allow measurement for each disaggregated load in the system.

This method allows distribution equipment to serve more than one load type while allowing the separate energy use of each load to be determined. More effort may be required in obtaining the energy usage of each load type.

Figure 6-24: Separation of Electrical Circuits by Panelboards and Subpanels

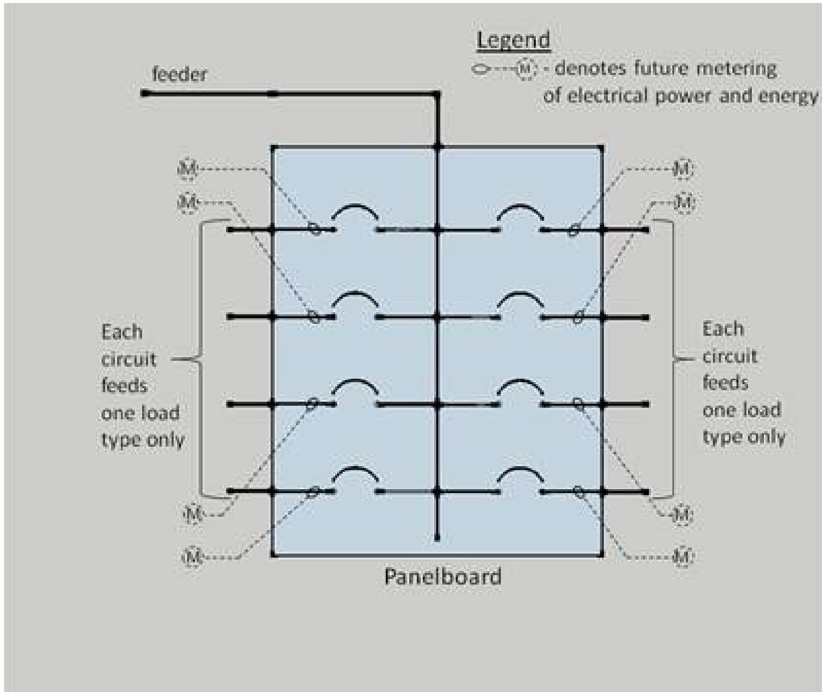


Source: California Energy Commission

Example Method 3

Switchboards, motor control centers, or panelboards may supply more than one load type as long as each branch circuit serves a single load type, and the equipment includes provisions for measuring individual branch circuits. For example, neighboring branch circuits in a panelboard may serve receptacles and fans, respectively, but the branch circuits cannot serve mixed load types.

Figure 6-25: Separation of Electrical Circuits by Branch Circuits



Source: California Energy Commission

Example Method 4

Buildings for which a complete metering and measurement system is provided so each load type can be measured separately. Such an installation goes beyond the requirement of the Energy Code as it meters and measures the power and energy usage of each load type. It provides benefits for building owners and operators by giving them a readily available tool for assessing the building energy usage as soon as the facility is turned over to them. «»

(c) Voltage drop. The maximum combined voltage drop on both installed feeder conductors and branch circuit conductors to the farthest connected load or outlet shall not exceed 5 percent.

Exception to Section 160.6(c): Voltage drop permitted by California Electrical Code Sections 647.4, 695.6 and 695.7.

«» Commentary for Section 160.6(c):

The maximum combined voltage drop on both installed feeder conductors and branch circuit conductors to the farthest connected load or outlet must not exceed 5 percent. This is the steady-state voltage drop under normal load conditions.

The voltage drop permitted by California Electrical Code Sections 647.4, 695.6, and 695.7 are exempted from this requirement.

Voltage drop losses are cumulative, so voltage drop in feeders and voltage drop in branch circuits contribute to the load at the end of the branch circuit. Excessive voltage drop in the feeder conductors and branch circuit conductors can result in inefficient operation of electrical equipment and shortened equipment life expectancy. **«»**

(d) Circuit controls for 120-volt receptacles and controlled receptacles. In all common areas, both controlled and uncontrolled 120 volt receptacles shall be provided in office areas, lobbies, conference rooms, kitchen areas in office spaces, and copy rooms. Plug-in strips and other plug-in devices shall not be used to comply with the requirements of this section.

Controlled receptacles shall meet the following requirements, as applicable:

1. Install a control capable of automatically shutting OFF the controlled receptacles when the space is typically unoccupied, either at the receptacle or circuit level. When an automatic time switch control is installed it shall incorporate an override control that allows the controlled receptacle to remain ON for no more than 2 hours when an override is initiated and an automatic holiday "shut-OFF" feature that turns OFF all loads for at least 24 hours and then resumes the normally scheduled operation. Countdown timer switches shall not be used to comply with the automatic time switch control requirements; and
2. Install at least one controlled receptacle within 6 feet from each uncontrolled receptacle, or install a multiple receptacle outlet with at least one controlled and one uncontrolled receptacle. Where receptacles are installed in modular furniture in open office areas, at least one controlled receptacle shall be installed at each workstation; and
3. Provide a permanent marking for controlled receptacles or circuits to differentiate them from uncontrolled receptacles or circuits; and

Exception 1 to Section 160.6(d): Receptacles that are only for the following purposes:

A. Receptacles specifically for refrigerators and water dispensers in kitchen areas.

B. Receptacles located a minimum of six feet above the floor that are specifically for clocks.

C. Receptacles for network copiers, fax machines, A/V and data equipment other than personal computers in copy rooms.

D. Receptacles on circuits rated more than 20 amperes.

E. Receptacles connected to an uninterruptible power supply (UPS) that are intended to be in continuous use, 24 hours per day/365 days per year, and are marked to differentiate them from other uncontrolled receptacles or circuits.

Exception 2 to Section 160.6(d): Receptacles in common use areas providing shared provisions for living, eating, cooking or sanitation to dwelling units that would otherwise lack these provisions.

«» Commentary for Section 160.6(d):

In multifamily common use areas, the Energy Code requires controlled and uncontrolled 120-volt receptacles. Controlled receptacles allow plug loads to be turned off automatically when the space is unoccupied, resulting in energy savings.

The following are example approaches to meeting the controlled receptacle requirement.

Private Offices, Conference Rooms, and Other Spaces With Periodic Occupancy

Occupant-sensing controls that are part of a lighting control system may be used to control general lighting and receptacles. For example, a common occupancy sensor can control general lighting and receptacles, with auxiliary relays connected to the lights and the controlled receptacles to provide the needed functionality.

Lobbies, Break Rooms, and Other Spaces With Frequent Occupancy During Business Hours

Astronomical time-switch controls, with either a vacancy sensor or switch override, can be used to control receptacles. Programmable relay panels or controllable breakers can be used, or, for simpler projects, a combination of vacancy sensors and programmable time switches can accomplish the same task. If vacancy sensing is used, controls will likely need to be room-by-room or space-by-space, but if time-switch control with manual override is used, whole circuits may be controlled together.

Open Office Areas

Receptacles in open office areas can be controlled by the automatic shutoff system of the building or by controls integrated into the modular furniture systems. Automatic time-switch controls with relays or controllable breakers, and manual override switches, may be used for zones within an open office space. A system using vacancy sensors might also be considered if sensors can be added as needed to address partitioning of the workstations (thus ensuring proper operation). Systems contained within workstation systems are an acceptable alternative provided that they are hardwired as part of the workstation wiring system.

Networked Control Systems and Building Automation Systems

Most advanced lighting and energy control systems can be easily designed to accommodate receptacle controls.

Certain office appliances, such as computers, need to be powered continuously during normal operating hours to provide uninterrupted service. These would be connected to uncontrolled receptacles. Other appliances, such as task lamps, fans, heaters, and monitors, do not need to be powered when occupants are not present. These controllable loads would be plugged into the controlled receptacles to ensure they are automatically shut off and to prevent any unnecessary standby power draw.

In open office areas, it is advisable to implement vacancy sensor controls at each workstation or cubicle to maximize the opportunities of shutoff controls. Modular office system furniture is usually equipped with more than one internal electrical circuit, and some of these circuits can be dedicated for controllable plug loads. **«»**

(e) Demand responsive controls and equipment**.** See Section 110.12 for requirements for demand responsive controls and equipment, including demand responsive controls for controlled receptacles.

NOTE: Definitions of terms and phrases in Section 160.6 are determined as specified in Section 100.1(b). Terms and phrases not found in Section 100.1(b) shall be defined as specified in Title 24, Part 3, Article 100 of the California Electrical Code.

SECTION 160.9 – MANDATORY REQUIREMENTS FOR ELECTRIC READY BUILDINGS

(a) General requirements. Multifamily buildings shall comply with the applicable requirements of subsection 160.9. The building electrical system shall be sized to meet the future electric requirements of the electric ready equipment specified in sections 160.9(b) through (f). The building main service conduit, the electrical system to the point specified in each subsection, and any on-site distribution transformers shall have sufficient capacity to supply full rated amperage at each electric ready appliance in accordance with the California Electrical Code.

«» Commentary for Section 160.9(a):

The electric ready requirements apply to gas equipment used for dwelling unit space heating, water heating, and cooking as well as dwelling unit and common area clothes dryers. Electric ready requirements minimize future retrofit costs when electric appliances replace gas appliances.

In addition to appliance-specific electric ready requirements outlined below, Section 160.9(a) requires building main service conduit, the electrical system to the point specified in each subsection, and any onsite distribution transformers to have sufficient capacity to supply full rated amperage for each electric ready appliance in accordance with California Electric Code.

Some provisions should be appropriately labelled as specified so that they can be readily identified in the future when it comes to the time that the electric appliances (such as heat pump space heaters) are installed.

Note that the electric ready requirements may involve more than one design professional or trade installers work to meet. In an example of the heat pump space heater ready requirements, it could require a mechanical engineer to select the heat pump space heater in terms of its cooling and heating capacity and could require an electrical engineer to select the branch circuiting requirement for the heat pump space heater.«»

(b) Heat Pump Space Heater Ready. Systems using gas or propane furnaces to serve individual dwelling units shall include the following:

1. A dedicated 240 volt branch circuit wiring shall be installed within 3 feet from the furnace and accessible to the furnace with no obstructions. The branch circuit conductors shall be rated at 30 amps minimum. The blank cover shall be

identified as “240V ready.” All electrical components shall be installed in accordance with the California Electrical Code.

2. The main electrical service panel shall have a reserved space to allow for the installation of a double pole circuit breaker for a future heat pump space heater installation. The reserved space shall be permanently marked as “For Future 240V use.”

«» Commentary for Section 160.9(b):

This section ensures that individual dwelling unit space heating systems using gas or propane are "electric ready," facilitating a future transition to heat pump space heaters. These requirements ensure adequate electrical infrastructure to serve a future heat pump space heater installed in the same location as the existing gas or propane furnace. Receptacles are not required. Equipment serving multifamily common use areas are not subject to electric ready requirements. **«»**

(c) Electric Cooktop Ready. Systems using gas or propane cooktops to serve individual dwelling units shall include the following:

1. A dedicated 240 volt branch circuit wiring shall be installed within 3 feet from the cooktop and accessible to the cooktop with no obstructions. The branch circuit conductors shall be rated at 50 amps minimum. The blank cover shall be identified as “240V ready.” All electrical components shall be installed in accordance with the California Electrical Code.

2. The main electrical service panel shall have a reserved space to allow for the installation of a double pole circuit breaker for a future electric cooktop installation. The reserved space shall be permanently marked as “For Future 240V use.”

«» Commentary for Section 160.9(c):

This section ensures that dwelling units with gas or propane cooktops are "electric ready," facilitating a future transition to an electric cooktop. These requirements ensure adequate electrical infrastructure to serve a future electric cooktop installed in the same location as the existing gas or propane cooktop. Receptacles are not required. Cooktops in multifamily common use areas are not subject to electric ready requirements. **«»**

(d) Electric Clothes Dryer Ready. Clothes dryer locations with gas or propane plumbing shall include the following:

1. Systems serving individual dwelling units shall include:

   A. A dedicated 240 volt branch circuit wiring shall be installed within 3 feet from the clothes dryer location and accessible to the clothes dryer location with no obstructions. The branch circuit conductors shall be rated at 30 amps minimum. The blank cover shall be identified as “240V ready.” All electrical components shall be installed in accordance with the California Electrical Code.

B. The main electrical service panel shall have a reserved space to allow for the installation of a double pole circuit breaker for a future electric clothes dryer installation. The reserved space shall be permanently marked as "For Future 240V use."

2. Systems in common use areas shall include:

A. Conductors or raceway shall be installed with termination points at the main electrical panel, via subpanels panels if applicable, to a location no more than 3 feet from each gas outlet or a designated location of future electric replacement equipment. Both ends of the conductors or raceway shall be labelled "Future 240V Use." Gas flow rates shall be determined in accordance with the California Plumbing Code. Capacity shall be one of the following:

i. 24 amps at 208/240 volts per clothes dryer;

ii. 2.6 kVA for each 10,000 Btu per hour of rated gas input or gas pipe capacity; or

iii. The electrical power required to provide equivalent functionality of the gas-powered equipment as calculated and documented by the responsible person associated with the project.

«» Commentary for Section 160.9(d):

This section ensures that gas or propane clothes dryers in multifamily dwelling units or common use areas are "electric ready," facilitating a future transition to electric clothes dryers. These requirements ensure adequate electrical infrastructure to serve a future electric clothes drying in the same location as the existing gas or propane clothes dryer(s). Receptacles are not required. **«»**

(e) Individual Heat Pump Water Heater Ready. Systems using gas or propane water heaters to serve individual dwelling units shall include the following components for each gas or propane water heater:

1. A dedicated 125 volt, 20 amp electrical receptacle that is connected to the electric panel with a 120/240 volt 3 conductor branch circuit rated to 30 amps minimum, within 3 feet from the water heater and accessible to the water heater with no obstructions. In addition, all the following:

A. Both ends of the unused conductor shall be labeled with the word "spare" and be electrically isolated; and

B. A reserved single pole circuit breaker space in the electrical panel adjacent to the circuit breaker for the branch circuit in A above and labeled with the words "Future 240V Use"; and

2. A condensate drain that is no more than 2 inches higher than the base of the installed water heater and allows natural draining without pump assistance, and

3. The construction drawings shall designate a space at least 39 inches by 39 inches and 96 inches tall for the future location of heat pump water heater.

4. A ventilation method meeting one of the following:

A. The designated space for the future heat pump water heater shall have a minimum volume of 700 cubic feet; or

B. If the future HPWH space is designed to vent indoors, the designated space for the future heat pump water heater shall vent to a communicating space in the same pressure boundary. The total combined volume connected shall be 700 cubic feet or larger and vent to the interior via:

i. Fully louvered doors with fixed louvers consisting of a single layer of fixed flat slats and a minimum total NFA of 250 square inches; or

ii. Two permanent openings of equal area with a minimum total NFA of 250 square inches located within 12 inches from the enclosure top and bottom; or

iii Two 8-inch ducts to a communicating space.

C. If the future HPWH space is designed to vent to the building exterior, the designated space for the future heat pump water heater shall vent to the exterior via:

i. Fully louvered doors with fixed louvers consisting of a single layer of fixed flat slats and a minimum total NFA of 250 square inches; or

ii. Two permanent openings of equal area with a minimum total NFA of 250 square inches located within 12 inches from the enclosure top and bottom; or

iii. Two 8 inches capped ducts. All ducts that cross the pressure boundary shall be insulated to a minimum insulation level of R-6 and the ducts, connections, and building penetrations shall be sealed.

«» Commentary for Section 160.9(e):

This section ensures that individual water heating systems (one water heater serving one dwelling unit) using gas or propane to generate hot water for a single dwelling unit are "electric ready," facilitating a future transition to heat pump water heaters. In addition to ensuring adequate electrical infrastructure to serve a future heat pump water heater, the code requirements also ensure adequate space, ventilation, and condensate drainage to serve a future heat pump water heater based on products that are currently on the market. Receptacles are required for dwelling unit water heating and must be connected to the panel with a 120/240V, 3-conductor of 30 amp ampacity minimum (such as 10 AWG copper wire conductor) with both ends of the unused conductor labeled as spare and be electrically isolated. **«»**

(f) Central Heat Pump Water Heater Ready. Central water heating systems using gas or propane to serve multiple dwelling units shall meet the following requirements:

1. The system input capacity of the gas or propane water heating system shall be determined as the sum of the input gas or propane capacity of all water heating devices associated with each gas or propane water heating system.

2. Space reserved shall include:

   A. Heat Pump. The minimum space reserved shall include space for service clearances and air flow clearances and shall meet one of the following:

      i. The space reserved shall be the space required for a heat pump water heater system that meets the total building hot water demand as calculated and documented by the responsible person associated with the project; or

   ii. The space reserved shall meet the requirements specified in Joint Appendix JA15.2.1.

«» Commentary for Section 160.9(f):

This section ensures that central water heating systems using gas or propane for multiple dwelling units are "electric ready," facilitating a future transition to heat pump water heaters. The code language was developed to address retrofit installation challenges that are very costly or make retrofit to heat pumps infeasible, based on input from practitioners. There are two primary approaches to achieve this:

1. Design Approach: This approach allows designers to assess the specific heating load and requirements of their project, providing flexibility in planning for space reserved, ventilation, condensate drainage, and electrical infrastructure. Each building's unique characteristics can be accounted for, resulting in a more tailored and potentially smaller infrastructure setup. Furthermore, this pathway allows for more flexibility to plan for system types that do not require a swing tank.
2. Sizing Factors Approach (Joint Appendix): This method follows the sizing factors set forth in Joint Appendix JA15. This approach allows for easier implementation, but is intended to be conservative and may result in larger reserved spaces and capacities than the Design Approach. There are two sets of sizing factors for the Sizing Factors Approach. One set of sizing factors is used for gas water heaters with an input rate less than 200,000 BTU/hr and one set of sizing factors is used

for systems with higher input rates. Having two sets of sizing factors reduces the cost of compliance. «»

B. Tanks. The minimum space reserved shall include space for service clearances and shall meet one of the following:

i. The space reserved shall be the space required for a heat pump water heater system that meets the total building hot water demand as calculated and documented by the responsible person associated with the project; or

ii. The space reserved shall meet the requirements specified in Joint Appendix JA15.2.2.

3. Ventilation shall be provided by meeting one of the following:

A. Physical space reserved for the heat pump shall be located outside; or

B. A pathway shall be reserved for future routing of supply and exhaust air via ductwork from the reserved heat pump location to a suitable outdoor location. Penetrations through the building envelope for louvers and ducts shall be planned and identified for future use. The reserved pathway and penetrations through the building envelope shall be sized to meet one of the following:

i. The reserved pathway and penetrations shall be sized to serve a heat pump water heater system that meets the total building hot water demand as calculated and documented by the responsible person associated with the project.

ii. The reserved pathway and penetrations shall be sized to meet the requirements specified in Joint Appendix JA15.2.3.

«» Commentary for Section 160.9(f)3:

Heat pumps may be installed outside to simplify access to adequate air flow and clearance. However, when an indoor installation is necessary, it's critical to plan for future ductwork and building envelope penetrations. This planning ensures the heat pump can be properly ventilated, maintaining its efficiency and performance. «»

4. Condensate drainage piping. An approved receptacle that is sized per the California Plumbing Code for condensate drainage shall be installed within 3 feet of the reserved heat pump location, or piping shall be installed from within 3 feet of the reserved heat pump location to an approved discharge location that is sized in accordance with the California Plumbing Code, and meet one of the following:

i. Condensate drainage shall be sized to serve a heat pump water heater system that meets the total building hot water demand as calculated and documented by the responsible person associated with the project.

ii. Condensate drainage piping shall be sized to meet the requirements specified in Joint Appendix JA15.2.4.

«» Commentary for Section 160.9(f)4:

Air source heat pump water heaters may produce condensate on the air-source coil. Unlike the condensate generated by some gas-fired water heaters which requires acid neutralization, the condensate from a heat pump water heater is not acidic and simply requires proper drainage. The intent of the electric ready condensate drainage requirement is to ensure that a future heat pump water heater has access to a suitable drainage system to discharge condensate. **«»**

5. Electrical

A. Physical space shall be reserved on the bus system of the main switchboard or on the bus system of a distribution board to serve the future heat pump water heater system, including the heat pump and temperature maintenance tanks. In addition, the physical space reserved shall be capable of providing adequate power to the future heat pump water heater in accordance with the following:

i. Heat Pump. Meet one of the following.

A. The electrical power required to power a heat pump water heater system that meets the total building hot water demand as calculated and documented by the responsible person associated with the project.

B. The electrical power required that meets the requirements specified for the heat pump in Joint Appendix JA15.2.5.

«» Commentary for Section 160.9(f)5:

Unlike some electric readiness requirements that mandate installation of conductors and/or conduit to the future equipment location, the requirements of this section are focused on ensuring adequate physical space and capacity in the upstream electrical infrastructure. The reason for this difference is that adequately sized building level infrastructure is critical to enabling a future low cost retrofit whereas a single conduit and conductor can often be retrofitted with relative ease. Furthermore, as compared to other equipment there is a higher possibility that the location of the future heat pump water heater may change from what is originally planned. The combination of these factors is why conduit and conductors are not required for central heat pump water heater electric readiness. **«»**

ii. Temperature Maintenance Tank. Meet one of the following.

A. The electrical power required to power a heat pump water heater system temperature maintenance tank that meets the total building hot water demand as calculated and documented by the responsible person associated with the project.

B. The electrical power required that meets the requirements specified for the temperature maintenance tank in Joint Appendix JA15.2.5.

SECTION 170.1 – PERFORMANCE APPROACH

A building complies with the performance approach if the energy consumption calculated for the proposed design building is no greater than the energy budget calculated for the standard design building using Commission-certified compliance software as specified by Sections 10-109, 10-116 and the Alternative Calculation Method Reference Manual.

(a) Energy budget. The Energy budget is expressed in terms of long-term system cost (LSC) and source energy:

1. **Long-term system cost (LSC).** The LSC energy budget is determined by applying the mandatory and prescriptive requirements of the standard design to the proposed design building and has two components, the Efficiency LSC and the Total LSC.
   A. The Efficiency LSC energy is the sum of the LSC energy for space-conditioning, water heating, mechanical ventilation, lighting and the self-utilization credit.
   B. The Total LSC energy is the sum of the Efficiency LSC energy and LSC energy from the photovoltaic system, battery energy storage systems (BESS), and demand flexibility.
2. **Source energy.** The source energy budget is determined by applying the mandatory and prescriptive requirements of the standard design, except with a consumer gas or propane water heater, to the proposed design building.

Exception to Section 170.1(a): A community shared solar electric generation system, or other renewable electric generation system, and/or community shared BESS, that provides dedicated power, utility energy reduction credits or payments for energy bill reductions to the permitted building and is approved by the Energy Commission as specified in Title 24, Part 1, Section 10-115, may offset part or all of the solar electric generation system or BESS LSC energy required to comply with the standards, as calculated according to methods established by the Commission in the Nonresidential ACM Reference Manual.

(b) Compliance demonstration requirements for performance standards.

1. Certificate of Compliance and Application for a Building Permit. The application for a building permit shall include documentation pursuant to Sections 10-103(a)1 and 10-103(a)2 that demonstrates, using an approved calculation method, that the building has been designed so that its source energy and LSC energy consumption do not exceed the standard design energy budgets for the applicable climate zone.

2. Field verification of individual dwelling unit systems. When performance of installed features, materials, components, manufactured devices or systems above the minimum specified in Section 170.2 is necessary for the building to comply with Section 170.1, or is necessary to achieve a more stringent local ordinance, field verification shall be performed in accordance with the applicable requirements in the following subsections, and the results of the verification(s) shall be documented on applicable Certificates of Installation pursuant to Section 10-103(a)3 and applicable Certificates of Verification pursuant to Section 10-103(a)5.

«» Commentary for Section 170.1(a):

The performance approach is applicable when the designer uses a compliance software program approved by the Energy Commission to demonstrate that the proposed building's energy consumption (including common use area indoor lighting power) meets the energy budget.

The energy budget assumes a standard dwelling unit lighting energy use (based on mandatory dwelling unit lighting requirements), and those requirements cannot be traded off using the performance approach. The performance approach cannot be used to comply with outdoor or sign lighting requirements, those systems must comply with mandatory and prescriptive requirements.

No additional lighting power allotment is gained by using the performance method unless it is traded from the space conditioning, mechanical ventilation, service water heating, envelope, or covered process systems. **«»**

SECTION 170.2 – PRESCRIPTIVE APPROACH

(e) **Lighting.** Dwelling unit lighting shall meet the applicable mandatory requirements of Section 160.5(a). Common use area lighting shall meet the following requirements:

Exception to Section 170.2(e): Common use areas providing shared provisions for living, eating, cooking or sanitation to dwelling units that would otherwise lack these provisions may instead comply with Section 160.5(a).

«» Commentary for Section 170.2(e):

The prescriptive compliance approach for multifamily common use area lighting establishes an adjusted lighting power for a proposed design as well as a maximum lighting power that can be installed based on the space types. The process for calculating adjusted lighting power for multifamily common use area indoor lighting is closely aligned to the corresponding process for nonresidential buildings.

The differences between the prescriptive requirements for common use areas in multifamily buildings and nonresidential buildings include:

1. Only the area category method may be used per Section 170.2(e)3. Common use areas may not use the complete building method for lighting power allowance calculations.
2. The primary function area types included in the multifamily common use area lighting power density Table 170.2-M differ from the corresponding nonresidential primary function area types included in Table 140.6-C.
3. The primary function area types included in Table 170.2-M are specific to multifamily common use areas and do not include nonresidential primary function area types.
4. Common use areas providing shared provisions for living, eating, cooking, or sanitation to dwelling units that would otherwise lack these provisions may instead comply with the requirements for dwelling units per Section 160.5(a).

Lighting Terms Related to the Area Category Method

1. Accent Lighting is directional lighting to emphasize a particular object or surface feature, or to draw attention to a part of the field of view. It can be recessed, surface mounted, or mounted to a pendant, stem, or track, and can be display lighting. It shall not provide general lighting.
2. Decorative Lighting/Luminaires is lighting or luminaires installed only for aesthetic purposes and that does not serve as display lighting or general lighting. Decorative luminaires are chandeliers, sconces, lanterns, neon or cold cathode, light emitting diodes, theatrical projectors, moving lights, and light color panels, not providing general lighting or task lighting.

3. Dim-to-warm (also known as warm dim) light source is capable of simultaneously decreasing its correlated color temperature as its light output decreases, typically resembling the change in color temperature of an incandescent lamp as it dims.
4. Floor Display Lighting is supplementary lighting that provides a higher level of illuminance to a specific area than the level of surrounding ambient illuminance required to highlight features, such as merchandise on a clothing rack or sculpture or free standing artwork, which is not displayed against a wall.
5. General lighting (also known as ambient lighting) is electric lighting that provides a uniform level of illumination throughout an area exclusive of any provision for special visual tasks or decorative effect, or exclusive of daylighting.
   - Typical luminaires used for general lighting are troffers (prismatic, parabolic, or indirect diffusers), pendants (direct, indirect, or direct/indirect), high bay, low bay, and “aisle-lighter” fixtures. General lighting does not include display lighting (typically using directional MR, PAR, flood, spot, or wall washers) or decorative lighting (such as drum fixtures, chandeliers, or projection lighting.)
   - When there is only one lighting system type in a space, that system type will be treated as general lighting. Thus, light fixtures that might ordinarily be considered decorative or display luminaires are considered general lighting luminaires if they are the only system type in a given enclosed space.
6. Special Effects Lighting is lighting installed to give off luminance instead of providing illuminance, which does not serve as general, task, or display lighting.
7. Tunable white light source is capable of adjusting its correlated color temperature while maintaining its relative light output and capable of adjusting its light output while maintaining its correlated color temperature.
8. Wall Display Lighting is supplementary lighting that provides a higher level of illuminance to a specific area than the level of surrounding ambient illuminance required to highlight features, such as wall-mounted artwork, which is displayed on perimeter walls.
9. Window Display Lighting is lighting that provides a higher level of illuminance to a specific area than the level of surrounding ambient illuminance of objects such as artwork and artifacts, in a show window, to be viewed from the outside of a space.

«»

1. **Interior common use area lighting.** A building complies with Section 170.2(e)1 if:

   A. The calculation of adjusted indoor lighting power of all proposed building areas combined, calculated under Subsection 170.2(e)2, is no greater than the calculation of allowed indoor lighting power, specific methodologies calculated under Subsection 170.2(e)4; and

   B. The calculation of allowed indoor lighting power, general rules comply with Subsection 170.2(e)3.

   The prescriptive limits on indoor lighting power are the smaller of the actual and allowed indoor lighting power values determined in accordance with Item A.

2. **Calculation of Adjusted Indoor Lighting Power.** The Adjusted Indoor Lighting Power of all proposed building areas is the total watts of all planned permanent and portable lighting systems in all areas of the proposed building; subject to the applicable adjustments under Subdivisions A through D of this subsection.

   A. **Two interlocked lighting systems**: No more than two lighting systems may be used for an area, and if there are two they must be interlocked. Where there are two interlocked lighting systems, the watts of the lower wattage system may be excluded from the Adjusted Indoor Lighting Power if:

      i. An installation certificate detailing compliance with Section 170.2(e)1A is submitted in accordance with Section 10-103 and Section 160.5(e); and

      ii. The area (or areas) served by the interlocking systems is an auditorium, a conference room, a multipurpose room or a theater; and

      iii. The two lighting systems are interlocked with a nonprogrammable double-throw switch to prevent simultaneous operation of both systems.

      For compliance with Part 6, a nonprogrammable double-throw switch is an electrical switch commonly called a "single pole double throw" or "three-way" switch that is wired as a selector switch allowing one of two loads to be enabled. It can be a line voltage switch or a low voltage switch selecting between two relays. It cannot be overridden or changed in any manner that would permit both loads to operate simultaneously.

«» Commentary for Section 170.2(e)2A:

Where there are two interlocked lighting systems (two lighting systems may be installed provided they are interlocked so that both lighting systems cannot operate simultaneously) the lower-wattage system may be excluded from determining the adjusted indoor lighting power under the following conditions:

1. The person who is eligible under Division 3 of the Business and Professions Code to accept responsibility for the construction or installation of features, materials,

components, or manufactured devices must sign and submit the certificate of installation before two interlocked lighting systems will be recognized for compliance.

2. If any of the requirements in the certificate of installation are not met, the two interlocked lighting systems will not be recognized for compliance.
3. The two lighting systems shall be interlocked with a nonprogrammable double-throw switch to prevent simultaneous operation of both systems. For compliance with the Energy Code, a nonprogrammable double-throw switch is an electrical switch commonly called a "single pole double throw" or "three-way" switch that is wired as a selector switch allowing one of two loads to be enabled. It can be a line voltage switch or a low-voltage switch selecting between two relays. It cannot be overridden or changed in any manner that would permit both loads to operate simultaneously. «»

B. **Reduction of wattage through controls.** In calculating Adjusted Indoor Lighting Power, the installed watts of a luminaire providing general lighting in an area listed in Table 170.2-L may be reduced by the product of (i) the number of watts controlled as described in Table 170.2-L, times (ii) the applicable power adjustment factor (PAF), if all of the following conditions are met:

i. An installation certificate is submitted in accordance with Section 160.5(e)2; and

ii. Luminaires and controls meet the applicable requirements of Section 110.9 and Sections 160.5(b) through 160.6; and

iii. The controlled lighting is permanently installed general lighting systems and the controls are permanently installed nonresidential-rated lighting controls.

When used for determining PAFs for general lighting in offices, furniture mounted luminaires that comply with all of the following conditions shall qualify as permanently installed general lighting systems:

a. The furniture mounted luminaires shall be permanently installed no later than the time of building permit inspection; and

b. The furniture mounted luminaires shall be permanently hardwired; and

c. The furniture mounted lighting system shall be designed to provide indirect general lighting; and

d. Before multiplying the installed watts of the furniture mounted luminaire by the applicable PAF, 0.3 watts per square foot of the area illuminated by the furniture mounted luminaires shall be subtracted from installed watts of the furniture mounted luminaires; and

e. The lighting control for the furniture mounted luminaire complies with all other applicable requirements in Section 170.2(e)2B.

«» Commentary for Section 170.2(e)2B:

Section 170.2(e)2 of the Energy Code requires that all planned lighting, including portable and permanent lighting systems, be counted toward the lighting energy use of the common use area, regardless of when it is planned to be installed.

When the common use area includes offices with cubicles with portable lighting, the area category method include an additional lighting power provision is available. Because office cubicles (including their portable lighting) are typically not installed until after the building inspection is complete, the portable lighting power is counted together with the permanent lighting as the adjusted lighting power for compliance.

The Energy Code defines portable lighting as lighting with plug-in connections for electric power. That includes table and floor lamps, those attached to modular furniture, workstation task luminaires, luminaires attached to workstation panels, those attached to movable displays, or those attached to personal property. «»

iv. At least 50 percent of the light output of the controlled luminaire is within the applicable area listed in Table 170.2-L. Luminaires on lighting tracks shall be within the applicable area in order to qualify for a PAF.

v. Only one PAF from Table 170.2-L may be used for each qualifying luminaire. PAFs shall not be added together unless allowed in Table 170.2-L.

vi. Only lighting wattage directly controlled in accordance with Section 170.2(e)2B shall be used to reduce the installed watts as allowed by Section 170.2(e)2B for calculating the Adjusted Indoor Lighting Power. If only a portion of the wattage in a luminaire is controlled in accordance with Section 170.2(e)2B, then only that portion of controlled wattage may be reduced in calculating Adjusted Indoor Lighting Power.

vii. Lighting controls used to qualify for a PAF shall be designed and installed in addition to manual, multilevel and automatic lighting controls required in Section 160.5(b)4, and in addition to any other lighting controls required by any provision of Part 6. PAFs shall not be available for lighting controls required by Part 6.

viii. To qualify for the PAF for daylight continuous dimming plus OFF control, the daylight control and controlled luminaires shall comply with Sections 160.5(b)4D, 160.5(e)1C and 160.5(e)1G, and the controls shall be continuous dimming and shall additionally turn lights completely OFF when the daylight available in the daylit zone is greater than 150 percent of the illuminance received from the general lighting system at full power. The

PAF shall apply to the luminaires in the primary sidelit daylit zone, secondary sidelit daylit zone and skylit daylit zone.

ix. To qualify for the PAF for an occupant sensing control controlling the general lighting in large-office areas above workstations, in accordance with Table 170.2-L, the following requirements shall be met:

a. The office area shall be greater than 250 square feet; and

b. This PAF shall be available only in office areas that contain workstations; and

c. Controlled luminaires shall only be those that provide general lighting directly above the controlled area, or furniture mounted luminaires that comply with Section 170.2(e)1Aii and provide general lighting directly above the controlled area; and

d. Qualifying luminaires shall be controlled by occupant sensing controls that meet all of the following requirements, as applicable:

I. Infrared sensors shall be equipped by the manufacturer, or fitted in the field by the installer, with lenses or shrouds to prevent them from being triggered by movement outside of the controlled area.

II. Ultrasonic sensors shall be tuned to reduce their sensitivity to prevent them from being triggered by movements outside of the controlled area.

III. All other sensors shall be installed and adjusted as necessary to prevent them from being triggered by movements outside of the controlled area.

e. Occupant sensing control zones, in offices greater than 250 square feet, shall be shown on the plans.

x. To qualify for the PAF for an Institutional Tuning in Table 170.2-L, the tuned lighting system shall comply with all of the following requirements:

a. The lighting controls shall limit the maximum output or maximum power draw of the controlled lighting to 85 percent or less of full light output or full power draw; and

b. The means of setting the limit is accessible only to authorized personnel; and

c. The setting of the limit is verified by the acceptance test required by Section 160.5(e)1G; and

d. The construction documents specify which lighting systems shall have their maximum light output or maximum power draw set to no greater than 85 percent of full light output or full power draw.

xi. To qualify for the PAF for a demand responsive control in Table 170.2-L, the general lighting wattage receiving the PAF shall not be within the scope of Section 110.12(c) and a demand responsive control shall meet all of the following requirements:

a. The controlled lighting shall be capable of being automatically reduced in response to a demand response signal; and

b. General lighting shall be reduced in a manner consistent with the illuminance uniformity requirements of Section 160.5(b)4B.

xii. To qualify for the PAFs for clerestory fenestration, horizontal slats or light shelves in Table 170.2-L, the daylighting design shall meet the requirements in Section 170.2(b). The PAFs shall only apply to lighting in a primary or secondary sidelit daylit zone where continuous dimming daylighting controls meeting the requirements of Section 160.5(b)4D are installed.

TABLE 170.2-L LIGHTING POWER ADJUSTMENT FACTORS (PAF)

TYPE OF CONTROL	TYPE OF AREA	FACTOR
1. Daylight Continuous Dimming plus OFF Control	Luminaires in skylit daylit zone or primary sidelit daylit zone	0.10
2. Occupant Sensing Controls in Office Spaces larger than 250 square feet	In open plan offices > 250 square feet: One sensor controlling an area that is: No larger than 125 square feet	0.30
	In open plan offices > 250 square feet: One sensor controlling an area that is: From 126 to 250 square feet	0.20
3.Institutional Tuning	Luminaires in non-daylit areas. Luminaires that qualify for other PAFs in this table may also qualify for this tuning PAF.	0.10
	Luminaires in daylit areas. Luminaires that qualify for other PAFs in this table may also qualify for this tuning PAF.	0.05
4. Demand Responsive Control	General lighting luminaires not in the scope of Section 110.12(c). If DR controls are required of Section 110.12(c), this PAF is not available for any lighting in the project. Luminaires that qualify for other PAFs in this table may also qualify for this demand responsive control PAF	0.05

5. Clerestory Fenestration	Luminaires in daylit areas adjacent to the clerestory. Luminaires that qualify for daylight dimming plus OFF control may also qualify for this PAF.	0.05
6. Horizontal Slats	Luminaires in daylit areas adjacent to vertical fenestration with interior or exterior horizontal slats. Luminaires that qualify for daylight dimming plus OFF control may also qualify for this PAF.	0.05
7.Light Shelves	Luminaires in daylit areas adjacent to clerestory fenestration with interior or exterior light shelves. This PAF may be combined with the PAF for clerestory fenestration. Luminaires that qualify for daylight dimming plus OFF control may also qualify for this PAF	0.10

«» Commentary for Section 170.2(e)2B:

The Energy Code provides an option for a lighting power reduction credit when specific lighting controls are installed, provided those lighting controls are not otherwise required. A power adjustment factor (PAF) is an adjustment to the installed lighting power in an area that allows some of the installed lighting power to not be counted toward the building's total installed lighting load. «»

C. **Lighting wattage excluded.** The watts of the following indoor lighting applications may be excluded from Adjusted Indoor Lighting Power:

   i. Lighting installed by the manufacturer in walk-in coolers or freezers, vending machines and food preparation equipment.

   ii. Lighting that is required for exit signs subject to the CBC. Exit signs shall meet the requirements of the Appliance Efficiency Regulations.

   iii. Exit way or egress illumination that is normally off and that is subject to the CBC.

   iv. Temporary lighting systems.

   v. Lighting systems in qualified historic buildings, as defined in the California Historical Building Code (Title 24, Part 8), are exempt from the lighting power density allowances if they consist solely of historic lighting components or replicas of historic lighting components. If lighting systems in qualified buildings contain some historic lighting components or replicas of historic components, combined with other lighting components, only those historic or historic replica components are exempt. All other lighting systems in qualified historic buildings shall comply with the lighting power density allowances.

   vi. Lighting for signs shall comply with Section 170.2(e)7.

vii. Lighting in elevators where the lighting meets the requirements in Section 120.6(f).

viii. Lighting connected to a Life Safety Branch or Critical Branch, as specified in Section 517 of the California Electrical Code.

D. Luminaire classification and power adjustment.

i. Luminaire classification and power shall be determined in accordance with Section 160.5(b)1.

ii. Small Aperture Tunable-White and Dim-to-Warm Luminaires Lighting Power Adjustment. For qualifying small aperture tunable-white and dim-to-warm LED luminaires, the adjusted indoor lighting power of these luminaires shall be calculated by multiplying their maximum rated wattage by 0.75. Qualifying luminaires shall meet all of the following:

a. Small aperture. Qualifying luminaires with a luminaire aperture length longer than 18 inches shall have a luminaire aperture no wider than four inches. Qualifying luminaires with a luminaire aperture length of 18 inches or less shall have a luminaire aperture no wider than 8 inches.

b. Color changing. Qualifying tunable-white luminaires shall be capable of a color change greater than or equal to 2000 Kelvin correlated color temperature (CCT). Qualifying dim-to-warm luminaires shall be capable of color change greater than or equal to 500 Kelvin CCT.

c. Controls. Qualifying luminaires shall be connected to controls that allow color changing of the luminaires.

«» Commentary for Section 170.2(e)2D:

Color-tunable LED lighting technologies provide adjustable correlated color temperatures (CCT) to match the current use of a space or to reflect changes in time of day.

Two categories of color tunable luminaires – tunable-white LED and dim-to-warm LED luminaires – can qualify for a luminaire lighting power adjustment multiplier of 0.75 if the luminaires meet all of the requirements of Section 170.2(e)2Dii, described below.

1. Small Aperture: Luminaire aperture width no wider than 4 inches for an aperture length longer than 18 inches; aperture width no wider than 8 inches otherwise.
2. Color Changing Capability: Capable of color change greater than or equal to 2000K CCT for tunable-white LED luminaires; capable of color change greater than or equal to 500K CCT for dim-to-warm LED luminaires.
3. Controls: Connected to controls that allow color changing of the illumination.

Figure 6-26: Example of Dim-to-Warm Lighting: An Indoor Space With Dim-to-Warm Luminaires

Image Source: NORA Lighting

Figure 6-27: Relationship of Dimming to Change in Correlated Color Temperature of Dim-to-Warm (aka "WarmDim") Lighting Technology

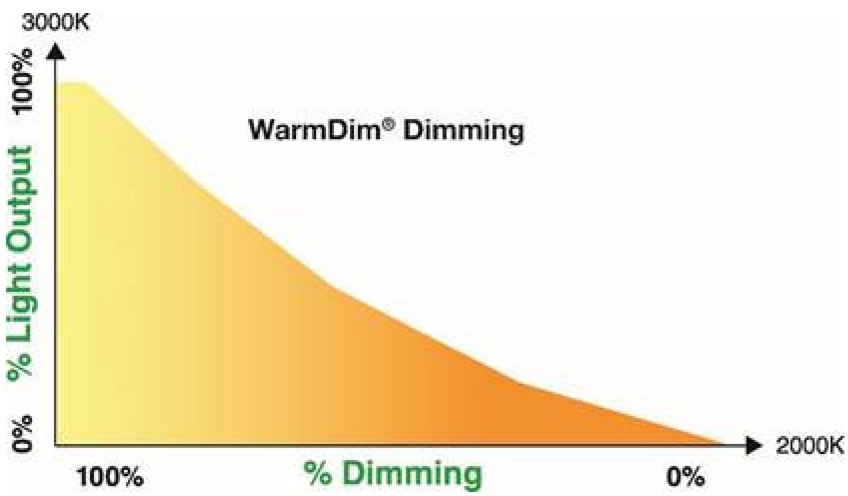


Image Source: Juno WarmDimming® Dimming courtesy of Acuity Brands Lighting, Inc.

«»

3. **Calculation of allowed indoor lighting power: general rules.**

   A. The allowed indoor lighting power allotment for conditioned areas shall be calculated separately from the allowed lighting power allotment for unconditioned areas. Each allotment is applicable solely to the area to which it applies, and there shall be no trade-offs between conditioned and unconditioned area allotments.

   B. The allowed indoor lighting power allotment shall be calculated separately from the allowed outdoor lighting power allotment. Each allotment is applicable solely to the area to which it applies, and there shall be no trade-offs between the separate indoor and outdoor allotments.

C. The allowed indoor lighting power allotment for general lighting shall be calculated as follows:

   i. The Area Category Method, as described in Section 170.2(e)4A, shall be used for all common use areas in the building. Under the Area Category Method as described more fully in Section 170.2(e)4A, and subject to the adjustments listed there, the allowed indoor lighting power allotment for general lighting shall be calculated for each area in the building as follows:

      a. For conditioned areas, by multiplying the conditioned square feet of the area times the applicable allotment of watts per square foot for the area shown in Table 170.2-M.

      b. For unconditioned areas, by multiplying the unconditioned square feet of the area times the applicable allotment of watts per square foot for the area shown in Table 170.2-M.

   The allowed indoor lighting power allotment for general lighting for one area for which the Area Category Method was used may be increased up to the amount that the allowed indoor lighting power allotment for general lighting for another area using the Area Category Method, except that such increases and decreases shall not be made beeD. Additional lighting power allowances other than general lighting power allowances shall be restricted when using the Area Category Method. Additional lighting power allowances for display; decorative, wall display, floor display, or task, may not be increased as a result of, or otherwise traded off against, decreasing any other allotment.

«» Commentary for Section 170.2(e)3D:

Under the Area Category Method, an "area" is defined as all contiguous spaces that accommodate or are associated with a single primary function as listed in Table 170.2-M. For primary function areas not listed, selection of a reasonably equivalent type shall be permitted.

The Area Category Method divides the common use area into primary function areas. Each function area is defined in Section 100.1. The allowed lighting power is determined by multiplying the area of each function times the lighting power density for that function. Where areas are bounded or separated by interior partitions, the floor space occupied by those interior partitions shall be included in any area. The total allowed watts are the summation of the allowed lighting power for each area covered by the permit application.

When using this method, each common use function area must be included as a separate area. Boundaries between primary function areas may or may not consist of walls or partitions. For example, common use kitchen and dining areas may or may not be separated by walls. For purposes of compliance, they must still be separated into two different function areas. However, it is not necessary to separate aisles or entries within primary function areas. When the Area Category Method is used to calculate the allowed total lighting power the main entry lobbies, corridors, restrooms, and support functions shall each be treated as separate function areas. «»

TABLE 170.2-M AREA CATEGORY METHOD - LIGHTING POWER DENSITY VALUES (WATTS/FT²)

Primary Function Area	Allowed Lighting Power Density for General Lighting (W/ft²)	Additional Lighting Power Qualified Lighting Systems	Additional Lighting Power Additional Allowance (W/ft², unless noted otherwise)
Storage	0.4	NA	NA
Conference, Multipurpose and Meeting Area	0.75	Display	0.25
Conference, Multipurpose and Meeting Area	0.75	Wall Display MH <= 10'6"	2 W/ft
Conference, Multipurpose and Meeting Area	0.75	Wall Display MH 10'7"to 14'	2.35 W/ft
Conference, Multipurpose and Meeting Area	0.75	Wall Display MH > 14'	2.66 W/ft
Conference, Multipurpose and Meeting Area	0.75	Floor Display & Task MH <= 10'6"	0.30
Conference, Multipurpose and Meeting Area	0.75	Floor Display & Task MH 10'7" to 14'	0.35
Conference, Multipurpose and Meeting Area	0.75	Floor Display & Task MH > 14'	0.40
Copy Room	0.50	NA	NA
Corridor Area	0.40	Decorative/Display	0.25
Dining Area Bar/Lounge and Fine Dining	0.45	Display	0.35
Dining Area Bar/Lounge and Fine Dining	0.45	Wall Display MH <= 10'6"	1.25 W/ft
Dining Area Bar/Lounge and Fine Dining	0.45	Wall Display MH 10'7" to 14'	1.5 W/ft

Dining Area Bar/Lounge and Fine Dining	0.45	Wall Display MH > 14′	1.7 W/ft
Dining Area Bar/Lounge and Fine Dining	0.45	Floor Display & Task MH <= 10′6″	0.45
Dining Area Bar/Lounge and Fine Dining	0.45	Floor Display & Task MH 10′7″ to 14′	0.52
Dining Area Bar/Lounge and Fine Dining	0.45	Floor Display & Task MH > 14′	0.60
Dining Area Bar/Lounge and Fine Dining	0.45	General Lighting in the enclosed space of ceiling height > 10′	0.25
Dining Area Cafeteria/Fast Food	0.45	Display/Decorative	0.25
Dining Area Family and Leisure	0.40	Display/Decorative	0.25
Health Care / Assisted Living Nurse's Station	0.85	Tunable white or dim-to-warm[8]	0.10

TABLE 170.2-M AREA CATEGORY METHOD - LIGHTING POWER DENSITY VALUES (WATTS/FT²) (Continue)

Primary Function Area	**Allowed Lighting Power Density for General Lighting (W/ft^2)**	**Additional Lighting Power Qualified Lighting Systems**	**Additional Lighting Power Additional Allowance (W/ft^2, unless noted otherwise)**
Health Care / Assisted Living Physical Therapy Room	0.75	Tunable white or dim-to-warm[8]	0.10
Kitchen/Food Preparation Area	0.95	NA	NA
Electrical, Mechanical, Telephone Rooms	0.40	Detailed Task Work[1]	0.20
Exercise/Fitness Center and Gymnasium Area	0.50	NA	NA
Lobby, Main Entry	0.70	Display	0.25

Lobby, Main Entry	0.70	Wall Display MH <= 10’6”	3 W/ft
Lobby, Main Entry	0.70	Wall Display MH 10’7” to 14’	3.5 W/ft
Lobby, Main Entry	0.70	Wall Display MH > 14’	4 W/ft
Locker Room	0.45	NA	NA
Lounge, Breakroom, or Waiting Area	0.55	Display/Decorative	0.25
Concourse and Atria Area	0.60	Display/Decorative	0.25
Office Area > 250 square feet	0.60	Decorative/Display and Portable lighting for office areas[5]	0.20
Office Area ≤ 250 square feet	0.65	Decorative/Display and Portable lighting for office areas[5]	0.20
Parking Garage Area Parking Zone and Ramps	0.10	First ATM or Ticket Machine	100 W
Parking Garage Area Parking Zone and Ramps	0.10	Additional ATM or Ticket machine	50 W each
Parking Garage Area Daylight Adaptation Zones[3]	1.00	-	-
Laundry Area	0.45	-	-
Restrooms	0.65	Decorative/ Display	0.35
Stairwell	0.60	Decorative/ Display	0.35
All other	0.40	-	-
Aging Eye/Low-vision[6] Lobby, Main Entry	0.85	Display/Decorative	0.30
Aging Eye/Low-vision[6] Lobby, Main Entry	0.85	Transition Lighting OFF at night[7]	0.95
Aging Eye/Low-vision[6] Stairwell	0.80	Display/Decorative	0.30
Aging Eye/Low-vision[6] Corridor Area	0.70	Display/Decorative	0.30
Aging Eye/Low-vision[6] Lounge/Waiting Area	0.80	Display/Decorative	0.30
Aging Eye/Low-vision[6] Multipurpose Room	0.85	Display/Decorative	0.30
Aging Eye/Low-vision[6] Dining	0.80	Display/Decorative	0.30
Aging Eye/Low-vision[6] Restroom	1.00	Display/Decorative	0.20

Footnotes for this table are listed below.

1. Detailed task work – Lighting provides high level of visual acuity required for activities with close attention to small elements and/or extreme close up work.
2. MH denotes the luminaire mounting height of the qualified lighting systems.
3. Daylight Adaptation Zones shall be no longer than 66 feet from the entrance to the parking garage.
4. RESERVED
5. Portable lighting in office areas includes under shelf or furniture-mounted supplemental task lighting qualifies when controlled by a time clock or an occupancy sensor.
6. Aging Eye/Low-vision areas can be documented as being designed to comply with the light levels in ANSI/IES RP-28 and are or will be licensed by local or state authorities for either senior long-term care, adult day care, senior support, and/or people with special visual needs.
7. Transition lighting OFF at night. Lighting power controlled by astronomical time clock or other control to shut off lighting at night. Additional LPD only applies to area within 30 feet of an exit. Not applicable to lighting in daylittTunable white luminaires capable of color change greater than or equal to 2000K CCT, or dim-to-warm luminaires capable of color change greater than or equal to 500K CCT, connected to controls that allows color changing of the luminaires.

4. **Calculation of allowed indoor lighting power: specific methodologies.** The allowed indoor lighting power for each common use primary function area shall be calculated using the following method.

   A. Area Category Method. Requirements for using the Area Category Method include all of the following:

      i. The Area Category Method shall be used only for primary function areas, as defined in Section 100.1, that are listed in Table 170.2-M. For primary function areas not listed, selection of a reasonably equivalent type shall be permitted.

      ii. For purposes of compliance with Section 170.2(e)4A, an "area" shall be defined as all contiguous areas that accommodate or are associated with a single primary function area listed in Table 170.2-M.

      iii. Where areas are bounded or separated by interior partitions, the floor area occupied by those interior partitions may be included in a primary function area.

      iv. The allowed indoor lighting power for each primary function area is the Lighting Power Density value in Table 170.2-M times the square feet of the primary function area. The total allowed indoor lighting power for the building is the sum of all allowed indoor lighting power for all areas in the building.

      v. In addition to the allowed indoor lighting power calculated according to Sections 170.2(e)4Ai through iv, the building may add additional lighting power allowances for qualifying lighting systems as specified in the Qualifying Lighting Systems column in Table 170.2-M under the following conditions:

         a. Only primary function areas having a lighting system as specified in the Qualifying Lighting Systems column in Table 170.2-M and in accordance with the corresponding footnote of the table shall qualify for the additional lighting power allowances; and

         b. The additional lighting power allowances shall be used only if the plans clearly identify all applicable task areas and the lighting equipment designed to illuminate these tasks; and

         c. Tasks that are performed less than two hours per day or poor quality tasks that can be improved are not eligible for the additional lighting power allowances; and

         d. The additional lighting power allowances shall not utilize any type of luminaires that are used for general lighting in the building; and

         e. RESERVED; and

f. The additional lighting power allowed is the smaller of:

   I. the lighting power density listed in the "Allowed Additional Lighting LPD" column in Table 170.2-M, times the square feet of the primary function, or

   II. the adjusted indoor lighting power of the applicable lighting; and

g. Floor displays shall not qualify for wall display allowances.

h. Qualifying wall lighting shall:

   I. Be mounted within 10 feet of the wall having the wall display. When track lighting is used for wall display, and where portions of that lighting track are more than 10 feet from the wall and other portions are within 10 feet of the wall, portions of track more than 10 feet from the wall shall not be used for the wall display allowance; and

   II. Be a lighting system type appropriate for wall lighting. Lighting systems appropriate for wall lighting are lighting track adjacent to the wall, wall-washer luminaai. Mounting height shall be the luminaire mounting height measured from the finished floor to the bottom of the luminaire. If luminaires are mounted at different mounting height within the same space, the average mounting height of the luminaires qualified for the additional lighting power allowances in Table 170.2-M can be used to establish the mounting height of the qualified luminaires for calculations of the additional lighting power allowances of the qualified luminaires.a«» Commentary for Section 170.2(e)4A:aAdditional lighting power allowance examples: A corridor may have a lighting system to provide both accent lighting and general lighting as illustrated in the following images about three different corridor scenarios.

Figure 6-28: Corridors With Accent Lighting and General Lighting: A Corridor With Wall Washer and Accent Luminaires (left image), a Corridor With Recessed Troffer Luminaires (center image), and a Corridor With Sconce Luminaires (right image)

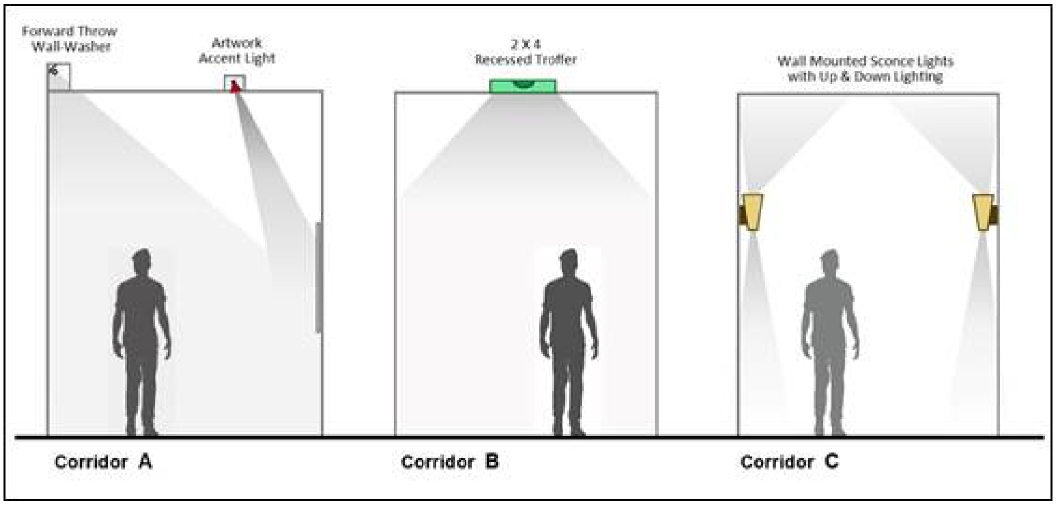


Image Source: Bernie Bauer

Corridor A has two lighting systems: forward wall-washers which provide the primary illumination and recessed accent lights for highlighting artwork. Wall-washers (asymmetric optics) are generally used as accent or feature lighting. However, in this scenario since they provide the general or ambient illumination, the lighting power for these luminaires is general lighting for corridor spaces. The artwork recessed accent lights are providing focal illumination to highlight the art. Therefore, the lighting power for these luminaires may be assigned to the decorative/display lighting allowance listed under the "Additional Lighting Power" column of Table 170.2-M.

Corridor B has one lighting system (2 by 4 recessed LED basket troffers) which provides all the illumination for the space. Basket troffers (symmetric wide distribution optics) are primarily to provide general or ambient illumination. Therefore, the lighting power for these luminaires must be assigned to the general lighting power allowance for corridor spaces. The decorative/display lighting allowance does not apply in this scenario as there are no luminaires providing directional illumination.

Corridor C has one lighting system: wall sconces that provide up-lighting on the ceiling for general /ambient illumination, but the sconces also include a downlight element. However, in this scenario since they provide the general or ambient illumination, the lighting power for these luminaires is general lighting. The decorative/display lighting allowance could also apply in this scenario. However, the up-light and downlight components of the luminaries must be placed on separate circuits. «»

5. RESERVED.

6. **Outdoor lighting.**

   A. A multifamily or mixed occupancy outdoor lighting installation complies with this section if it meets the requirements in Subsections 170.2(e)6B and C, and the actual outdoor lighting power installed is no greater than the allowed outdoor lighting power calculated under Subsection 170.2(e)6D. The allowed outdoor lighting shall be calculated according to outdoor lighting zone in Title 24, Part 1, Section 10-114.

«» Commentary for Section 170.2(e)6A:

In a mixed use building with a multifamily occupancy, the multifamily outdoor lighting requirements described in this section are to be used for the entire site. **«»**

Exceptions to Section 170.2(e)6A: When more than 50 percent of the light from a luminaire falls within one or more of the following applications, the lighting power for that luminaire shall not be required to comply with Section 170.2(e)6:

i. Temporary outdoor lighting.

ii. Lighting required and regulated by the Federal Aviation Administration and the Coast Guard.

iii. Lighting for public streets, roadways, highways and traffic signage lighting, including lighting for driveway entrances occurring in the public right-of-way owned or maintained by a local municipality or utility.

iv. Lighting for sports and athletic fields, and children's playgrounds.

v. Reserved.

vi. Lighting of public monuments.

vii. Lighting of signs complying with the requirements of Sections 160.5(d) and 170.2(e)7.

viii. Lighting of stairs, wheelchair elevator lifts for American with Disabilities Act (ADA) compliance, and ramps that are other than parking garage ramps.

ix. Landscape lighting.

x. Reserved.

xi. Lighting for outdoor theatrical and other outdoor live performances, provided that these lighting systems are additions to area lighting systems and are controlled by a multi-scene or theatrical cross-fade control station accessible only to authorized operators.

xii. Outdoor lighting systems for qualified historic buildings, as defined in the California Historic Building Code (Title 24, Part 8), if they consist solely of historic lighting components or replicas of historic lighting components. If lighting systems for qualified historic buildings contain some historic lighting components or replicas of historic components, combined with other lighting components, only those historic or historic replica components are exempt. All other outdoor lighting systems for qualified historic buildings shall comply with Section 170.2(e)6.

B. **Outdoor lighting power trade-offs.** Outdoor lighting power trade-offs shall be determined as follows:

i. Allowed lighting power determined according to Section 170.2(e)6Di for general hardscape lighting allowance may be traded to specific applications in Section 170.2(e)6Dii, provided the hardscape area from which the lighting power is traded continues to be illuminated in accordance with Section 170.2(e)6Dia.

ii. Allowed lighting power determined according to Section 170.2(e)2Dii for additional lighting power allowances for specific applications shall not be traded between specific applications, or to hardscape lighting in Section 170.2(e)6Di.

iii. Trading off lighting power allowances between outdoor and indoor areas shall not be permitted.

C. **Calculation of actual lighting power.** The wattage of outdoor luminaires shall be determined in accordance with Section 160.5(b)1.

D. **Calculation of allowed lighting power.** The allowed lighting power shall be the combined total of the sum of the general hardscape lighting allowance determined in accordance with Section 170.2(e)2Di, and the sum of the additional lighting power allowance for specific applications determined in accordance with Section 170.2(e)6Dii.

i. **General hardscape lighting allowance**. Determine the general hardscape lighting power allowances as follows:

a. The general hardscape area of a site shall include parking lot(s), roadway(s), driveway(s), sidewalk(s), walkway(s), bikeway(s), plaza(s), bridge(s), tunnel(s) and other improved area(s) that are illuminated. Public roadway(s) that are illuminated by a lighting system owned or maintained by the local municipality or utility shall not be included in the area calculations. In plan view of the site, determine the illuminated hardscape area, which is defined as any hardscape area that is within a square pattern around each luminaire or pole that is ten times the luminaire mounting height with the luminaire in the middle of the pattern, less any areas that are within a building, beyond the hardscape area, beyond property lines or obstructed by a structure. The illuminated hardscape area shall include portions of planters and landscaped areas that are within the lighting application and are less than or equal to 10 feet wide in the short dimensions and are enclosed by hardscape or other improvement on at least three sides. Multiply the illuminated hardscape area by the Area Wattage Allowance (AWA) from Table 170.2-R for the appropriate lighting zone.

b. Determine the Initial Wattage Allowance (IWA) for general hardscape lighting from Table 170.2-R for the appropriate lighting zone. The hardscape area shall be permitted one IWA per site.

c. The general hardscape lighting allowance shall be the sum of the allowed watts determined from a and b above.

«» Commentary for Section 170.2(e)6D:

Allowed outdoor lighting power densities for multifamily buildings are structured using a layered approach. The first layer of allowed lighting power is general hardscape for the entire site. After the allowed lighting power has been determined for this first layer, additional layers of lighting power are allowed for specific applications when they occur on the site. The total allowed lighting power is the combined total of the allowed lighting power layers.

The allowed outdoor lighting power must be determined according to the outdoor lighting zone in which the site is located as defined in Section 10-114.

Figure 6-29: Concept of a Layered Lighting Approach for Outdoor Lighting - Lighting Power Allowance (LPA)

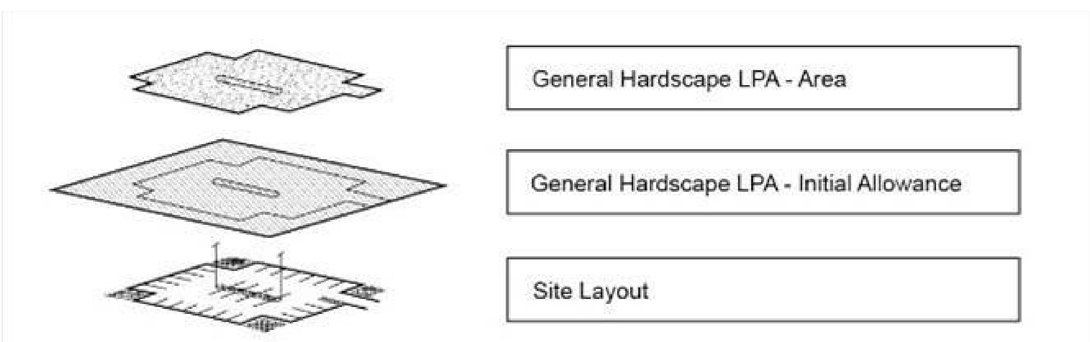


Image Source: Energy Solutions

The outdoor lighting applications addressed by the Energy Code are shown in the first two columns of Table 6-2: Scope of the Multifamily Outdoor Lighting Requirement. The first column is general site illumination applications which allow trade-offs within the outdoor portion only. The second column is specific outdoor lighting applications which do not allow trade-offs and are considered "*use it or lose it*". The lighting applications in the third column are exempt from lighting power requirements. However, these lighting applications must meet applicable lighting control requirements.

For the purpose of determining outdoor lighting allowances, only those areas where lighting is provided are considered *illuminated areas*, excluding any areas that do not have luminaires, areas that are obstructed by any other structure or within a building, and any areas beyond the property line of the project site. The details of the process for determining the illuminated area for multifamily outdoor lighting are consistent with the requirements for nonresidential outdoor lighting.

Illuminated Area

For outdoor lighting applications, the number of luminaires, mounting heights and layout affect the presumed illuminated area and, therefore, the allowed lighting power.

1. The area of the lighting application may not include any areas on the site that are not illuminated. The area beyond the last luminaire is considered illuminated only if it is located within 5 mounting heights of the nearest luminaire.
2. In plan view of the site, the "illuminated area" is defined as any hardscape area within a square pattern around each luminaire or pole that is 10 times the luminaire mounting height, with the luminaire in the middle of the pattern. Another way to envision this is to consider an illuminated area from a single luminaire as the area that is 5 times the mounting height in four directions.
3. Illuminated areas shall not include any area that is obstructed by any other structure, including a sign, within a building, or areas beyond property lines.
4. The primary purpose for validating the illuminated area is to exclude any areas that are not illuminated. Areas that are illuminated by more than one luminaire shall not be double-counted. An area is either illuminated or it is not illuminated.
5. When luminaires are located farther apart (more than 10 times their mounting height apart), then the illuminated area stops at 5 times the mounting height of each luminaire.
6. Planters and small landscape areas are included within the general hardscape area if the short dimension of the inclusion is less than 10 ft. wide, and the inclusion is bordered on at least three sides by illuminated areas.
7. Landscape areas that are greater than 10 ft. wide in the short dimension are excluded from the general hardscape area calculation, but the perimeter of these exclusions may be included.

Figure 6-30: Calculating the Power Allowance for a Parking Lot

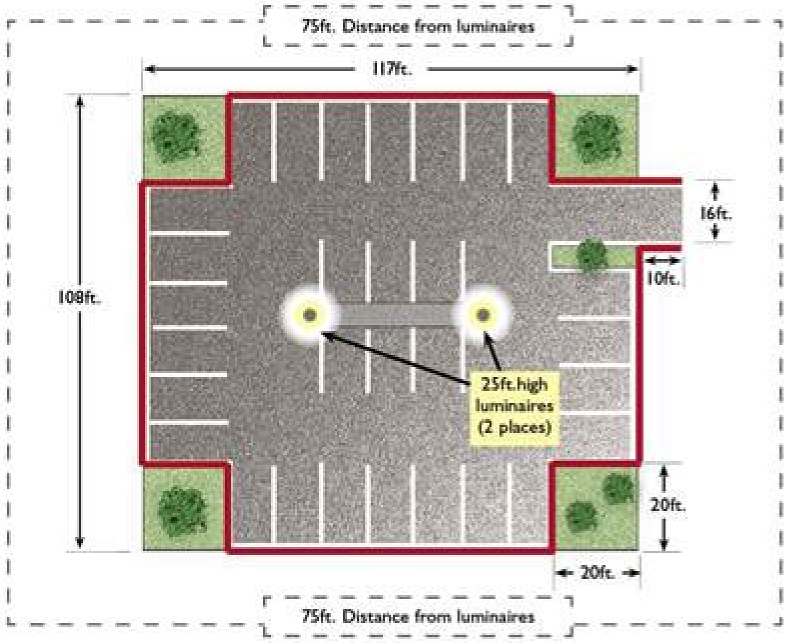


Image Source: California Energy Commission

Hardscape is defined in Section 100.1 as an improvement to a site that is paved and has other structural features, including but not limited to, curbs, plazas, entries, parking lots, site roadways, driveways, walkways, sidewalks, bikeways, water features and pools, storage or service yards, loading docks, amphitheaters, outdoor sales lots, and private monuments and statuary.

Table 6-2: Scope of the Multifamily Outdoor Lighting Requirement

General Hardscape (trade-offs permitted)	Specific Applications (trade-offs not permitted)	Lighting Applications Not Regulated
The general hardscape area of a site must include parking lot(s), roadway(s), driveway(s), sidewalk(s), walkway(s), bikeway(s), plaza(s), bridge(s), tunnel(s), and other improved area(s) that are illuminated.	Building Entrances or Exits Primary Entrances for Senior Care Facilities ATM Machine Lighting Hardscape Ornamental Lighting Building Facades Canopies Tunnels Outdoor Dining Special Security Lighting for Pedestrian Hardscape Security Cameras	Temporary outdoor lighting Required and regulated by FAA Required and regulated by the Coast Guard. For public streets, roadways, highways, and traffic signage lighting, and occurring in the public right-of-way Signs regulated by Section 160.5(d) and Section 170.2(e)7 For stairs and wheelchair elevator lifts For ramps that are not parking garage ramps Landscape lighting For qualified historic buildings

Source: California Energy Commission

«»

ii. **Additional lighting power allowance for specific applications.** Additional lighting power for specific applications shall be the smaller of the additional lighting allowances for specific applications determined in accordance with Table 170.2-S for the appropriate lighting zone, or the actual installed lighting power meeting the requirements for the allowance.

«» Commentary for Section 170.2(e)6D:

The lighting power allowances for specific applications provide additional lighting power that can be layered in addition to the general hardscape lighting power allowances as applicable.

Most of a site will be classified as general hardscape and will be calculated using Table 170.2-R as the only source of allowance. Additional allowances for specific applications can be per application, per hardscape area, per specific application unit length, or per specific application area. Hardscape ornamental lighting is calculated independent of the rest of the specific applications. «»

TABLE 170.2-R GENERAL HARDSCAPE MULTIFAMILY LIGHTING POWER ALLOWANCE

Type of Power Allowance	Lighting Zone 0[2]	Lighting Zone 1[2]	Lighting Zone 2[2]	Lighting Zone 3[2]	Lighting Zone 4[2]
Area Wattage Allowance (AWA)	No allowance[1]	0.026 W/ft²	0.030 W/ft²	0.038 W/ft²	0.055 W/ft²
Initial Wattage Allowance (IWA)	No allowance[1]	300 W	350 W	400 W	450 W

Footnotes to TABLE 170.2-R:

1. Continuous lighting is explicitly prohibited in Lighting Zone 0. A single luminaire of 15 Watts or less may be installed at an entrance to a parking area, trail head, fee payment kiosk, outhouse, or toilet facility, as required to provide safe navigation of the site infrastructure. Luminaires installed shall meet the maximum zonal lumen limits as specified in Section 160.5(c)1.
2. Narrow band spectrum light sources with a dominant peak wavelength greater than 580 nm – as mandated by local, state, or federal agg«» Commentary for Section 170.2(e)6D:

The 2025 Energy Code includes a lighting power provision for narrow band spectrum light source application to minimize the impact of electric light on local, active professional astronomy or nocturnal habitat of specific local fauna. The provision is in the format of lighting power multiplier as specified on the footnote of Table 170.2-R (footnote 2).

Narrow band spectrum light sources are those which have a spectral power distribution closely distributed around the wavelength of peak spectral power. There are no spectral power limitations on the wavelengths that are within 20 nm of the peak wavelength. As the spectrum diverges from the peak wavelength, the allowed relative spectral power declines rapidly.

1. Between 20 to 75nm from peak wavelength, the spectral power shall be no greater than 50% of the peak spectral power.
2. Beyond 75 nm the spectral power shall be no greater than 10% of the peak spectral power. This distribution is reflected in the narrow ban spectrum criteria line centered around the peak wavelength in Figure 6-31 Spectral Distribution with Narrow Band Criteria Superimposed.

Figure 6-31 Spectral Distribution with Narrow Band Criteria Superimposed

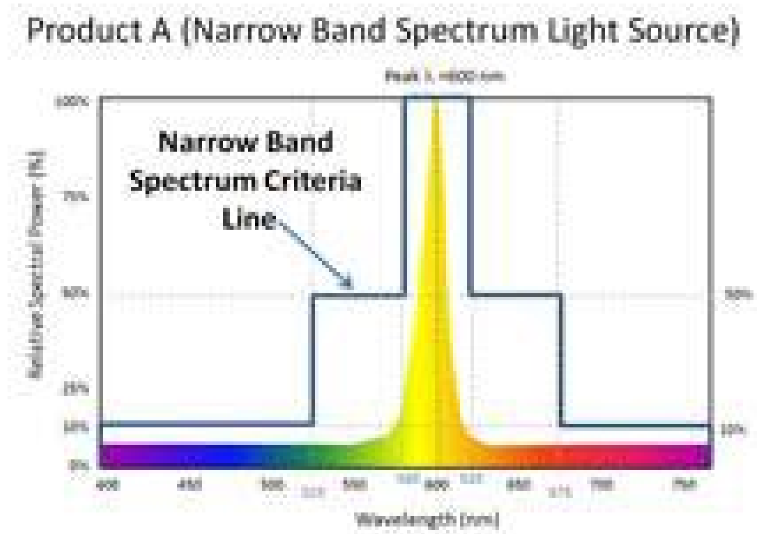


Image Source: Clanton Associates

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TABLE 170.2-S ADDITIONAL MULTIFAMILY LIGHTING POWER ALLOWANCE FOR SPECIFIC APPLICATIONS

All area and distance measurements in plan view unless otherwise noted.

PER APPLICATION: WATTAGE ALLOWANCE PER APPLICATION. Use all that apply as appropriate.

Lighting Application	**Lighting Zone 0**	**Lighting Zone 1**	**Lighting Zone 2**	**Lighting Zone 3**	**Lighting Zone 4**
Building Entrances or Exits. Allowance per door. Luminaires qualifying for this allowance shall be within 20 feet of the door.	Not applicabl e	9 watts	15 watts	19 watts	21 watts
Primary Entrances to Senior Care Facilities Allowance per primary entrance(s) only. Primary entrances shall provide access for the general public and shall not be used exclusively for staff or service personnel. This allowance shall be in addition to the building entrance or exit allowance above. Luminaires qualifying for this allowance shall be within 100 feet of the primary entrance.	Not applicabl e	20 watts	40 watts	57 watts	60 watts

ATM Lighting. Allowance per ATM. Luminaires qualifying for this allowance shall be within 50 feet of the dispenser.	Not applicabl e	100 watts for first ATM, 35 watts for each additiona l ATM.	100 watts for first ATM, 35 watts for each additiona l ATM	100 watts for first ATM, 35 watts for each additiona l ATM	100 watts for first ATM, 35 watts for each additiona l ATM

TABLE 170.2-S ADDITIONAL MULTIFAMILY LIGHTING POWER ALLOWANCE FOR SPECIFIC APPLICATIONS (continued)

All area and distance measurements in plan view unless otherwise noted.

PER APPLICATION: WATTAGE ALLOWANCE PER HARDSCAPE AREA (W/ft²). May be used for any illuminated hardscape area on the site.

Lighting Application	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Hardscape Ornamental Lighting. Allowance for the total site illuminated hardscape area. Luminaires qualifying for this allowance shall be rated for 50 watts or less as determined in accordance with Section 160.5(b)1 and shall be post-top luminaires, lanterns, pendant luminaires, or chandeliers.	Not applicabl e	No Allowanc e	0.007 W/ft²	0.013 W/ft²	0.019 W/ft²

TABLE 170.2-S ADDITIONAL MULTIFAMILY LIGHTING POWER ALLOWANCE FOR SPECIFIC APPLICATIONS (continued)

All area and distance measurements in plan view unless otherwise noted.

PER APPLICATION: WATTAGE ALLOWANCE PER SPECIFIC AREA (W/ft²). Use as appropriate provided that none of the following specific applications shall be used for the same area.

Lighting Application	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Building Facades. Only areas of building façade that are illuminated shall qualify for this allowance. Luminaires qualifying for this allowance shall be aimed at the façade and shall be capable of illuminating it without obstruction or interference by permanent building features or other objects. This allowance calculation shall not include portions of the building facades within 20 feet of residence bedroom windows.	Not applicabl e	No Allowanc e	0.100 W/ft²	0.170 W/ft²	0.225 W/ft²

Canopies and Tunnels. Allowance for the total area within the drip line of the canopy or inside the tunnel. Luminaires qualifying for this allowance shall be located under the canopy or tunnel.	Not applicable	0.057 W/ft²	0.137 W/ft²	0.270 W/ft²	0.370 W/ft²
Student Pick-up/Drop-off zone. Allowance for the area of the student pick-up/drop-off zone, with or without canopy, for preschool through 12th grade school campuses. A student pick-up/drop off zone is a curbside, controlled traffic area on a school campus where students are picked-up and dropped off from vehicles. The allowed area shall be the smaller of the actual width or 25 feet, times the smaller of the actual length or 250 feet. Qualifying luminaires shall be within 2 mounting heights of the student pick-up/drop-off zone.	Not applicable	No Allowance	0.056 W/ft²	0.200 W/ft²	No Allowance
Outdoor Dining. Allowance for the total illuminated hardscape of outdoor dining. Outdoor dining areas are hardscape areas used to serve and consume food and beverages. Qualifying luminaires shall be within 2 mounting heights of the hardscape area of outdoor dining.	Not applicable	0.004 W/ft²	0.030 W/ft²	0.050 W/ft²	0.075 W/ft²

TABLE 170.2-S ADDITIONAL MULTIFAMILY LIGHTING POWER ALLOWANCE FOR SPECIFIC APPLICATIONS (continued)

All area and distance measurements in plan view unless otherwise noted.

PER SITE: WATTAGE ALLOWANCE PER HARDSCAPE AREA (W/ft²). May be used as additional allowance for applicable illuminated hardscape area on the site.

Lighting Application	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Special Security Lighting for Retail Parking and Pedestrian Hardscape. This additional allowance is for illuminated retail parking and pedestrian hardscape identified as having special security needs. This allowance shall be in addition to the building entrance or exit allowance.	Not applicable	0.004 W/ft²	0.005 W/ft²	0.010 W/ft²	No Allowance

TABLE 170.2-S ADDITIONAL MULTIFAMILY LIGHTING POWER ALLOWANCE FOR SPECIFIC APPLICATIONS (continued)

All area and distance measurements in plan view unless otherwise noted.

PER SITE: WATTAGE ALLOWANCE PER HARDSCAPE AREA (W/ft²). May be used as additional allowance for applicable illuminated hardscape area on the site.

Lighting Application	Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
Security Camera. This additional allowance is for the illuminated general hardscape area. This allowance shall apply when a security camera is installed within 2 mounting heights of the general hardscape area and mounted more than 10 feet away from a building.	Not applicable	No Allowance	0.018 W/ft²	0.018 W/ft²	0.018 W/ft²

«» Commentary for Section 170.2(e)6D:

The lighting power allowances for specific applications provide additional lighting power that can be layered in addition to the general hardscape lighting power allowances, as applicable. Some portions of the site may fit use categories that permit the inclusion of an additional lighting allowance for that portion of the site. These specific applications are detailed in Table 170.2-S. Additional allowances for specific applications can be per application, per hardscape area, per specific application unit length, or per specific application area.

As noted previously, all these additional allowances are *use it or lose it* allowances and cannot be traded between applications or to general hardscape lighting. However, general hardscape lighting allowance may be traded to supplement these specific applications.

Building façade lighting is permitted in a similar manner as the nonresidential sections of the Energy Code. However, multifamily buildings have a specific stipulation to the facade lighting allowance that the allowance is not permitted to count areas of the facade that are within 20 feet of a bedroom window. This means design of the building facade will either have no facade lighting or the allowance will be smaller because of the excluded area from the allowance.

Other outdoor lighting applications that are not included in Energy Code Tables 170.2-R and 170.2-S are assumed to be not regulated by the Energy Code. This includes decorative gas lighting and emergency lighting powered by an emergency source as defined by the California Electrical Code.

Even if the lighting is exempted from the wattage allowance requirements, it is still subject to the lighting controls requirements that may apply to the respective lighting systems. «»

7. **Requirements for signs**. Section 170.2(e)7 applies to all internally illuminated and externally illuminated signs, unfiltered light emitting diodes (LEDs), and unfiltered neon, both indoor and outdoor. Each sign shall comply with either Subsection A or B, as applicable.

   A. **Maximum allowed lighting power.**

      i. For internally illuminated signs, the maximum allowed lighting power shall not exceed the product of the illuminated sign area and 12 watts per square foot. For double-faced signs, only the area of a single face shall be used to determine the allowed lighting power.

      ii. For externally illuminated signs, the maximum allowed lighting power shall not exceed the product of the illuminated sign area and 2.3 watts per square foot. Only areas of an externally lighted sign that are illuminated without obstruction or interference, by one or more luminaires, shall be used.

      iii. Lighting for unfiltered light emitting diodes (LEDs) and unfiltered neon shall comply with Section 170.2(e)7B.

   B. **Alternate lighting sources.** The sign shall be equipped with one or more of the following light sources:

      i. Reserved

      ii. Reserved

      iii. Neon or cold cathode lamps with transformer or power supply efficiency greater than or equal to the following:

         a. A minimum efficiency of 75 percent when the transformer or power supply rated output current is less than 50 mA; or

         b. A minimum efficiency of 68 percent when the transformer or power supply rated output current is 50 mA or greater.

      The ratio of the output wattage to the input wattage is at 100 percent tubing load.

      iv. Reserved

      v. Light emitting diodes (LEDs) with a power supply having an efficiency of 80 percent or greater; or

         Exception to Section 170.2(e)7Bv: Single voltage external power supplies that are designed to convert 120 volt AC input into lower voltage DC or AC output, and have a nameplate output power less than or equal to 250 watts, shall comply with the applicable requirements of the Appliance Efficiency Regulations (Title 20).

Exception 1 to Section 170.2(e)7: Unfiltered incandescent lamps that are not part of an electronic message center (EMC), an internally illuminated sign or an externally illuminated sign.

Exception 2 to Section 170.2(e)7: Exit signs. Exit signs shall meet the requirements of the Appliance Efficiency Regulations.

Exception 3 to Section 170.2(e)7: Traffic signs that meet the requirements of the Appliance Efficiency Regulations, Sections 1601(m), 1602, 1602.1, 1603, 1604(m), 1605, 1605.1(m), 1605.2(m), 1605.3(m), 1606, 1607, 1608, and 1609.

«» Commentary for Section 170.2(e)7B:

Sign Lighting Compliance Options

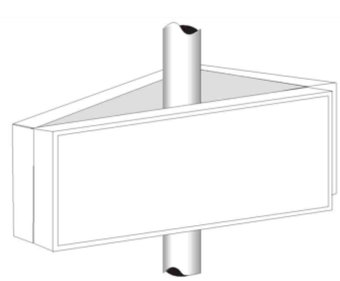
There are two options for complying with the sign lighting power requirements:

1. Maximum allowed lighting power (watts per square foot): The maximum allowed lighting power compliance approach limits allowed sign lighting power based on the illuminated sign area. When using this approach, there are rules in the Energy Code for classifying the lighting technology used and determining luminaire power. This compliance approach may be used for any light source type except unfiltered LED and unfiltered neon lighting.
2. List of compliant alternate lighting sources: The alternate lighting sources compliance approach specifies lighting technologies that may be used to meet the sign lighting power requirements. A sign is in compliance if it is equipped only with one or more of the listed light sources.

Internally and Externally Illuminated Signs

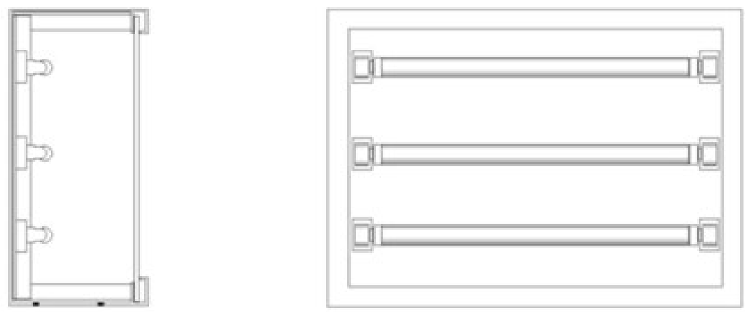
Internally illuminated signs (see Figure 6-32 Multifaced Sign, Figure 6-33: Single-Faced Internally Illuminated Cabinet Sign With Linear Lamps and Translucent Face, and Figure 6-34: Double-Faced Internally Illuminated Cabinet Sign With Linear Lamps and Translucent Faces) are defined in the Energy Code as signs that are illuminated by a light source that is contained inside a sign where the message area is luminous, including cabinet signs and channel letter signs.

Figure 6-32 Multifaced Sign



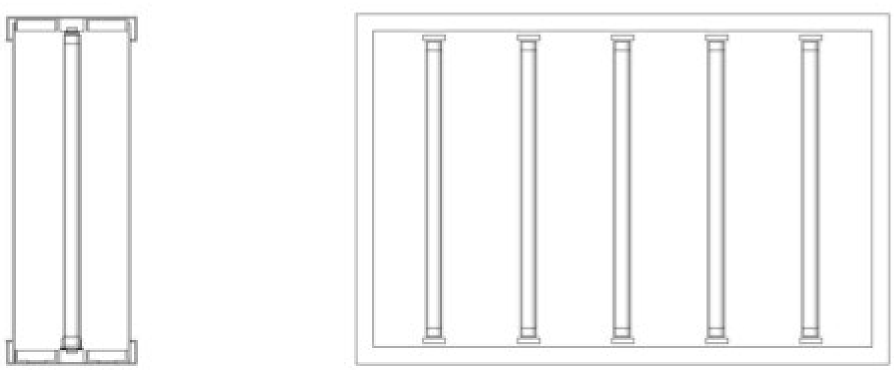
Source: California Statewide CASE Team

Figure 6-33: Single-Faced Internally Illuminated Cabinet Sign With Linear Lamps and Translucent Face



Source: California Statewide CASE Team

Figure 6-34: Double-Faced Internally Illuminated Cabinet Sign With Linear Lamps and Translucent Faces

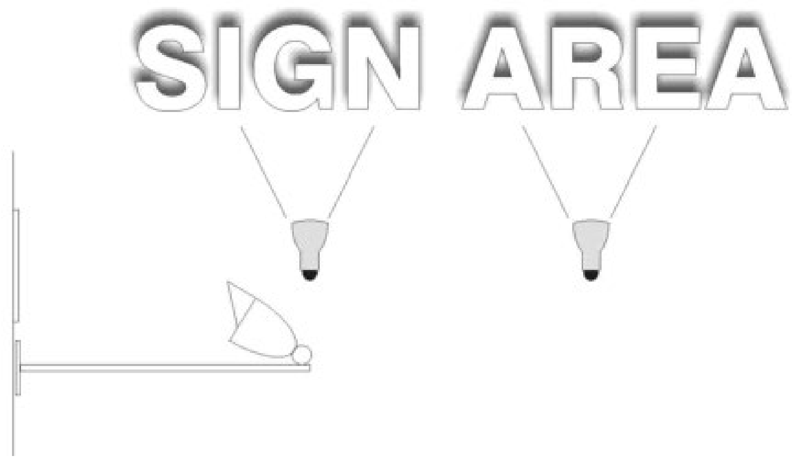


Source: California Statewide CASE Team

Externally Illuminated Signs

Externally illuminated signs (see Figure 6-35: Externally Illuminated Sign Using Flood Lighting) are defined in the Energy Code as any sign or billboard that is lit by a light source that is external to the sign directed toward and shining on the face of the sign.

Figure 6-35: Externally Illuminated Sign Using Flood Lighting

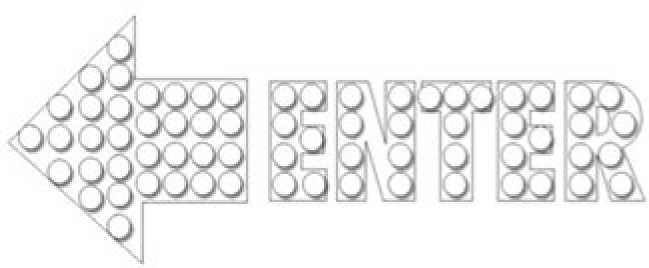


Source: California Statewide CASE Team

Hybrid Signs

A sign may consist of both regulated and non-regulated component. For example, a single sign structure may have a regulated internally illuminated cabinet, regulated externally illuminated letters attached to a brick pedestal, and unregulated unfiltered incandescent "chaser" lamps forming an illuminated arrow. Figure 6-36: Unfiltered Incandescent Sign shows an arrow, which is not part of an EMC using unfiltered incandescent lamps. If the lamps are not covered by a lens, then only the control regulations apply to the sign. This type of unfiltered incandescent sign is not regulated by Section 170.2(e)7.

Figure 6-36: Unfiltered Incandescent Sign



Source: California Statewide CASE Team

«»

SECTION 180.1 – ADDITIONS

Additions to existing multifamily buildings shall meet the applicable requirements of Sections 110.0 through 110.9; Sections 160.0, 160.1, and 160.2(c) and (d); Sections 160.3 through 160.7; and either Section 180.1(a) or 180.1(b).

«» Commentary for Section 180.1:

New additions, similar to newly constructed buildings, must meet all mandatory measures for the prescriptive and performance method of compliance. Prescriptive requirements, including the lighting power densities, must be met if the prescriptive method of compliance is used. If the performance approach is used and the new addition includes envelope or mechanical systems in the performance analysis, the lighting power densities in common use area conditioned spaces may be traded-off against other system energy budgets.

Outdoor lighting additions include adding illuminated area to an existing outdoor lighting site. The additional illuminated area must comply with all mandatory lighting control requirements and lighting power allowance requirements.

All new signs, regardless of whether they are installed in conjunction with an indoor or outdoor addition or alteration to a building or lighting system, must meet the Energy Code requirements. «»

(a) Prescriptive approach. The envelope and lighting of the addition; any newly installed space-conditioning or ventilation system, electrical power distribution system, or water-heating system; any addition to an outdoor lighting system; and any new sign installed in conjunction with an indoor or outdoor addition shall meet the applicable requirements of Sections 110.0 through 110.12**;** 160.0, 160.1, and 160.2(c) and (d); and 160.3 through 170.2.

(b) Performance approach. Performance calculations shall meet the requirements of Sections 170.0 through 170.2(a), pursuant to the applicable requirements in Items 1, 2 and 3 below.

1. **For additions alone.** The addition complies if the addition alone meets the energy budgets expressed in terms of Long-Term System Cost (LSC) energy.
2. **Existing plus alteration plus addition.** The standard design for existing plus alteration plus addition energy use is the combination of the existing building's unaltered components to remain; existing building altered components that are the more efficient, in LSC energy, of either the existing conditions or the requirements of Section 180.2(c); plus the proposed addition's energy use meeting the requirements of Section 180.1(a). The proposed design energy use is the combination of the existing building's unaltered components to remain and

the altered components’ energy features, plus the proposed energy features of the addition.

Exception to Section 180.1(b)2: Existing structures with a minimum R-11 insulation in framed walls showing compliance with Section 180.1(b) are not required to show compliance with Section 160.1(b).

SECTION 180.2 – ALTERATIONS

Alterations to components of existing multifamily buildings, including alterations made in conjunction with a change in building occupancy to a multifamily occupancy, shall meet Item (a), and either Item (b) or (c) below:

(a) Mandatory requirements. Altered components in a multifamily building shall meet the minimum requirements in this section.

(b) Prescriptive approach. The altered component and any newly installed equipment serving the alteration shall meet the applicable requirements of Sections 110.0 through 110.9 and all applicable requirements of Sections 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c) and 160.5; and

4. **Lighting**.

   A. **Dwelling unit lighting.** The altered lighting system shall meet the lighting requirements of Section 160.5(a). The altered luminaires shall meet the luminaire efficacy requirements of Section 160.5(a). Where existing screw base sockets are present in ceiling-recessed luminaires, removal of these sockets is not required, provided that new JA8 compliant trim kits or lamps designed for use with recessed downlights or luminaires are installed.

«» Commentary for Section 180.2(b)4A:

Dwelling unit lighting alterations must meet applicable mandatory requirements. There are no prescriptive lighting requirements for dwelling units.

Dwelling unit altered lighting and any newly installed lighting equipment are required to comply with the residential lighting standards, which apply to permanently installed lighting and associated lighting controls. Only the lighting equipment that is altered needs to comply with the Energy Code. Existing lighting equipment is not required to be replaced to comply. «»

   B. **Common use area—lighting, sign lighting, and electrical power distribution systems**.

      i. Spaces with lighting systems installed for the first time shall meet the applicable requirements of Sections 110.9, 160.5(b)1, 160.5(b)2, 160.5(b)3, 160.5(b)4, 160.5(c), 160.5(e), 170.2(b), and 170.2(e)1 through 170.2(e)6.

      ii. When the requirements of Section 160.5(b)4D are triggered by the addition of skylights to an existing building and the lighting system is not recircuited, the daylighting control need not meet the multi-level requirements in Section 160.5(b)4D.

iii. New internally and externally illuminated signs shall meet the requirements of Sections 110.9, 160.5(d) and 170.2(e)7.

iv. Altered indoor lighting systems. Alterations to indoor lighting systems that include 10% or more of the luminaires serving an enclosed space shall meet the requirements of a, b or c below:

a. The alteration shall comply with the indoor lighting power requirements specified in Sections 170.2(e)1 through 4 and the lighting control requirements specified in Table 180.2-E; or

b. The alteration shall not exceed 80% of the indoor lighting power requirements specified in Section 170.2(e)1 through 4, and shall comply with the lighting control requirements specified in Table 180.2-E; or

c. The alteration shall be a one-for-one luminaire alteration within a building or tenant space of 5,000 square feet or less, the total wattage of the altered luminaires shall be at least 40% lower compared to their total pre-alteration wattage and the alteration shall comply with the lighting control requirements specified in Table 180.2-E.

Alterations to indoor lighting systems shall not prevent the operation of existing, unaltered controls, and shall not alter controls to remove functions specified in SectiiAlterations to lighting wiring are considered alterations to the lighting system. Alterations to indoor lighting systems are not required to separate existing general, floor, wall, display or decorative lighting on shared circuits or controls. New or completely replaced lighting circuits shall comply with the control separation requirements of Sections 160.5(b)4Aiv.i**Exception 1 to Section 180.2(b)4Biv:** Alteration of portable luminaires, luminaires affixed to moveable partitions, or lighting excluded as specified in Section 170.2(e)2C. i**Exception 2 to Section 180.2(b)4Biv:** Any enclosed space with only one luminaire.

Exception 3 to Section 180.2(b)4Biv: Any alteration that would directly cause the disturbance of asbestos unless the alteration is made in conjunction with asbestos abatement.

Exception 4 to Section 180.2(b)4Biv: Acceptance testing requirements of Section 160.5(e) are not required for alterations where lighting controls are added to control 20 or fewer luminaires.

Exception 5 to Section 180.2(b)4Biv: Any alteration limited to adding lighting controls or replacing lamps, ballasts or drivers.

Exception 6 to Section 180.2(b)4Biv: One-for-one luminaire alteration of up to 50 luminaires either per complete floor of the building or per complete tenant space, per annum.

«» Commentary for Section 180.2(b)4B:

Alterations to indoor lighting systems in multifamily common use areas that include 10 percent or more of the existing luminaires serving an enclosed space must meet the indoor lighting alteration requirements in Section 180.2(b)4Biv. Indoor lighting alterations include adding luminaires, removing and reinstalling luminaires, modifying luminaires, or combining the replacement of lamps and ballasts or drivers. «»

v. Alterations to existing outdoor lighting systems in a lighting application listed in Table 170.2-R or 170.2-S shall meet the applicable requirements of Sections 160.5(b)1, 160.5(b)2, 160.5(b)3, 160.5(c)1 and 160.5(e), and:

   a. In alterations that increase the connected lighting load, the added or altered luminaires shall meet the applicable requirements of Section 160.5(c)2 and the requirements of Section 170.2(e)6 for general hardscape lighting or for the specific lighting applications containing the alterations; and

   b. In alterations that do not increase the connected lighting load, where 10 percent or more of the existing luminaires are replaced in a general hardscape or a specific lighting application, the alterations shall meet the following requirements:

«» Commentary for Section 180.2(b)4B:

"Outdoor lighting alterations" generally refer to replacing entire luminaires or adding luminaires to an existing outdoor lighting system. Modifications or retrofitting existing luminaires (for example changing the luminaire light source) are not considered outdoor lighting alterations unless the modification increases the connected lighting load.

For alterations that do not increase connected lighting load and replace fewer than five luminaires or fewer than 10 percent of the existing luminaires, the replacement luminaires must comply with the luminaire shielding (BUG) requirements of Section 160.5(c)1. «»

      I. In parking lots and outdoor sales lots where the bottom of the luminaire is mounted 24 feet or less above the ground, the replacement luminaires shall comply with Section 160.5(c)2A and Section 160.5(c)2C;

      II. For parking lots and outdoor sales lots where the bottom of the luminaire is mounted greater than 24 feet above the ground and for all other lighting applications, the replacement luminaires shall comply with Section 160.5(c)2A and either comply with Section 160.5(c)2B or be controlled by lighting control systems, including motion sensors, that automatically reduce lighting power by at least 40 percent in response to the area being vacated of occupants; and

Exception to Section 180.2(b)4Bvb: Alterations where less than 5 existing luminaires are replaced.

«» Commentary for Section 180.2(b)4B:

If fewer than five existing luminaires are replaced, the replacement luminaires are exempt from the control requirements for alterations to existing outdoor lighting systems. «»

c. In alterations that do not increase the connected lighting load, where 50 percent or more of the existing luminaires are replaced in general hardscape or a specific application, the replacement luminaires shall meet the requirements of Subsection b above and the requirements of Section 170.2(e)6 for general hardscape lighting or specific lighting applications containing the alterations.

Exception 1 to Section 180.2(b)4Bvc: Alterations where the replacement luminaires have at least 40 percent lower power consumption compared to the original luminaires are not required to comply with the lighting power allowances of Section 170.2(e)6.

Exception 2 to Section 180.2(b)4Bvc: Alterations where less than 5 existing luminaires are replaced.

Exception 3 to Section 180.2(b)4Bv: Acceptance testing requirements of Section 160.5(e) are not required for alterations where controls are added to 20 or fewer luminaires.

vi. Alterations to existing internally and externally illuminated signs that increase the connected lighting load, replace and rewire more than 50 percent of the ballasts, or relocate the sign to a different location on the same site or on a different site shall meet the requirements of Section 170.2(e)7.

Exception to Section 180.2(b)4Bvi: Replacement of parts of an existing sign, including replacing lamps, the sign face or ballasts, that do not require rewiring or that are done at a time other than when the sign is relocated, is not an alteration subject to the requirements of Section 180.2(b)4Bvi.

«» Commentary for Section 180.2(b)4B:

These requirements are not triggered when only the lamps are replaced, the sign face is replaced, or the ballasts are replaced without rewiring.

Sign ballast rewiring that triggers the alterations requirements generally involves rewiring from parallel to series or vice versa, or when a ballast(s) is relocated within the same sign requiring relocating the wires. This does not include routine in-place ballast replacements. «»

vii. Alterations to existing electrical power distribution systems shall meet the applicable requirements of the following sections:

a. Service electrical metering. New or replacement electrical service equipment shall meet the requirements of Section 160.6(a) applicable to the electrical power distribution system altered; and

b. Separation of electrical circuits for electrical energy monitoring. For entirely new or complete replacement of electrical power distribution systems, the entire system shall meet the applicable requirements of Section 160.6(b); and

c. Voltage drop. For alterations of feeders and branch circuits where the alteration includes addition, modification or replacement of both feeders and branch circuits, the altered circuits shall meet the requirements of Section 160.6(c); and

Exception to Section 180.2(b)4Bviic: Voltage drop permitted by California Electrical Code Sections 647.4, 695.6 and 695.7.

d. Circuit controls for 120-volt receptacles and controlled receptacles. For entirely new or complete replacement of electrical power distribution systems, the entire system shall meet the applicable requirements of Section 160.6(d).

«» Commentary for Section 180.2(b)4B:

"Entirely new or complete replacement" applies to the electrical power distribution system within the building and therefore effectively refers to the entire building. A modification of only part of the electrical power distribution system does not trigger the requirement.

For example, the scope of work for a tenant improvement project does not typically involve installing or replacing the entire electrical power distribution system; therefore, separation of electrical circuits would not typically be required.

Another example is a project where a portion of the system is upgraded for greater electrical capacity and the work scope includes replacement of panelboards, associated feeders, and overcurrent protection devices. This is not a complete replacement or entirely new electrical power distribution system, since there is existing equipment that is not changed or replaced.

Controlled receptacle and separation of electrical circuit requirements will apply only to alterations where there is an entirely new or complete replacement of the electrical power distribution system for the entire building. «»

TABLE 180.2-E Control Requirements for Indoor Lighting System Alterations for Common Use Areas

Control Specifications	Projects complying with Section 180.2(b)4Biva	Projects complying with Sections 180.2(b)4Bivb or 180.2(b)4Bivc
Manual Area Controls 160.5(b)4Ai	Required	Required
Manual Area Controls 160.5(b)4Aii	Required	Required
Manual Area Controls 160.5(b)4Aiii	Only required for new or completely replaced circuits	Only required for new or completely replaced circuits
Multilevel Controls 160.5(b)4B	Required	Not Required
Automatic Shut Off Controls 160.5(b)4Ci	Required	Required
Automatic Shut Off Controls 160.5(b)4Cii	Required	Required
Automatic Shut Off Controls 160.5(b)4Ciii	Required	Required
Automatic Shut Off Controls 160.5(b)4Civ	Required	Required
Automatic Shut Off Controls 160.5(b)4Cv	Required	Required
Automatic Shut Off Controls 160.5(b)4Cvi	Required	Required; except for 160.5(b)4Cvib

Daylight Responsive Controls 160.5(b)4D	Required	Not Required
Demand Responsive Controls 110.12(a) and 110.12(b)	Required	Not Required

(c) Performance approach. The altered component(s) and any newly installed equipment serving the alteration shall meet the applicable requirements of Subsections 1, 2 and 3 below. The energy budget for alterations is expressed in terms of Long-Term System Cost (LSC) energy.

1. The altered components shall meet the applicable requirements of Sections 110.0 through 110.9, 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c), and 160.5. Entirely new or complete replacement mechanical ventilation systems as these terms are used in Section 180.2(b)5A shall comply with the requirements in Section 180.2(b)5A. Altered mechanical ventilation systems shall comply with the requirements of Sections 180.2(b)5B. Entirely new or complete replacement space-conditioning systems, and entirely new or complete replacement duct systems, as these terms are used in Sections 180.2(b)2Ai and 180.2(b)2Aiia, shall comply with the requirements of Sections 160.2(a)1 and 160.3(b)5L.
2. The standard design for an altered component shall be the higher efficiency of existing conditions or the requirements of Section 180.2(b). For components not being altered, the standard design shall be based on the unaltered existing conditions such that the standard and proposed designs for these components are identical. When the third-party verification option is specified, all components proposed for alteration for which the additional credit is taken, must be verified by a certified ECC-rater.
3. The proposed design shall be based on the actual values of the altered components.

NOTES TO SECTION 180.2(c):

1. If an existing component must be replaced with a new component, that component is considered an altered component for the purpose of determining the standard design altered component energy budget and must meet the requirements of Section 180.2(c)2.
2. The standard design shall assume the same geometry and orientation as the proposed design.
3. The "existing efficiency level" modeling rules, including situations where nameplate data is not available, are described in Section 10-109(c) and Section 10-116.

«» Commentary for Section 180.2(c):

If the performance approach is used and the alteration includes envelope or mechanical systems, the lighting power densities in common use area conditioned spaces may be traded-off against other system energy budgets. «»

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INTRODUCTION

Chapter 7 Introduction

This chapter covers the requirements in multifamily buildings (dwelling units and common use areas) for solar photovoltaic and battery storage systems in newly constructed buildings and solar readiness requirements for newly constructed building and additions to existing buildings.

Table 7-1: Excerpt from Table 100.0-A Application of Standards provides an overview of the location of the solar photovoltaic, battery storage and solar readiness requirements that apply to multifamily occupancies in the Energy Code.

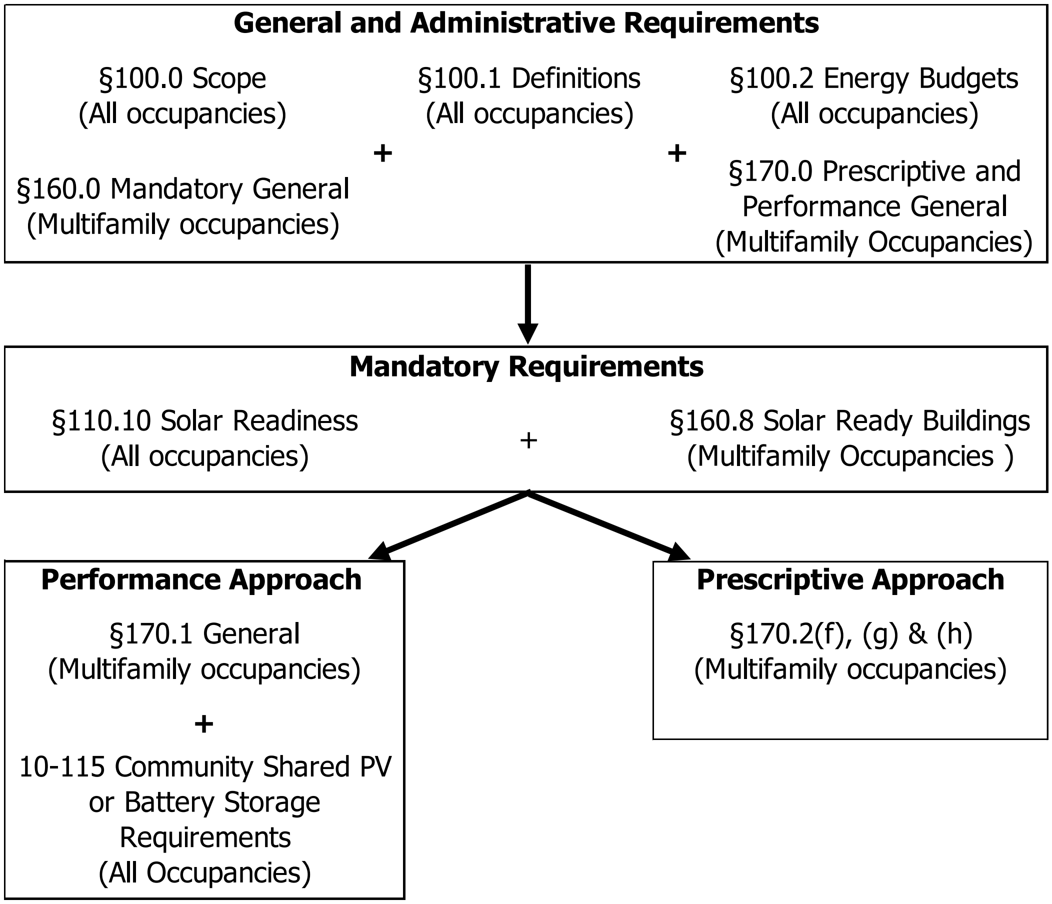
Table 7-1: Excerpt from Table 100.0-A Application of Standards

Application	Mandatory	Prescriptive	Performance	Additions/ Alterations
General[1]	160.0	170.0	170.0	180.0
Solar Readiness (When PV not installed)	110.10, 160.8	N/A	N/A	180.1(a)1B Exception (*Additions),* N/A (Alterations)
Solar PV and Battery Energy Storage Systems[2]	N/A	170.2(f), 170.2(g), 170.2(h),	170.1(a), 10-115	N/A

1. Guidance on General Requirements from Sections 160.0, 170.0 and 180.0 are included in the Multifamily Compliance Manual Chapter 1 General Requirements. Guidance specific to multifamily solar photovoltaic, battery storage and solar readiness is included in this chapter.
2. Section 10-115 provides community shared solar electric or Battery Energy Storage System (BESS) compliance options that may be used to partially or totally use the performance method to comply with the on-site solar electric generation system and/or BESS requirements.

Figure 7-1: Flowchart Guidance for Application of Newly Constructed Multifamily Solar Photovoltaic, Battery Storage and Solar Readiness Requirements and Figure 7-2: Flowchart Guidance for Application of Addition or Alteration of Multifamily Solar Photovoltaic, Battery Storage and Solar Readiness Requirements below illustrate the applicable sections for newly constructed buildings and additions or alterations to existing buildings.

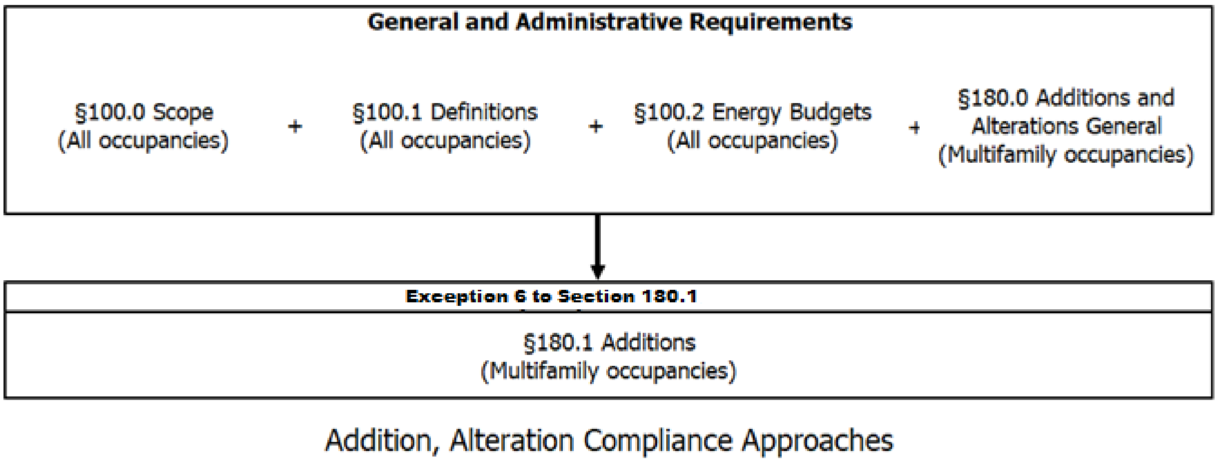
Figure 7-1: Flowchart Guidance for Application of Newly Constructed Multifamily Solar Photovoltaic, Battery Storage and Solar Readiness Requirements



Newly Constructed Buildings Compliance Approaches

Source: California Energy Commission

Figure 7-2: Flowchart Guidance for Application of Addition or Alteration of Multifamily Solar Photovoltaic, Battery Storage and Solar Readiness Requirements



Source: California Energy Commission

10-115 – COMMUNITY SHARED SOLAR ELECTRIC GENERATION SYSTEM OR COMMUNITY SHARED BATTERY ENERGY STORAGE SYSTEM COMPLIANCE OPTION FOR ON-SITE SOLAR ELECTRIC GENERATION OR BATTERY ENERGY STORAGE REQUIREMENTS

(a) **Community Shared Solar Electric Generation System or Battery Energy Storage System (BESS) Offset**. If approved by the commission, a community shared solar system, other community shared renewable system, community shared BESS, or combination of the aforementioned systems (hereinafter referred to as a community shared solar or BESS) may be used as a compliance option to partially or totally meet the on-site solar electric generation system and/or BESS that is otherwise required by Section 140.0(c), 150.1(a)3, or 170.0(a)3 of Title 24, California Code of Regulations, Part 6. To be approved, the community shared solar electric generation or community shared BESS must demonstrate, to the Commission's satisfaction, that all the following requirements will be met:

1. **Enforcement Agency.** The community shared solar electric generation system and/or community shared BESS shall be installed and available for enforcement agency site inspection no later than the point in time the enforcement agency must physically verify compliance of the building which would otherwise be required to have an on-site solar electric generation and/or BESS, and shall not cause delay in the process of enforcement agency review and approval of that building. The enforcement agency shall have jurisdiction and facilitated access to make site inspections. All documentation for the community solar electric generation system and/or community solar BESS that is required to demonstrate compliance for the building shall be completed prior to building permit application.
2. **Energy Performance.** The community shared solar electric generation system and/or community shared BESS shall be demonstrated to provide the same or better energy performance equal to the partial or total compliance with the energy performance of the on-site solar electric generation and/or BESS that would otherwise have been required for the building, computed by compliance software certified for use by the Commission.
3. **Participating Building Energy Savings Benefits.** The community shared solar electric generation system and/or community shared BESS shall provide energy saving benefits directly to the building. The energy savings benefits allocated to the building shall be in the form of:

A. actual reductions in the energy consumption of the participating building;

B. energy reduction credits that will result in virtual reductions in the building’s energy consumption that is subject to energy bill payments; or

C. payments to the building that will have an equivalent effect as energy bill reductions.

The reduction in the building’s energy bill resulting from A, B, or C above shall be greater than the added cost to the building resulting from the building’s share in the community shared solar and/or BESS.

4. **Durability, Participation, and Building Opt-out.**

A**. Durability**. The community shared solar electric generation system and/or community shared BESS shall be designed and installed to provide the energy savings benefits to the participating building(s) specified in Section 10-115(a)3 for a period of no less than 20 years.

B. **Participation.** The Administrator(s) approved by the Energy Commission pursuant to Section 10-115(b)1 shall ensure that all participating buildings, which use the community shared solar and/or community shared BESS to comply with Section 140.0(c), 150.1(a)3, or 170.0(a)3, remain participating buildings for no less than a 20-year period (“Participation Period”), regardless of who owns or occupies the participating building, unless the building owner discontinues participation after causing the on-site solar electric generation system to be installed and interconnected pursuant to the Opt-Out Requirements. For purposes of this Section, "Opt-Out Requirements" shall mean installation and interconnection of an on-site solar electric generation system that meets or exceeds. the requirements of Section 140.0(c), 150.1(a)3, or 170.0(a)3 in effect at the time the builder applied for the original building permit for the participating building. To demonstrate compliance, the Administrator shall require either:

i. **Equitable Servitude.** As a condition for a building to participate, participating builders shall impose an equitable servitude through a properly recorded declaration of covenants, conditions and restrictions ("CC&Rs") or other properly recorded covenant, deed restriction or other legally binding method referenced in each deed transferring title for each participating building. This equitable servitude shall run with the land and obligate the original owner(s)/tenant(s) and all subsequent owner(s)/tenant(s) of the participating building to maintain the building's participation in the community shared solar and/or community shared BESS for the Participation Period, or ensure installation and interconnection of an on-site solar electric generation system that satisfies the Opt-Out Requirements. The equitable servitude shall specify that in order to discontinue participation in the community shared solar and/or BESS, the building owner must satisfy the Opt-Out Requirements. The builder shall ensure that the equitable servitude provides the Administrator approved by the Commission the right to enforce the above provisions. The equitable servitude shall remain in force for a period of 20 years from the date of first participation of the building in the community shared solar and/or BESS. The equitable servitude shall not be revocable. The equitable servitude shall be delivered to all responsible parties through transfer disclosure statements.

ii. **Other system**. The Commission may approve another program, structure, or system by which an Administrator (or other entity approved by the Commission) ensures the requirements of this Section 10-115(a)4B will be satisfied for a Participation Period of no less than 20 years.

C. **Compliance Documentation.** The Administrator shall maintain record(s) of the compliance documentation that determined the requirements for the on-site solar electric generation system and/or BESS to comply with the standards in effect at the time the builder applied for the original building permit, and which establishes participants' obligations to meet the Opt-Out Requirements. The Administrator shall provide a copy of this compliance documentation upon a participating building owner's request, to every new owner of a participating building when the Administrator is notified that title has transferred, and to any participating building owner who requests to Opt-Out.

D. **Building Opt-Out.** At any time during the Participation Period, a participating building owner shall have the option to discontinue the participation of the building in the community shared solar and/or BESS ("Opt-Out") if the building satisfies the Opt-Out Requirement.

i. Prior to Opt-Out, the building owner shall demonstrate that they have installed such an on-site solar electric generation system and met the Opt-Out Requirements by providing documentation from the installer of the on-site solar system or an attestation of the building owner with supporting documentation. The building owner shall be responsible for all costs associated with documenting that the on-site solar generation system satisfies the Opt-Out Requirements.

ii. Upon receiving documentation regarding Opt-Out from a building owner, the Administrator shall compare the documentation to the compliance documentation specified in Section 10-115(a)4C and confirm whether, based on the documentation, the installed solar system meets or exceeds the Opt-Out Requirements. Within 30 days of a building owner providing documentation, the Administrator shall provide written confirmation to the building owner whether, based on the Administrator's review of that documentation, the on-site solar generation system satisfies the Opt-Out Requirements. The Administrator may, at its discretion, verify the documentation through a physical inspection. The Administrator shall maintain record of the documentation that demonstrates and confirms the on-site solar generation system met the Opt-Out requirements for the remainder of the Participation Period.

iii. Upon a building owner's exercise of the Opt-Out, all costs and benefits associated with participation in the community shared solar and/or BESS shall cease. If any balance of costs or benefits is owed to either party at the time of Opt-Out, such balance shall be paid to that party.

iv. The Administrator (or other entity approved by the Commission pursuant to Section 10-115(a)4Bii) shall not impose any penalty related to a participating building's Opt-Out, or charge participants for recuperation of unrealized revenue that would have been expected to accrue beyond the end of participation. If the Administrator (or other entity approved by the Commission) plans to charge any other fees at the time of building Opt-Out, the Application for Commission Approval shall explain the purpose of those fees.

5. **Additionality.** The community shared solar electric generation system and/or community shared BESS shall provide the energy savings benefits specified in Section 10-115(a)3 exclusively to the participating building(s). Those energy savings benefits shall in no way be attributed to other purposes or transferred to other buildings or property.

   A. The participating building(s) shall be served primarily by renewable resources developed specifically for the community solar electric generation system.

   B. Other renewable resources may be used when participating buildings are permitted before the renewable resources developed for the program start operating or after they cease operating. During these times, other renewable resources may be used to meet the requirements of Section 10-115(a)4 for each participating building.

   C. The renewable resources, including those developed primarily to serve participating buildings and those utilized to serve participating buildings during the time periods described in Section 10-115(a)5B for the purpose of meeting the requirements of Section 10-115(a)4, shall meet the following requirement:

i. For each renewable resource used to serve participating buildings, bundled Renewable Energy Credits (RECs), which satisfy the criteria of Portfolio Content Category 1, shall be retired and tracked in the Western Renewable Energy Generation Information System (WREGIS) on the behalf of program participants, to ensure that they will not be allocated to or used for any other purpose, including Renewable Performance Standard (RPS) compliance, resale of RECs or renewable generation to any other person or entity, or any other mandatory or voluntary renewable electricity program requirement or claim.

D. Renewable resources developed to serve participating buildings may also be used to serve other loads when there is excess generation beyond what is needed to serve participating buildings. Any excess generation used for such other loads shall be isolated from the generation serving participating buildings and shall not result in violation of Section 10-115(a)5C.

6. **Location.** The community shared solar electric generation system and/or community shared BESS shall be located on a distribution system of the load serving entity providing service to the participating buildings. The distribution system shall have an electrical voltage less than 100kV.

7. **Size.** The community shared solar electric generation system and/or community shared BESS shall not be served by any individual source larger than 20 MW.

8. **Accountability and Recordkeeping.** Applicants for Commission approval of community shared solar electric generation systems and/or community shared BESSs shall be accountable to all parties who relied on these systems for partial or total compliance with the on-site solar electric generation and/or BESS that would otherwise be required, including but not limited to builders of the buildings, owners of the buildings, enforcement agencies, and the Commission.

   A. Each year beginning twelve months after initial approval, the Administrator shall provide to the Commission a report demonstrating the previous year’s compliance with each requirement of Section 10-115.

   B. Recordkeeping regarding compliance with the requirements in Sections 10-115(a) shall be maintained over the period of time specified in Section 10-115(a)4 for each building for which the community shared solar electric generation or BESS is used to demonstrate partial or total compliance. Access to these records shall be provided to any entity approved by the Commission for auditing compliance with these requirements.

(b) Application for Commission Approval. Any entity may apply to the Commission for approval to administer a community shared solar electric generation or community shared BESS to provide partial or total compliance with the on-site solar electric generation system and/or BESS required by Section 150.1 of Title 24, California Code of Regulations, Part 6. Once approved, the entity shall be the Administrator of the community shared solar electric generation or community shared BESS.

1. The application shall demonstrate to the Commission's satisfaction that each of the requirements specified in Section 10-115(a) will be met and shall include detailed explanation of the actions that will be taken by the applicant to ensure that each requirement is met over the period of time specified in Section 10-115(a)4 for each building for which a partial or total offset is used to demonstrate compliance.
2. All applicants have the burden of proof to establish that their application should be granted.
3. Applications from public agencies shall be submitted to the Energy Commission only after public review through at least one public meeting within the jurisdiction of the public entity or service area of the load-serving entity and adoption by the public agency. The Commission shall have the authority to not approve any application that the Commission determines to be inconsistent with the requirements of Section 10-115.

(c) Executive Director Approval of Revised Applications. The Administrator of an approved community shared solar electric generation system and/or community shared BESS shall submit a revised application demonstrating compliance with the Section 10-115 requirements to the Executive Director for approval, when:

1. A new renewable resource is proposed to be added to a community shared solar electric generation system and/or community shared BESS, and/or
2. The Commission modifies the requirements of Section 10-115 in a building standards rulemaking. Such modified requirements would not apply retroactively to the buildings for which building permit applications are submitted prior to the effective date of the modified standards or to the continued use of previously approved renewable resources developed to serve a community shared solar electric generation system and/or community shared BESS.

Within 60 days of receiving a revised application, the Executive Director may either: approve the revised application by letter if the Executive Director concludes that the requirements of Section 10-115 will be met, request the Administrator to resubmit their revised application with changes, or disapprove the application. If the Executive Director disapproves the application, the applicant may request that the Commission review the Executive Director's determination. The petition must be filed in writing in accordance with Title 20, California Code of Regulations, Section 1208 within 15 days of the date of the filing of the Executive Director's determination and must state the basis for requesting review of the Executive

Director's determination. Within 45 days of receiving a request for review, the Commission shall issue a written decision affirming or modifying the Executive Director's determination. If the Commission does not issue a written decision within 45 days, the request for review shall be deemed denied. The Administrator shall have the burden of proof to establish that its revised application should be approved.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402, 25402.1, and 25605, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.8, 25605, and 25943, Public Resources Code

«» Commentary for Section 10-115

The 2025 Energy Code allows the possibility for the required solar photovoltaics on the site of the residential building to be offset by community-shared solar electric generation. "Community-shared solar electric generation" means solar electric generation, battery storage or other renewable technology electric generation that is provided as part of a community or neighborhood program that is approved to share the generation resources it develops with individual homes to demonstrate compliance with the Energy Code. Also, the batteries that otherwise would be installed in combination with photovoltaics on the building site to comply with battery storage requirements for multifamily buildings with four or more habitable stories or to gain performance standards compliance credit potentially for multifamily buildings with three habitable stories or less could be offset by a community-shared BESSs can be combined or separate. All of these possibilities are hereinafter referred to as "community-shared solar electric generation systems."BESSs can be combined or separate. All of these possibilities are hereinafter referred to as "community-shared solar electric generation systems."

The 2019 Energy Code first allowed the possibility for the Energy Code requirement for PV on the site of the residential building to be fully or partially offset by community shared solar electric generation.

For these offsets to become available, entities who wish to serve as administrators of a proposed community-shared solar electric generation system must apply to the Energy Commission for approval, demonstrating that the requirements specified in Section 10-115 of the Energy Code are met. The Energy Commission will review these applications to determine if the applicant meets these requirements.

Any entity may apply to serve as administrator of a proposed community-shared solar electric generation system. Potential entities include, but are not limited to, utilities or load serving entities, developers, builders, solar companies, or local governments. The entity will be responsible for ensuring that the requirements for approval are met throughout at least a 20-year period for each building that uses shares of the community-shared solar electric generation system to offset the onsite solar electric generation and batteries, which would otherwise be required for the building to comply with the Energy Code. Throughout that period, the administrator will be accountable to builders, building owners, enforcement agencies, the Energy Commission, and other parties who relied on these systems for offset compliance with the Energy Code. Records demonstrating compliance with the requirements must be maintained over that period, with access to those records provided to any entity approved by the Energy Commission.

Entities interested in applying to serve as an administrator of a proposed community-shared solar electric generation system should become thoroughly familiar with the requirements for approval specified in Section 10-115 and contact the CEC Building Standards Branch for further discussion and explanation of the requirements as necessary. «»

SECTION 110.10 – MANDATORY REQUIREMENTS FOR SOLAR READINESS

(a) Covered occupancies.

1. **Single-family residences.** Single-family residences located in subdivisions with ten or more single-family residences and where the application for a tentative subdivision map for the residences has been deemed complete or approved by the enforcement agency, which do not have a photovoltaic system installed, shall comply with the requirements of Sections 110.10(b) through 110.10(e)
2. **Low-rise multifamily buildings.** Low-rise multifamily buildings that do not have a photovoltaic system installed shall comply with the requirements of Sections 110.10(b) through 110.10(d).
3. **Hotel/motel occupancies and high-rise multifamily buildings.** Hotel/motel occupancies and high-rise multifamily buildings with ten habitable stories or fewer, that do not have a photovoltaic system installed, shall comply with the requirements of Sections 110.10(b) through 110.10(d).
4. **Nonresidential buildings.** Nonresidential buildings with three habitable stories or fewer, other than I-2 and I-2.1 buildings, that do not have a photovoltaic system installed, shall comply with the requirements of Sections 110.10(b) through 110.10(d).

«» Commentary for Section 110.10(a):

These requirements in Section 110.10 are mandatory for newly constructed buildings and additions where the total roof area is increased by at least 2,000 square feet. The solar-ready requirement is implemented when designing the building rooftop and associated equipment and when the building is not installing a photovoltaic system to comply with Section 170.2(f) or 170.2(g) or voluntarily to meet Exception 1 to Section 110.10(b)1B. Requirements for additions with new roof area greater than 2,000 square feet are specified in the Exception to Section 180.1(a)1B. The intent is to reserve a penetration-free and shade-free portion of the roof for the potential future installation of a solar energy system, plan for a pathway for connecting the components of the system, and install a main electrical service panel that will enable the future system. There are no requirements to install panels, conduit, piping, or mounting hardware. «»

(b) Solar zone.

1. **Minimum solar zone area.** The solar zone shall have a minimum total area as described below. The solar zone shall comply with access, pathway, smoke ventilation, and spacing requirements as specified in Title 24, Part 9 or other Parts of Title 24 or in any requirements adopted by a local jurisdiction. The solar zone total area shall be comprised of areas that have no dimension less than five feet and are no less than 80 square feet each for buildings with roof areas less than or equal to 10,000 square feet or no less than 160 square feet each for buildings with roof areas greater than 10,000 square feet.

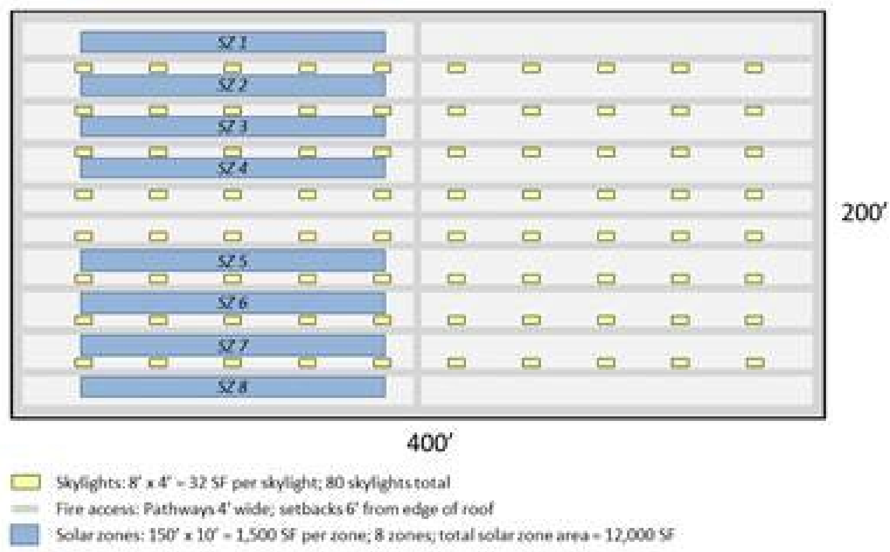
«» Commentary for Section 110.10(b)1:

The solar zone is a designated place where solar panels can be installed at a future date if the owner chooses to do so.

The total solar zone can be composed of multiple smaller areas. To enable a future solar system to fit within a reserved solar area(s), subareas are to meet minimum space dimension requirements. A subarea cannot be narrower than 5 feet in any dimension. If the total roof area is 10,000 sq. ft or less, each subarea must be at least 80 sq. ft. If the total roof area is greater than 10,000 sq. ft, each subarea must be at least 160 sq. ft.

Figure 7-3: Solar Zone Layout Showing Subareas, Skylights, and Fire Access below illustrates a solar zone layout that is composed of eight smaller subareas. The sum of all the smaller areas must equal the minimum total solar zone area. For example, the sum of all areas for a hypothetical building must be at least 11,616 sq. ft. The solar zones in this example total 12,000 sq. ft., which is greater than the minimum required for the hypothetical building. The solar zones must also comply with fire code requirements, including, but not limited to, setback and pathway requirements. Current setback and pathway requirements can be found in Title 24 Part 2 Section 3111, Title 24 Part 2.5 Section R324, and Title 24 Part 9 Section 1205.

Figure 7-3: Solar Zone Layout Showing Subareas, Skylights, and Fire Access



Source: California Energy Commission

California Fire Code Solar Access Requirements

The current versions of Title 24, Part 2, California Building Code (multifamily), Section 3111; Part 2.5, California Residential Code (single family up to 2 dwelling units), Section R324; and Part 9, California Fire Code (multifamily), Section 1205 of include requirements for installing rooftop solar photovoltaic systems. These regulations cover the marking and location of DC conductors and access and pathways for photovoltaic systems. «»

B. Multifamily buildings, hotel/motel occupancies and nonresidential buildings. The solar zone shall be located on the roof or overhang of the building or on the roof or overhang of another structure located within 250 feet of the building or on covered parking installed with the building project, and shall have a total area no less than 15 percent of the total roof area of the building excluding any skylight area. The solar zone requirement is applicable to the entire building, including mixed occupancy.

«» Commentary for Section 110.10(b)1B:

Other structures include, but are not limited to: other buildings, trellises, arbors, patio covers, carports, gazebos, and similar accessory structures. «»

Exception 1 to Section 110.10(b)1B: High-rise multifamily buildings, hotel/motel occupancies, and nonresidential buildings with a permanently installed solar electric system having a nameplate DC power rating, measured under Standard Test Conditions, of no less than one watt per square foot of roof area.

«» Commentary for Exception 1 to Section 110.10(b)1B:

If a photovoltaic system meeting the requirements of Exception 1 is installed, the solar readiness requirements do not apply. The compliant solar electric system must be permanently installed with a nameplate direct current (DC) power rating of no less than 1 watt per sq. ft of roof area. The nameplate rating must be measured under standard test conditions. This exception cannot be used to meet the prescriptive photovoltaic requirements of Sections 170.2(f) or 170.2(g). «»

> **Exception 2 to Section 110.10(b)1B:** High-rise multifamily buildings, hotel/motel occupancies with a permanently installed domestic solar water-heating system complying with Section 150.1(c)8Biii.

«» Commentary for Exception 2 to Section 110.10(b)1B:

When a solar water heating system (SWH) is permanently installed meeting the prescriptive solar water heating system requirements of Section 170.2(d)3C, the solar readiness requirements do not apply. «»

> **Exception 3 to Section 110.10(b)1B:** Buildings with a designated solar zone area that is no less than 50 percent of the potential solar zone area. The potential solar zone area is the total area of any low-sloped roofs where the annual solar access is 70 percent or greater and any steep-sloped roofs oriented between 90 degrees and 300 degrees of true north where the annual solar access is 70 percent or greater. Solar access is the ratio of solar insolation including shade to the solar insolation without shade. Shading from obstructions located on the roof or any other part of the building shall not be included in the determination of annual solar access.

«» Commentary for Exception 3 to Section 110.10(b)1B:

The solar zone area may be reduced if the roof is shaded by obstructions that are not part of the building and beyond the designer's control, such as existing buildings, telephone poles, communication towers, trees, or other objects, and therefore cannot meet the 15% designated solar zone requirements of Section 110.10(b)1B at ≥ 70% annual solar access. Once the potential solar zone at ≥ 70% annual solar access is determined, and if it is not ≥ 15% of the total roof area, then the reduced solar zone area up to 50% of the minimum solar zone area would be required.

When determining solar zone area, solar access shall not take into account shading from objects that are included in the building project because the designer has control of potential obstructions such as the building itself, its HVAC equipment, outdoor lights, landscape features and other similar objects. This exception cannot be used for the prescriptive photovoltaic requirements of Sections 170.2(f) or 170.2(g).

Example: A 2,000 ft² roof is shaded by trees and is shown with a solar assessment study that only 150 ft² of the roof has an annual solar access ≥ 70%. In this example, the 15% of roof at 300 ft² would not be required, only 75 ft² (50% of 150 ft²) would be required for solar readiness. «»

Exception 4 to Section 110.10(b)1B: Low-rise and high-rise multifamily buildings with all thermostats in each dwelling unit are demand response controls that comply with Section 110.12(a), and are capable of receiving and responding to Demand Response Signals prior to granting of an occupancy permit by the enforcing agency. In addition, either A or B below:

«» Commentary for Section 4 to Section 110.10(b)1B:

A "demand-responsive control" is defined in Section 100.1. as an "automatic control capable of receiving and automatically responding to a demand response signal." The technical specifications for compliant demand responsive control thermostats are specified in JA5. In addition to a demand responsive thermostat in each dwelling unit, one of the following options must also be used to meet this exception. This exception cannot be used for the prescriptive photovoltaic requirements of Sections 170.2(f) or 170.2(g). «»

A. In each dwelling unit, comply with one of the following measures:

   i. Install a dishwasher that meets or exceeds the ENERGY STAR Program requirements with either a refrigerator that meets or exceeds the ENERGY STAR Program requirements or a whole house fan driven by an electronically commutated motor; or

   ii. Install a home automation system that complies with Section 110.12(a) and is capable of, at a minimum, controlling the appliances and lighting of the dwelling and responding to demand response signals; or

   iii. Install alternative plumbing piping to permit the discharge from the clothes washer and all showers and bathtubs to be used for an irrigation system in compliance with the *California Plumbing Code* and any applicable local ordinances; or

   iv. Install a rainwater catchment system designed to comply with the *California Plumbing Code* and any applicable local ordinances, and that uses rainwater flowing from at least 65 percent of the available roof area.

B. Meet the Title 24, Part 11, Section A4.106.8.2 requirements for electric vehicle charging spaces.

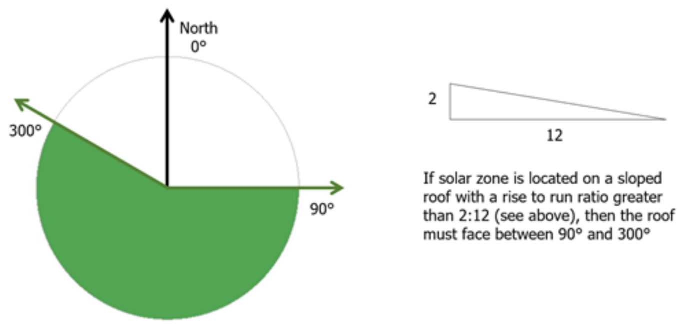
Exception 5 to Section 110.10(b)1B: Buildings where the roof is designed and approved to be used for vehicular traffic or parking or for a heliport.

2. **Azimuth range.** All sections of the solar zone located on steep-sloped roofs shall have an azimuth range between 90 degrees and 300 degrees of true north.

«» Commentary for Section 110.10(b)2:

This range of azimuths ensures an ample solar exposure if a solar energy system is installed in the future. On a low-sloped roof (rise-to-run ratio equal to or less than 2:12, or 10 degrees), the azimuth requirement does not apply.

Figure 7-4: Azimuth of Roof If Solar Zone Is Located on Steep-Sloped Roof



Source: California Energy Commission

«»

3. **Shading.**

   A. No obstructions, including but not limited to, vents, chimneys, architectural features and roof mounted equipment, shall be located in the solar zone.

   B. Any obstruction, located on the roof or any other part of the building that projects above a solar zone shall be located at least twice the distance, measured in the horizontal plane, of the height difference between the highest point of the obstruction and the horizontal projection of the nearest point of the solar zone, measured in the vertical plane.

   Exception to Section 110.10(b)3: Any roof obstruction, located on the roof or any other part of the building, that is oriented north of all points on the solar zone.

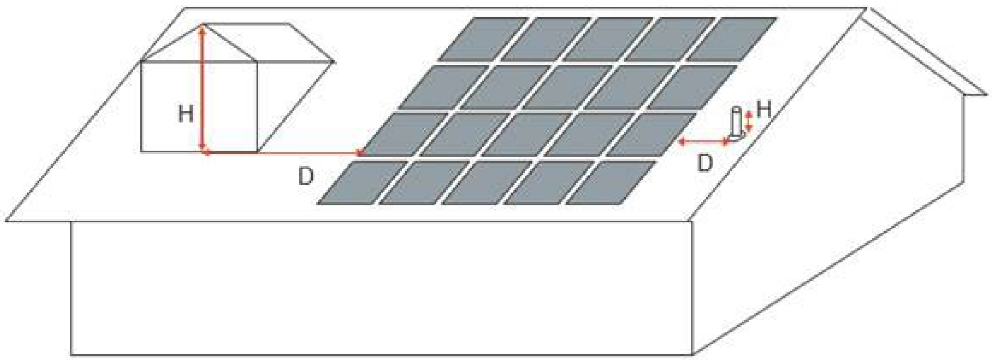
«» Commentary for Section (110.10)b:3

Obstructions such as vents, chimneys, architectural features, or roof-mounted equipment cannot be located in the solar zone. This requirement ensures the solar zone remains clear and open for the future installation of a solar energy system.

Any obstruction located on the roof or any other part of the building that projects above the solar zone must be located at a sufficient horizontal distance away from the solar zone such that the obstruction will not shade the solar zone. The following equation and Figure 7-5: Schematic of Allowable Setback for Rooftop Obstructions describe the allowable distance between any obstruction and the solar zone. For each obstruction, the horizontal distance ("D") from the obstruction to the solar zone has to be at least two times the height difference ("H") between the highest point of the obstruction and the horizontal projection of the nearest point of the solar zone.

$$D \geq 2H$$

Figure 7-5: Schematic of Allowable Setback for Rooftop Obstructions



Source: California Energy Commission

«»

4. **Structural design loads on construction documents.** For areas of the roof designated as solar zone, the structural design loads for roof dead load and roof live load shall be clearly indicated on the construction documents.

Note: Section 110.10(b)4 does not require the inclusion of any collateral loads for future solar energy systems.

«» Commentary for Section 110.10(b)4:

The structural design load documentation requirements apply if any portion of the solar zone is located on the roof of the building. This documentation is required so that at the time of a future solar PV installation, the structural design loads of the roof at the time the building was permitted are known. The Energy Code does not require estimating the structural loads of possible future solar equipment. «»

(c) Interconnection pathways.

1. The construction documents shall indicate a location reserved for inverters and metering equipment and a pathway reserved for routing of conduit from the solar zone to the point of interconnection with the electrical service.
2. For single-family residences and central water-heating systems, the construction documents shall indicate a pathway for routing of plumbing from the solar zone to the water-heating system

«» Commentary for Section 110.10(c)1:

All buildings that include a solar zone must also include a plan for how a future photovoltaic or solar water heating system would be connected to the electrical or plumbing system of the building. The construction documents must indicate the following:

A location for inverters and metering equipment for future solar electric systems. The allocated space should be appropriately sized for a PV system that could cover the entire solar zone.

A pathway for routing conduit from the solar zone to the point of interconnection with the electrical service. The design drawings must show where the conduit would be installed if a system were installed at a future date. There is no requirement to install conduit.

A pathway for routing plumbing from the solar zone to the water-heating system connection. The design drawings must show where the plumbing would be installed if a SWH system were installed at a future date. There is no requirement to install piping.

This requirement is not applicable if compliance is achieved by using Exceptions 1, 2, or 4 in lieu of a designated solar zone. «»

(d) Documentation. A copy of the construction documents or a comparable document indicating the information from Sections 110.10(b) through 110.10(c) shall be provided to the occupant.

«» Commentary for Section 110.10(d):

A copy of the construction documents that show the solar zone, the structural design loads, and the interconnection pathways must be provided to the building occupant. The building occupant must also receive a copy of compliance document NRCC-SAB-E or LMCC-SAB-E. The document copies are required so that the solar-ready information is available if the occupant decides to install a solar energy system in the future. This requirement is not applicable if compliance is achieved by using Exceptions 1, 2, or 4 in lieu of a designated solar zone. «»

(e) Main electrical service panel.

1. The main electrical service panel shall have a minimum busbar rating of 200 amps.
2. The main electrical service panel shall have a reserved space to allow for the installation of a double pole circuit breaker for a future solar electric installation. The reserved space shall be permanently marked as "For Future Solar Electric".

«» Commentary for Section 110.10(e)2:

These main electrical service panel specifications are required to enable the possible future installation of a solar electric system without a panel change at that time. «»

Note**:** Authority: Sections 25213, 25218, 25218.5, 25402, 25402.1, and 25605, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.8, 25605, and 25943, Public Resources Code.

SECTION 160.8 – MANDATORY REQUIREMENTS FOR SOLAR READY BUILDINGS

(a) Solar ready buildings. Newly constructed multifamily buildings shall meet the requirements of Section 110.10 applicable to the building project.

Note: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

«» Commentary for Section 160.8(a):

The requirements for solar-ready buildings are mandatory measures for newly constructed multifamily buildings that do not have a PV system because the building either qualifies for an exception in Section 170.2(f) or Section 170.2(g) or complies with the PV requirements using community shared solar as a performance compliance option. The solar-ready requirement must be addressed when designing the roof and associated equipment of a building, as described in the previous section. The intent is to reserve a penetration-free and shade-free portion of the roof for the potential future installation of a solar energy system, plan for a pathway for connecting the components of the system, and install a main electrical service panel that will enable the future system. There are no requirements to install solar panels, conduit, piping, or mounting hardware. «»

SECTION 170.1 – PERFORMANCE APPROACH

A building complies with the performance approach if the energy consumption calculated for the proposed design building is no greater than the energy budget calculated for the standard design building using Commission-certified compliance software as specified by Sections 10-109, 10-116 and the Alternative Calculation Method Reference Manual.

(a) Energy budget. The Energy budget is expressed in terms of long-term system cost (LSC) and source energy:

1. **Long-term system cost (LSC).** The LSC energy budget is determined by applying the mandatory and prescriptive requirements of the standard design to the proposed design building and has two components, the Efficiency LSC and the Total LSC.
    A. The Efficiency LSC energy is the sum of the LSC energy for space-conditioning, water heating, mechanical ventilation, lighting and the self-utilization credit.
    B. The Total LSC energy is the sum of the Efficiency LSC energy and LSC energy from the photovoltaic system, battery energy storage systems (BESS), and demand flexibility.
2. **Source energy.** The source energy budget is determined by applying the mandatory and prescriptive requirements of the standard design, except with a consumer gas or propane water heater, to the proposed design building.

Exception to Section 170.1(a): A community shared solar electric generation system, or other renewable electric generation system, and/or community shared BESS, that provides dedicated power, utility energy reduction credits or payments for energy bill reductions to the permitted building and is approved by the Energy Commission as specified in Title 24, Part 1, Section 10-115, may offset part or all of the solar electric generation system or BESS LSC energy required to comply with the standards, as calculated according to methods established by the Commission in the Nonresidential ACM Reference Manual.

«» Commentary for Section 170.1(a):

Using the performance approach, the PV array orientation is modeled as proposed. Any direction, including due north may be modeled; however, the more the orientation deviates from the southwest optimum, the worse the system performs, resulting in a larger PV system size to meet the same load. Designers and energy consultants may choose to model various orientations during the design phase to determine the preferred system size and orientation.

The California Flexible Installation (CFI) is a simplified modeling option in the performance approach. This option allows flexibility for a specific range of PV array azimuths and tilts, as long as the minimum shading criterion specified in JA11.3 is met. To use the CFI option for compliance:

For CFI1, the PV array azimuth angle must be anywhere between 150 to 270 degrees from true north, and the tilt must be anywhere between roof pitches of 0:12 to 7:12.

For CFI2, the PV array azimuth angle must be anywhere between 105 to 300 degrees from true north, and the tilt must be anywhere between roof pitches of 0:12 to 7:12.

As specified by Section 170.1, the Energy Code establishes energy budgets for showing compliance with the performance standards expressed in Long-term System Cost (LSC) and Source Energy. The LSC energy budget is partitioned into Efficiency LSC and Total LSC energy budgets. The Efficiency LSC energy budget is the sum of the LSC energy for space-conditioning, water heating, mechanical ventilation, and lighting. The Efficiency LSC also includes a self-utilization credit when a battery energy storage system (BESS) is installed in addition to PV. The Total LSC energy budget is the sum of the Efficiency LSC and LSC energy from the photovoltaic system, battery energy storage systems (BESS), and other demand flexibility compliance options that the CEC has approved. **«»**

(b) Compliance demonstration requirements for performance standards.

1. Certificate of Compliance and Application for a Building Permit. The application for a building permit shall include documentation pursuant to Sections 10-103(a)1 and 10-103(a)2 that demonstrates, using an approved calculation method, that the building has been designed so that its source energy and LSC energy consumption do not exceed the standard design energy budgets for the applicable climate zone.
2. Field verification of individual dwelling unit systems. When performance of installed features, materials, components, manufactured devices or systems above the minimum specified in Section 170.2 is necessary for the building to comply with Section 170.1, or is necessary to achieve a more stringent local ordinance, field verification shall be performed in accordance with the applicable requirements in the following subsections, and the results of the verification(s) shall be documented on applicable Certificates of Installation pursuant to Section 10-103(a)3 and applicable Certificates of Verification pursuant to Section 10-103(a)5.

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8, and 25943, Public Resources Code.

SECTION 170.2 – PRESCRIPTIVE APPROACH

Prescriptive requirements for photovoltaic systems for low-rise multifamily buildings are specified in Section 170.2(f), for photovoltaic systems for high-rise multifamily buildings in Section 170.2(g), and for battery energy storage systems (BESS) in Section 170.2(h).

«» Commentary for Solar PV Prescriptive Requirements:

The prescriptive compliance approach for solar PV systems is summarized in Table 7-2: Guide to Solar PV Prescriptive Requirements, which provides the sequence of steps that identifies if the PV system's installation is required and the corresponding requirements for each step to comply with the prescriptive approach.

Table 7-2: Guide to Solar PV Prescriptive Requirements

Step	Three or fewer stories	Four or more stories
Check for virtual energy bill credit program with the load serving entity (typically the electric utility company)	N/A	If virtual energy bill credit program is not available, PV is not required unless there is a CEC-approved community solar program available. Solar readiness will then apply.
Check with Enforcement Authority if high snow load design exception applies	If the roof and required PV structure cannot support the snow load design, PV is excepted, and solar readiness applies.	If the roof and required PV structure cannot support the snow load design, PV is not required, and solar readiness will apply.
Calculate Solar Access Roof Area (SARA) using CEC-approved solar assessment tool	If SARA is less than 3% of Conditioned Floor Area (CFA), no PV is required, and solar readiness will apply. If SARA is greater than 3% of CFA, proceed to the following steps	If SARA is less than 3% of Conditioned Floor Area (CFA), no PV is required, and solar readiness will apply. If SARA is greater than 3% of CFA, proceed to the following steps
Check contiguous SARA	When the SARA for any individual roof area is less than 80 contiguous ft², that area is not included in determining PV kW sizing. When the SARA for any	When the SARA for any individual roof area is less than 80 contiguous ft², that area is not included in determining PV kW sizing. When the SARA for any

Step	Three or fewer stories	Four or more stories
	individual roof area is ≥ 80 contiguous ft², that roof area is included in determining PV kW sizing. If there is no SARA with ≥ 80 contiguous ft² on any portion of the roof, PV is not required, and solar readiness will apply.	individual roof area is ≥ 80 contiguous ft², that roof area is included in determining PV kW sizing. If there is no SARA with ≥ 80 contiguous ft² on any portion of the roof, PV is not required, and solar readiness will apply.
Calculate prescriptive PV size using both the prescriptive equation (based on CFA) and the SARA approach	Calculate PV size using Equation 170.2-C and SARA*14W/ft^2 (for low-slope roofs) or SARA*18W/ft^2 (for steep-slope roofs). Determine the lower PV size for the two approaches.	Calculate PV size using Equation 170.2-D and SARA*14W/ft^2 (for low-slope roofs) or SARA*18W/ft^2 (for steep-slope roofs). Determine the lower PV size for the two approaches.
Check that the lower calculated PV size is more than minimum requirement	If PV size for the building is less than 4kW, PV is not required, and solar readiness applies	If PV size for the building is less than 4kW, PV is not required, and solar readiness applies.
Check for PV size reduction when battery energy storage system (BESS) is installed	If ≥7.5 kWh BESS is installed complying with JA12 requirements, PV size can be reduced by 25%.	Check BESS requirements for compliance with Section 170.2(h).
Provide Certificate of Compliance and solar assessment report supporting compliant design	This could be the LMCC-PRF-01-E if using the performance approach, or the LMCC-SAB-E if using the prescriptive approach.	This could be the NRCC-PRF-01-E if using the performance approach, or the NRCC-SAB-E if using the prescriptive approach.

Source: California Energy Commission

The installed PV system for any multifamily building must meet the applicable requirements specified in JA11 for both the prescriptive and performance approach. Requirements include provisions for system orientation, shading criteria, solar access verification, remote monitoring, and interconnection.

When using the prescriptive approach, the weighted average annual solar access must be at least 98% across all solar panels and is to be verified by the installing contractor with the Certificate of Installation. If the solar access is less than 98%, then the performance approach may be used.

The PV system must be integrated with a monitoring system that can provide remote monitoring capability to its user. The monitoring data must be accessible through a web-based portal and a mobile device application that enables the building manager, owner, or occupants to monitor the performance of their PV system. This data can be useful to identify, report, and correct performance issues with the panels, inverters, shading, or other issues that may adversely impact the performance of the PV system. At a minimum, the building manager, building owner, or occupants must have access to the following information:

The nominal kW rating of the PV system.

Number of PV modules and the nominal watt rating of each module.

Hourly (or 15-minute interval), daily, monthly, and annual kWh production in numeric and graphic formats for the system.

Running total of daily kWh production.

Daily kW peak power production.

Current kW production of the entire PV system.

Interconnection Requirements

The installed inverters must be tested in accordance with the applicable requirements in UL1741 and UL1741 Supplement A.

The PV system and the associated components, including the inverters, must comply with the California Public Utilities Commission (CPUC) Electric Tariff Rule 21, which governs CPUC-jurisdictional interconnections for all net energy metering customers. Rule 21 requires that inverters have certain capabilities to ensure proper operation of the electrical grid as solar photovoltaic systems are interconnected.

Solar Assessment

A solar assessment tool that is certified by the Executive Director, and complies with JA11.4.1 requirements, must be used to document and verify the shading conditions of the PV system. The results of the solar access verification tool are used to determine the SARA. The CEC approved list of solar assessment tools can be found here: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/solar-assessment-tools

The CEC approved solar assessment tools can be of one of the following types:

Physical tool that measures the availability of solar energy on installation site

Software tool that models the physical features of the building and surrounding shading conditions including roofs and trees, and then calculates their solar potential by analyzing it against historical weather data

Satellite or drone imaging data if it can demonstrate solar access percentages similar to on-site measurements.

Table 7-3: Solar Access Verification Tool Requirements summarizes the Energy Commission's required functionality for developing a solar access verification tool as specified in JA11.4.1.

Table 7-3: Solar Access Verification Tool Requirements

Category	Requirements
Input	Physical features of building and other obstructions that shade the PV array that are specified in JA11.3 Historical weather data
Solar Access Tool Calculations	Calculate annual solar access percentage of each individual solar array. Calculate annual solar access percentage as a weighted average of the whole. Include all obstructions, including any tree that is planted on the building lot or neighboring lots including any existing trees on the building lot or neighboring lots and trees planned to be planted in association with the building permit included in the landscape documents. Do not include horizon shading in the calculation
Reporting	Produce a shade report with a summary of the PV system, including the address of the project, individual array panel count, orientation, annual solar access percentage, and weighted average of the PV system as whole.

Source: California Energy Commission

«»

(f) Photovoltaic requirements—three habitable stories or fewer. All multifamily buildings up to three habitable stories shall have a newly installed photovoltaic (PV) system or newly installed PV modules meeting the minimum qualification requirements specified in Joint Appendix JA11. The annual electrical output of the PV system shall be no less than the smaller of a PV system size determined using Equation 170.2-C, or the total Solar Access Roof Area (SARA) multiplied by 18 for steep-sloped roofs or SARA multiplied by 14 for low-sloped roofs.

A. SARA includes the area of the building's roof space capable of structurally supporting a PV system, and the area of all roof space on covered parking areas, carports, and all other newly constructed structures on the site that are compatible with supporting a PV system per Title 24, Part 2, Section 1511.2.

B. SARA does NOT include:

i. Any roof area that has less than 70 percent annual solar access. Annual solar access is determined by dividing the total annual solar insolation, accounting for shading obstructions, by the total annual solar insolation if the same areas were unshaded by obstructions. For steep-sloped roofs, only shading from existing permanent natural or manmade obstructions that are external to the dwelling, including but not limited to trees, hills and adjacent structures, shall be considered for annual solar access calculations. For low slope roofs, all obstructions including those that are external to the dwelling unit, and obstructions that are part of the building design and elevation features, shall be considered for the annual solar access calculations.

ii. Occupied roof areas as specified by CBC Section 503.1.4.

iii. Roof area that is otherwise not available due to compliance with:

a. Other state building code requirements, or

b. Local building code requirements if local building code requirements are confirmed by the Executive Director.

«» Commentary for Section 170.2(f):

The installed PV system for any multifamily building must meet the applicable requirements specified in JA11 for both the prescriptive and performance approach. Requirements include provisions for system orientation, shading criteria, solar access verification, remote monitoring, and interconnection requirements.

When there is a state building code requirement that would not allow PV systems to be installed on a specific area of the roof, that roof area is removed from the SARA. This can include Fire Code setback provisions, Mechanical Code setback and access provisions, and Building Code envelope maintenance system setback provisions.

Some local building codes or ordinances require the roof to be used for specific purposes, such as for “living roofs.” Areas of the roof that are required by local building codes to be used for specific purposes can be removed from the SARA if the CEC’s Executive Director has approved the SARA removal for the specific local code/ordinance. The local enforcement agency must apply to the CEC for that approval.

For multifamily buildings up to three habitable stories that have a steep sloped roof, existing permanent natural or manmade obstructions that are external to the building (such as trees, hills and adjacent structures) may be determined using solar assessment tools to be shading obstructions that reduce the annual solar access for a particular roof area to be less than 70 percent. Roof areas shaded to this extent by those obstructions are not included in the SARA. Obstructions that are part of the building design cannot be considered as shading obstructions and cannot be used to reduce the SARA. Once the SARA is determined for the steep sloped roof, the SARA is multiplied by 18 watts to determine the minimum PV sizing (any roof area with a northernly azimuth between 300 degrees and 90 degrees from true north is not considered in the SARA consistent with exception 1 to Section 170.2(f)).

EQUATION 170.2-C ANNUAL PHOTOVOLTAIC ELECTRICAL OUTPUT

$$kW_{PV} = (CFA \times A)/1000 + (N_{DU} \times B)$$

where:

kW_{PV}	=	kW_{dc} size of the PV system.
CFA	=	Conditioned floor area.
N_{DU}	=	Number of dwelling units.
A	=	CFA adjustment factor from Table 170.2-T.
B	=	Dwelling unit adjustment factor from Table 170.2-T

Exception 1 to Section 170.2(f): For steep slope roofs, SARA shall not consider roof areas with a northerly azimuth that lies between 300 degrees and 90 degrees from true north. No PV system is required if the SARA is less than 80 contiguous square feet.

«» Commentary for Exception 1 to Section 170.2(f):

When a roof has a pitch greater than 2:12 (steep sloped roof), any roof area with a northernly azimuth between 300 and 90 degrees is not included in the SARA.

When any individual roof area has a SARA that is less than 80 contiguous square feet, no PV system is required for that individual roof area. «»

Exception 2 to Section 170.2(f): No PV system is required when the minimum PV system size specified by Section 170.2(f) is less than 4 kW_{dc}.

«» Commentary for Exception 2 to Section 170.2(f):

When the Section 170.2(f) requires a PV kW of less than 4 kWdc for the entire building, PV will not be required. «»

Exception 3 to Section 170.2(f): Buildings with enforcement-authority-approved roof designs, where the enforcement authority determines it is not possible for the PV system, including panels, modules and components and supports and attachments to the roof structure, to meet the requirements of American Society of Civil Engineers (ASCE) Standard 7-16, Chapter 7, Snow Loads.

«» Commentary for Exception 3 to Section 170.2(f):

If the building is in an area that receives large amounts of snow, PV systems are not required when the enforcement authority determines, consistent with the American Society of Civil Engineers (ASCE) Standard 7-16, Chapter 7, that heavy snow loads in that specific location cannot be met for PV systems.

Exception 4 to Section 170.2(f): For buildings that are approved by the local planning department prior to January 1, 2020, with mandatory conditions of approval:

a. Shading from roof designs and configurations for steep slope roofs shall be considered for the annual solar access calculations; and

b. Roof areas that are not allowed to have PVs by the mandatory conditions of approval shall not be considered in determining the SARA.

«» Commentary for Exception 4 to Section 170.2(f):

Before January 1, 2020, the Energy Code did not include PV requirements; therefore, the building design presented for approval at the planning department would not have included PV in compliance with the Energy Code. The planning department may have mandatory conditions of approval that allow roof designs and configurations that would potentially shade PV panels or limit the roof area where PV panels could be installed. For steep sloped roofs, any planning department approved roof designs/configurations that shade the roof shall be considered in determining the annual solar access. Also, any roof areas that the planning department expressly did not allow to have PVs in the mandatory conditions shall not be excluded from the SARA. Exception 4 does not apply if the building was approved by the planning department on or after January 1, 2020. **«»**

Exception 5 to Section 170.2(f): PV system sizes determined using Equation 170.2-C may be reduced by 25 percent if installed in conjunction with a BESS. The BESS shall meet the qualification requirements specified in Joint Appendix JA12 and have a minimum cycling capacity of 7.5 kWh as specified in Joint Appendix JA12.

«» Commentary for Exception 5 to Section 170.2(f):

Battery energy storage systems are not required for multifamily buildings 3 stories or less, but a minimum cycling capacity sizing of 7.5 kWh or greater per building, can be utilized to reduce the PV system sizing. This might be desired when there are limitations to the amount of PV panels that can be located on the project site. **«»**

TABLE 170.2-T CFA AND DWELLING UNIT ADJUSTMENT FACTORS

CLIMATE ZONE	A—CFA	B—DWELLING UNITS
1	0.793	1.27
2	0.621	1.22
3	0.628	1.12
4	0.586	1.21
5	0.585	1.06
6	0.594	1.23
7	0.572	1.15
8	0.586	1.37
9	0.613	1.36

10	0.627	1.41
11	0.836	1.44
12	0.613	1.40
13	0.894	1.51
14	0.741	1.26
15	1.56	1.47
16	0.59	1.22

(g) Photovoltaic requirements—more than three habitable stories. All newly constructed building types specified in Table 170.2-U, or mixed occupancy buildings where at least 80 percent of the floor area of the building serves one or more of these building types shall have a newly installed photovoltaic (PV) system meeting the minimum qualification requirements of Reference Joint Appendix JA11. The PV capacity in kW_{dc} shall not be less than the smaller of the minimum rated PV system capacity determined by Equation 170.2-D, or the total of all available Solar Access Roof Areas (SARA) multiplied by 18 for steep-sloped roofs or multiplied by 14 for low-sloped roofs. In mixed occupancy buildings, the minimum rated PV system capacity for the building shall be determined by applying Equation 170.2-D to the conditioned floor area of each of the listed building types and summing the capacities determined for each.

«» Commentary for Section 170.2(g):

The installed PV system for any multifamily building must meet the applicable requirements specified in JA11 for both the prescriptive and performance approach. Requirements include considerations such as system orientation, shading criteria, solar access verification, remote monitoring, and interconnection requirements. «»

1. SARA includes the area of the building’s roof space capable of structurally supporting a PV system, and the area of all roof space on covered parking areas, carports and all other newly constructed structures on the site that are compatible with supporting a PV system as specified by Title 24, Part 2, Section 1511.2.
2. SARA does not include:
   A. Any area that has less than 70 percent annual solar access. Annual solar access is determined by dividing the total annual solar insolation (accounting for shading obstructions) by the total annual solar insolation if the same areas were unshaded by those obstructions. For all roofs, all obstructions including those that are external to the building, and obstructions that are part of the building design and elevation features, may be considered for the annual solar access calculations.

   B. Occupied roofs as specified by CBC Section 503.1.4.

   C. Roof area that is otherwise not available due to compliance with:

      i. Other state building code requirements, or

      ii. Local building code requirements if the local building code requirements are confirmed by the Executive Director.

«» Commentary for Section 170.2(g)2:

If a building includes an occupied roof area meeting the requirements of the California Building Code (Title 24, Part 2) for occupied roofs (Section 503.1.4), that roof area is not included in the SARA.

When there is a building code requirement that would not allow PV systems to be installed on a specific area of the roof, that roof area is not included in the SARA. This can include Fire Code setback provisions, Mechanical Code setback and access provisions, and Building Code envelope maintenance system setback provisions.

Some local building codes or ordinances require the roof to be used for specific purposes, such as for “living roofs”. Areas of the roof that are required to be used for specific purposes can be removed from the SARA if the CEC’s Executive Director has approved the SARA removal for the specific local code/ordinance.

For multifamily buildings with four or more habitable stories, shading obstructions shall be considered for solar access calculations include all obstructions including those that are external to the building and all obstructions that are part of the building design and elevation features.

The PV system should eliminate or avoid shading from any obstruction to the array. Obstructions include the following:

Any vent, chimney, architectural feature, mechanical equipment, or other obstruction that is on the roof or any other part of the building.

Any part of the neighboring terrain.

Any tree that is mature at the time of installation of the PV system.

Any tree that is planted on the building lot or neighboring lots or planned to be planted as part of landscaping for the building associated with the building permit. (The expected shading must be based on the mature height of the tree.)

Any existing neighboring building or structure.

Any planned neighboring building or structure that is known to the applicant or building owner.

Any telephone or other utility pole that is closer than 30 ft. from the nearest point of the array.

Any obstruction located directly north of the array does not count as a shading obstruction.

For prescriptive compliance, the weighted average of annual solar access, determined by a solar access verification tool approved by the CEC to meet JA11.4 requirements, across each solar panel must be at least 98 percent. If the annual solar access is less than 98%, then the building does not meet the prescriptive requirement and the performance compliance method must be used instead.

The individual roof areas that constitute SARA must have greater than 70 percent annual solar access. If any individual roof area has a SARA that is less than 80 contiguous sq. ft., no PV is required for that individual roof area.

The code language specifies that the only local code requirements that are permissible for excluding area from SARA are those that have been confirmed by the Energy Commission Executive Director. **«»**

EQUATION 170.2-D PHOTOVOLTAIC DIRECT CURRENT CAPACITY

$kW_{PVdc} = (CFA \times A)/1000$

where:

kW_{PVdc} = Minimum rated PV system capacity in kW.

CFA = Conditioned floor area in square feet.

A = PV capacity factor in W/square foot as specified in Table 170.2-U for the building type.

Exception 1 to Section 170.2(g): No PV system is required where the total of all available SARA is less than 3 percent of the conditioned floor area.

«» Commentary for Exception 1 to Section 170.2(g):

The resulting SARA square footage is compared to the total conditioned floor area of the building. If the SARA ft^2 is less than 3% of the total CFA, a PV system is not required and solar readiness will apply. «»

Exception 2 to Section 170.2(g): No PV system is required where the required PV system capacity is less than 4 kW_{dc}.

«» Commentary for Exception 2 to Section 170.2(g):

When Section 170.2(g) requires a PV kW of less than 4 kW_{dc} for the entire building, PV will not be required and solar readiness will apply. «»

Exception 3 to Section 170.2(g): No PV system is required if the SARA contains less than 80 contiguous square feet.

«» Commentary for Exception to 3 Section 170.2(g):

When any individual roof area has a SARA that is less than 80 contiguous square feet, no PV system is required for that individual roof area. «»

Exception 4 to Section 170.2(g): Buildings with enforcement-authority-approved roof designs, where the enforcement authority determines it is not possible for the PV system, including panels, modules, components, supports and attachments to the roof structure, to meet ASCE 7-16, Chapter 7, Snow Loads.

«» Commentary for Exception 4 to Section 170.2(g):

If the building is in an area that receives large amounts of snow, PV systems are excepted when the enforcement agency determines, consistent with the American Society of Civil Engineers (ASCE) Standard 7-16, Chapter 7 that heavy snow loads in that specific location cannot be met with PV systems. «»

Exception 5 to Section 170.2(g): Multifamily buildings with more than three habitable stories in areas where a load serving entity does not provide a program where PV generation is compensated through virtual energy bill credits. This exception does not apply where the Commission has approved a community solar program for showing compliance as specified in Title 24, Part 1, Section 10-115, or where a load-serving entity provides a program where PV generation is compensated through virtual energy bill credits for occupants of nonresidential and hotel/motel tenant spaces to receive energy bill benefits from netting of energy generation and consumption.

«» Commentary for Exception 5 to Section 170.2(g):

When the load serving entity does not support a virtual energy bill credit program (the list of load serving entities can be found here: https://www.energy.ca.gov/sites/default/files/2023-09/California_Electric_Load-Serving_Entities_ADA.xlsx) , and the CEC has not approved a community solar program that is able to serve the project address, then PV will not be required for multifamily buildings with more than three habitable stories. Community solar programs are approved each code cycle, and when approved, are identified on the CEC's website under the applicable code cycle. «»

Table 170.2-U – PV Capacity Factors (W/ft² of conditioned floor area)

Building Type	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Events & Exhibit	3.48	4.28	3.66	4.32	3.77	4.05	4.28	4.83	4.63	4.80	5.04	4.44	4.95	4.36	5.48	3.38
Library	0.39	3.23	2.59	3.25	2.48	2.74	3.04	3.49	3.32	3.69	3.79	3.32	3.79	3.37	4.49	2.84
Hotel/Motel	1.69	1.90	1.66	1.97	1.69	1.87	1.94	2.22	2.09	2.20	2.30	2.05	2.30	2.02	2.72	1.73
Office, Financial Institution, Unleased Tenant Space, Medical Office Building/Clinic	2.59	3.13	2.59	3.13	2.59	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.13	3.80	2.59
Restaurant	8.55	9.32	8.16	9.65	8.21	8.73	9.11	10.18	9.75	10.28	10.85	9.73	10.69	9.73	12.25	8.47
Retail, Grocery	3.14	3.49	3.01	3.61	3.05	3.27	3.45	3.83	3.65	3.81	4.09	3.64	3.99	3.71	4.60	3.21
School	1.27	1.63	1.27	1.63	1.27	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	2.46	1.27
Warehouse	0.39	0.44	0.39	0.44	0.39	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.58	0.39
Religious Worship	4.25	4.65	3.49	4.52	3.72	4.29	4.64	5.89	5.30	5.67	5.89	4.99	5.78	4.63	7.57	3.90
Sports & Recreation	2.47	1.97	1.54	2.03	1.60	1.84	1.98	2.63	2.47	2.60	2.75	2.20	2.72	2.15	4.03	1.81
Multifamily > 3 stories	1.82	2.21	1.82	2.21	1.82	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.21	2.77	1.82

(h) Battery Energy Storage System (BESS) requirements—more than three habitable stories. All buildings that are required by Section 170.2(g) to have a PV system shall also have a BESS meeting the minimum qualification requirements of Reference Joint Appendix JA12. The rated energy capacity shall be not less than the Minimum Rated Useable Energy Capacity determined by Equation 170.2-E, or by Equation 170.2-F if SARA was used to determine the PV capacity in Section 170.2-D. and the rated power capacity shall be not less than the Minimum Power Capacity determined by Equation 170.2-G. In mixed occupancy buildings, the total battery system capacity for the building shall be determined by applying the Minimum Rated Usable Energy Capacity to each of the listed building types and summing the capacities determined for each.

«» Commentary for Section 170.2(h):

As specified by Section 170.2(h), multifamily buildings with four or more habitable stories are required to have battery storage under the prescriptive approach if solar PV is installed and meets the prescriptive requirements of Section 170.2(g). Multifamily buildings with three or less habitable floors have no prescriptive battery energy storage system requirements, but can include battery energy storage systems in the performance approach to qualify for a self-utilization credit or as a demand flexibility compliance measure.

In the performance approach, battery energy storage systems can be installed as a stand-alone system with a compliance cycling capacity of at least 5 kWh per building. This is an additional compliance credit for multifamily buildings three habitable stories or less, and a compliance option for four stories or more. When utilized, battery energy storage systems (BESS) are required to meet the qualifications of Joint Appendix JA12 for both the prescriptive and performance approach.

The primary function of the battery energy storage system is load shifting to harmonize the onsite PV system with the grid and deliver benefits to the environment, building owner, and building occupants. Installation of battery energy storage systems maximize self-utilization of PV array output, and limit grid exports to the benefit of the grid and the ratepayer. This is done by charging the battery from the PV system when there is limited electrical load at the building and the cost of electricity is low, usually in midday, and discharging to reduce the electrical load of the building when the cost of electricity is high, usually in the late afternoon and early evening hours.

The JA12 requirements are designed to ensure that the BESS remains in an active control mode and prevent the BESS from remaining in the backup mode indefinitely. While maintaining compliance with these requirements, the BESS can receive the latest firmware, software, control strategy, and other important updates.

All control strategies including Basic Control, Time-of-Use (TOU) Control, and Advanced Demand Response Control shall meet the following JA12 General Control Requirements.

Remote Capability: The BESS must have the capability of being remotely programmed to change the charge and discharge periods and to remotely switch between control strategies.

Charging Behavior: When combined with an on-site solar photovoltaic system, the BESS shall first charge from an on-site photovoltaic system when the photovoltaic system production is greater than the on-site electrical load. The BESS also may charge from the grid during off-peak TOU hours of the day if allowed by the load serving entity. In anticipation of severe weather, Public Safety Power Shutoff events, or demand response signal, the BESS may charge from the grid at any time if allowed by the load serving entity.

Discharge Behavior: During discharge, the BESS shall be programmed to first meet the electrical load of the building. If during the discharge period the electrical load of the building is less than the maximum discharge rate, the BESS shall have the capability to discharge electricity into the grid upon receipt of a demand response signal from the load serving entity or a third-party aggregator.

At the time of enforcement agency inspection, the BESS shall be installed and commissioned to meet one of the following control strategies in JA12.3.3.2.1 to JA12.3.3.2.5. JA12 includes three discharging control strategies.

The enforcement agency cannot enforce a particular control strategy after the BESS is installed and inspected. As a result, BESS can be operated with any JA12 control strategy, but the performance compliance software will only simulate time of use control strategy.

Basic Control: To qualify for the Basic Control strategy, when combined with an on-site solar photovoltaic system, the BESS shall only allow charging from an on-site photovoltaic system when the photovoltaic system production is greater than the on-site electrical load. The BESS shall discharge whenever the photovoltaic system production is less than the on-site electrical load.

Time-of-Use (TOU) Control: To qualify for the TOU Control strategy, when combined with an on-site solar photovoltaic system, the BESS shall begin discharging during the highest priced TOU hours of the day. The operation schedule shall be preprogrammed from the factory, updated remotely, or commissioned during the installation/commissioning of the system. At a minimum, the system shall be capable of programming three separate seasonal TOU schedules, such as spring, summer, and winter.

Advanced Demand Flexibility Control: Designed to bring the maximum value to the PV system generation by placing the charge/discharge functions of the BESS under the control of a load serving entity or a third-party aggregator. This control strategy enables discharging into the grid upon receiving a demand response signal from a grid operator. This option requires robust communication capabilities between the BESS and the load serving entity or the third-party aggregator. To qualify for the Advanced Demand Flexibility Control strategy, when combined with an on-site solar photovoltaic system, the BESS shall be programmed as either Basic Control or TOU control. The BESS shall meet the demand response control requirements specified in Section 110.12(a)1 and Section 110.12(a)2. Additionally, the BESS shall have the capability to change the charging and discharging periods in response to signals from the load serving entity or a third-party aggregator.

Controls for Separate Battery Energy Storage Systems

As specified in JA12.3.3.2.4, when a BESS system is installed separately from (not in combination with) an on-site solar photovoltaic system, including when the building is served by a community solar PV system to qualify for compliance, the BESS shall be programmed to:

Start charging from the grid during the lowest priced TOU hours of the day and start discharging during the highest priced TOU hours of the day, or

Meet all the demand response control requirements specified in Section 110.12(a)1 and Section 110.12(a)2, and shall have the capability to change the charging and discharging periods in response to signals from the load serving entity or a third-party aggregator.

Alternative Control Approved by the Executive Director

The Executive Director may approve applications for alternative control strategies that demonstrate equal or greater benefits to those strategies specified in JA12. To qualify for Alternative Control, the BESS shall be operated in a manner that increases self-utilization of the photovoltaic array output, responds to utility rates, responds to demand response signals, minimize greenhouse gas emissions from buildings, and/or implements other strategies that achieve equal or greater benefits than those specified in JA12. This application to the Executive Director for the alternative control option shall be accompanied with clear and easy to implement algorithms for incorporation into the compliance software for compliance credit calculations.

Safety Requirements

The BESS shall be tested in accordance with the applicable requirements specified in UL 1973 and UL 9540. Inverters used with BESS shall be tested in accordance with the applicable requirements in UL 1741, UL 1741 Supplement SA or UL1741 Supplement SB.

Enforcement Agency Requirements

The local enforcement agency shall verify that all Certificate of Installations are valid. The BESS shall be verified as a model certified to the Energy Commission as qualified for credit as a BESS is commissioned. In addition, the enforcement agency shall verify that the BESS is commissioned and operational with one of the controls specified in JA12. The control strategy and the compliance cycling capacity at system installation, final inspection and commissioning, and final inspection by the enforcement agency shall be the control strategy and the compliance cycling capacity that was used in the Certificate of Compliance

Certification Documentation Requirements

A specification sheet showing usable capacity, compliance cycling capacity, roundtrip efficiency and an identification as a field assembled or integrated BESS shall be submitted to CEC for JA12 certification.

«»

EQUATION 170.2-E BATTERY ENERGY STORAGE SYSTEM MINIMUM RATED USABLE ENERGY CAPACITY

$$kWh_{batt} = ((CFA \times B)/(1000 \times C^{0.5}))$$

EQUATION 170.2-F - BATTERY ENERGY STORAGE SYSTEM MINIMUM RATED USABLE ENERGY CAPACITY, SARA-ADJUSTED

$$kWh_{batt} = ((CFA \times B)/(1000 \times C^{0.5})) \times (kW_{PVdc,SARA}/kW_{PVdc})$$

WHERE:

kWh_{batt}= Minimum Rated Usable Energy Capacity of the BESS in kWh.

kW_{PVdc} = Minimum Rated PV System Capacity in kW from Equation 170.2-D

$kW_{PVdc,\ SARA}$ = Minimum Rated PV System Capacity in kW from the SARA calculation.

CFA = Conditioned floor area that is subject to the PV system requirements of Section 170.2(g) in square feet.

B = BESS Capacity Factor in Wh/square foot as specified in Table 170.2-V for the building type.

C = Rated single charge-discharge cycle AC to AC (round-trip) efficiency of the BESS.

EQUATION 170.2-G BATTERY ENERGY STORAGE SYSTEM MINIMUM RATED POWER CAPACITY

$kW_{batt} = kWh_{batt} / 4$

WHERE:

kW_{batt} = Minimum Rated Power Capacity of the BESS in kWdc

kWh_{batt} = Minimum Rated Usable Energy Capacity of the BESS in kWh

Exception 1 to Section 170.2(h): No BESS is required if the installed PV system capacity is less than 15 percent of the capacity determined by Equation 170.2-D.

«» Commentary for Exception 1 to Section 170.2(h):

Multifamily buildings, with a designed and installed PV system that is less than 15% of the prescriptive size calculated by Equation 170.2-D, are not required to install battery storage. When utilizing this exception for compliance, documentation supporting the designed PV system sizing with less than 15% from the prescriptive equation is required. «»

Exception 2 to Section 170.2(h): No BESS is required in buildings with BESS requirements with less than 10 kWh minimum rated usable energy capacity.

«» Commentary for Exception 2 to Section 170.2(h):

When using either the prescriptive battery energy capacity Equation 170.2-F, or the performance approach, if the minimum BESS-rated usable energy capacity is less than 10 kWh, BESS is not required. «»

TABLE *170.2-V – BESS Capacity Factors (Wh/ft² of conditioned floor area)*

Building Type	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
Events & Exhibits	1.82	1.95	1.74	2.12	1.91	2.13	2.24	2.30	2.36	2.47	2.62	2.16	2.64	2.68	3.22	1.89
Library	0.37	7.17	5.97	6.75	5.64	6.08	6.19	7.13	7.18	7.56	7.17	6.93	6.88	6.81	7.93	6.40
Hotel/Motel	0.86	0.84	0.77	0.92	0.81	0.89	0.90	1.01	1.00	1.11	1.14	0.96	1.18	1.18	1.49	0.85
Office, Financial Institution, Unleased Tenant Space, Medical Office Building/Clinic	NR[1]	5.26	4.35	5.26	4.35	5.26	5.26	5.26	5.26	5.26	5.26	5.26	5.26	5.26	6.39	4.35
Restaurants	4.36	4.11	3.78	4.37	3.89	4.02	4.11	4.49	4.47	4.82	5.05	4.43	5.05	5.24	6.23	4.11
Retail, Grocery	1.89	1.82	1.71	1.82	1.72	1.80	1.76	1.92	1.97	2.05	2.22	1.95	2.16	2.29	2.66	1.91
School	NR[1]	3.05	2.38	3.05	2.38	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	3.05	4.60	2.38
Warehouse	NR[1]	0.41	0.37	0.41	0.37	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.54	0.37
Religious Worship	2.21	2.25	1.74	2.42	2.08	2.75	2.94	3.37	3.17	3.37	3.58	2.72	3.62	3.21	4.89	2.37
Sports & Recreation	1.26	0.98	0.76	1.14	0.86	1.20	1.23	1.57	1.53	1.65	1.83	1.27	1.86	1.57	3.02	1.13
Multifamily > 3 stories	1.88	2.27	1.88	2.27	1.88	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.85	1.88

Footnote to TABLE 170.2-V:

1. NR = Not Required

SECTION 180.1 – ADDITIONS

Additions to existing multifamily buildings shall meet the applicable requirements of Sections 110.0 through 110.9; Sections 160.0, 160.1, and 160.2(c) and (d); Sections 160.3 through 160.7; and either Section 180.1(a) or 180.1(b).

Exception 6 to Section 180.1: Photovoltaic and BESS, as specified in Sections 170.2(f) through 170.2(h), are not required for additions.

(a) Prescriptive approach. The envelope and lighting of the addition; any newly installed space-conditioning or ventilation system, electrical power distribution system, or water-heating system; any addition to an outdoor lighting system; and any new sign installed in conjunction with an indoor or outdoor addition shall meet the applicable requirements of Sections 110.0 through 110.12**;** 160.0, 160.1, and 160.2(c) and (d); and 160.3 through 170.2.

Exception to Section 180.1(a)1: Additions that increase the area of the roof by 2,000 square feet or less are not required to comply with the solar ready requirements of Section 160.8.

«» Commentary for Section 180.1(a):

Alterations and additions to existing multifamily buildings do not trigger PV and BESS requirements under the Energy Code, nor are they allowed as compliance options within the performance approach. The prescriptive and performance requirements for PV and battery storage only apply to newly constructed buildings. When an addition to an existing building increases the area of the roof by greater than 2,000 ft², that roof area will need to meet the mandatory solar readiness requirements as specified by the Exception to Section 180.1(a)1B. «»

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INTRODUCTION

Chapter 8 Introduction

This chapter covers pool and spa requirements for all multifamily buildings for newly constructed buildings and additions or alterations to existing buildings.

Guidance on general requirements is included in the Multifamily Compliance Manual Chapter 1: General Requirements. Guidance on administrative requirements is included in the Multifamily Compliance Manual Chapter 2: Compliance and Enforcement. This chapter includes guidance on pool and spa requirements.

Table 8-1: Excerpt from Table 100.0-A Application of Standards provides an overview of the location of the pool and spa requirements that apply to multifamily occupancies in the Energy Code.

Table 8-1: Excerpt from Table 100.0-A Application of Standards

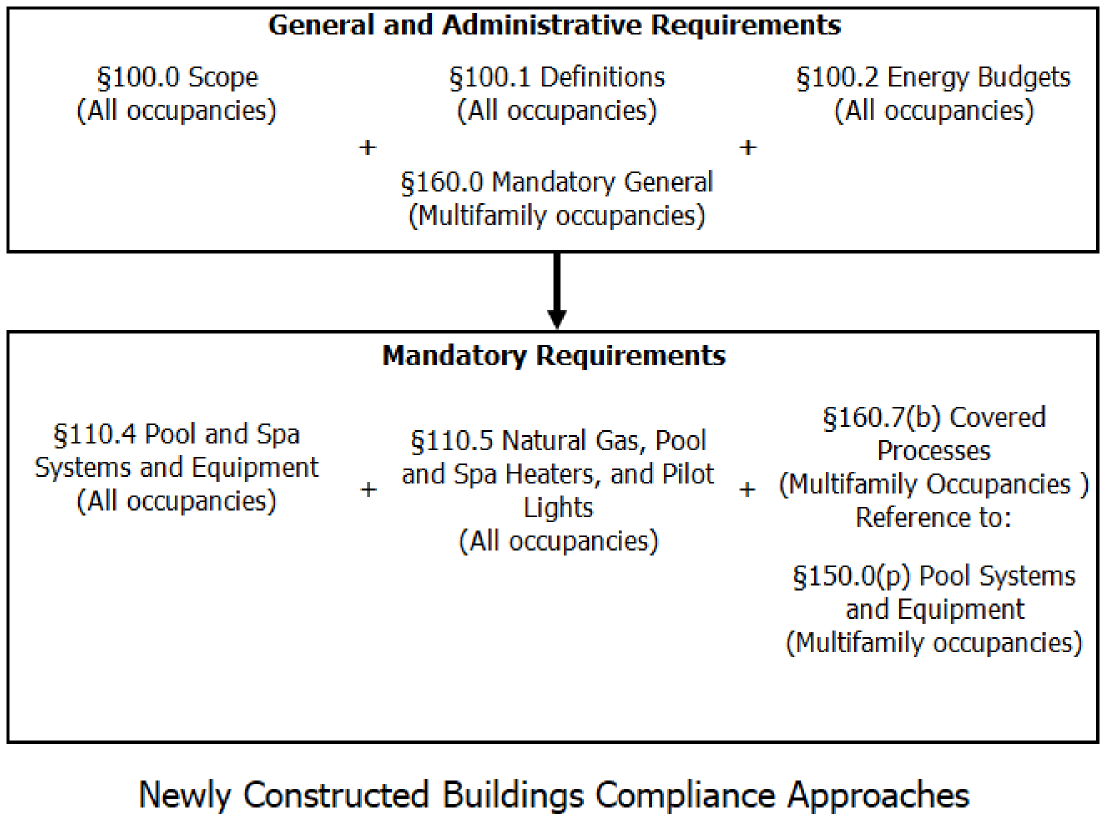
Application	Mandatory	Prescriptive	Performance	Additions/ Alterations
General[1]	160.0	N/A	N/A	180.0
Pool and Spa Systems	110.4, 110.5, 160.7(b), 150.0(p)	N/A	N/A	See Mandatory Requirements

1. Guidance on General Requirements from Sections 160.0 and 180.0 are included in the Multifamily Compliance Manual Chapter 1 General Requirements. Guidance specific to multifamily pools and spas is included in this chapter.

Source: California Energy Commission

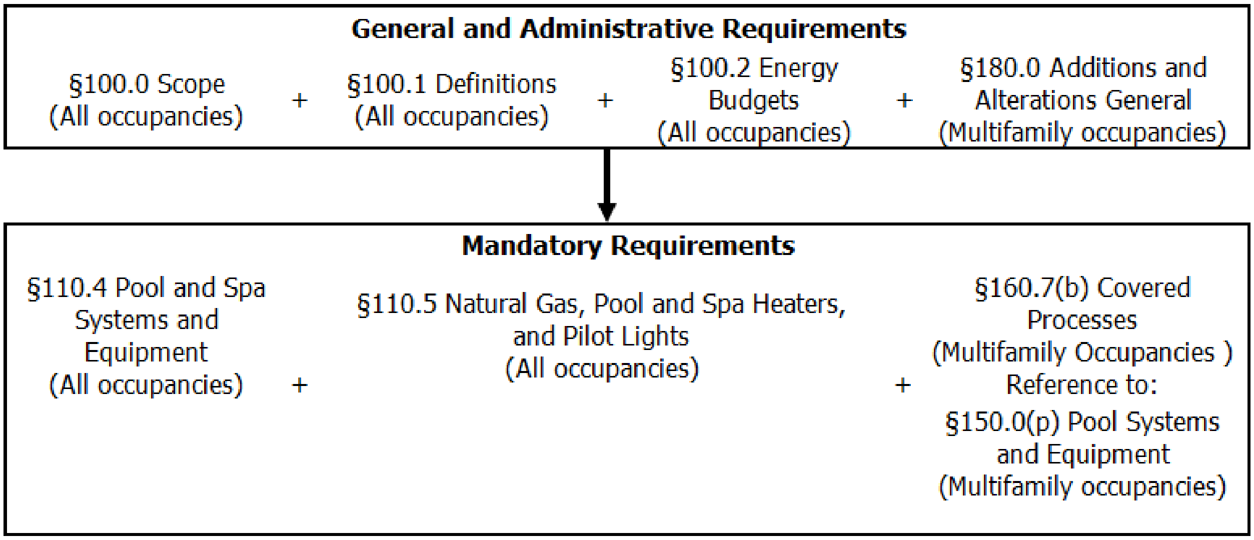
Figure 8-1: Flowchart Guidance for Application of New Construction Multifamily Pool and Spa Requirements and Figure 8-2: Flowchart Guidance for Application of Addition or Alteration Multifamily Pool and Spa Requirements below illustrate the applicable sections for newly constructed buildings and additions or alterations to existing buildings.

Figure 8-1: Flowchart Guidance for Application of New Construction Multifamily Pool and Spa Requirements



Source: California Energy Commission

Figure 8-2: Flowchart Guidance for Application of Addition or Alteration Multifamily Pool and Spa Requirements



Addition, Alteration Compliance Approaches

Source: California Energy Commission

SECTION 110.4 – MANDATORY REQUIREMENTS FOR POOL AND SPA SYSTEMS AND EQUIPMENT

(a) Certification by manufacturers. Any pool heater for a pool, spa, or a pool and spa combination shall be installed only if the manufacturer has certified that the system or equipment has all of the following:

1. **Efficiency.** Equipment subject to State or federal appliance efficiency standards shall comply with the applicable provisions of Section 110.1; and
2. **On-off switch.** A readily accessible on-off switch, mounted on the outside of the heater that allows shutting off the heater without adjusting the thermostat setting; and
3. **Instructions.** A permanent, easily readable and weatherproof plate or card that provides the energy efficiency rating and instruction for the energy efficient operation of the pool and/or spa heater; and

«» Commentary for Section 110.4(a):

The pool heater is subject to minimum efficiency requirements, much like other mechanical equipment under minimum state or federal appliance efficiency standards. This is so that the equipment manufacturers be held to the same standard for products sold to consumers. The equipment must have an on-off switch to allow the user to shut off heating completely when no heating is desired. An example would be when the user decides to close the pool for winter. The equipment must also have instructions to inform the user of the energy efficiency rating and methods for energy efficient use of the pool heater. «»

(b) Installation. Any pool and/or spa system or equipment shall meet the following requirements:

1. **Heating Equipment.** Equipment installed to heat water for pools and/or spas shall be selected from equipment meeting the standards shown in Table 110.4-A.

Table 110.4-A HEATING EQUIPMENT STANDARDS

Heating Energy Source	Standard
Electric Resistance	UL 1261
Gas-fired	ANSI Z21.56/CSA 4.7a
Heat Pump	AHRI 1160 and one of the following: CSA C22.2 No. 236, UL 1995, or UL/CSA 60335-2-40
Solar	ICC/APSP 902/SRCC 400 for solar pool heaters, ICC 901/SRCC 100 for solar collectors

«» Commentary for Section 110.4(b)1:

The pool heater shall meet the standards shown in the table to ensure that the equipment chosen to heat the pool is a pool heater rather than another type of water heater that would not be suitable for pool water heating. «»

2. **Piping.** At least 18 inches of horizontal or vertical pipe shall be installed between the filter and the heater or dedicated suction and return lines, or built-in or built-up connections shall be installed to allow for the future addition of solar heating equipment;

«» Commentary for Section 110.4(b)2:

If a pool or spa does not currently use solar heating collectors for heating of the water, piping must be installed to accommodate any future installation. Contractors can choose one of three options to allow for the future addition of solar heating equipment.

1. Leave at least 18 inches of horizontal or vertical pipe between the filter and heater to allow for the future addition of solar heating equipment
2. Plumb separate suction and return lines to the pool dedicated to future solar heating
3. Install built-up or built-in connections for future piping to solar water heating, (example: a built-in connection could be a capped off tee fitting between the filter and heater) «»

3. **Covers.** Outdoor pools and/or spa with electric or gas heating equipment shall be installed with a pool cover.

«» Commentary for Section 110.4(b)3:

The pool cover must be fitted and installed during the final inspection. The cover requirement is limited to pools that are heated by a heater that uses gas or electric. Pools that are not heated or are only heated by solar do not have a pool cover requirement. «»

4. **Directional inlets and time switches for pools.** If the system or equipment is for a pool:

   i. The pool shall have directional inlets that adequately mix the pool water; and

   ii. A time switch or similar control mechanism shall be permanently installed as part of a pool water circulation control system that will allow all pumps to be set or programmed to run only during off-peak electric demand period, and for the minimum time necessary to maintain the water in the condition required by applicable public health standards.

«» Commentary for Section 110.4(b)4:

Pool controls are a critical element of energy efficient pool design. Modern pool controls allow for auxiliary loads such as cleaning systems, solar heating, and temporary water features without compromising energy savings. «»

(c) Heating Source Sizing. Heating systems or equipment for pool and/or spa shall meet one of the sizing requirements 1 through 5 below:

1. A solar pool heating system with a solar collector surface area that is equivalent to the following:

   A. For nonresidential and multifamily buildings, 65 percent or greater of the pool and/or spa surface area.

   B. For single family buildings, 60 percent or greater of the pool and/or spa surface area.

2. A heat pump pool heater as the primary heating system that meets the sizing requirements of Reference Joint Appendix JA16.3. The supplementary heater can be of any energy source; or

3. A heating system that derives at least 60 percent of the annual heating energy from on-site renewable energy or on-site recovered energy.

4. A combination of a solar pool heating system and heat pump pool heater without any additional supplementary heater; or

5. A pool heating system determined by the Executive Director to use no more energy than the systems specified in Items 1, 2, 3, or 4 above.

Exception 1 to Section 110.4(c): Portable electric spas compliant with 20 CCR § 1605.3(g)(7) of the Appliance Efficiency Regulations.

Exception 2 to Section 110.4(c): Alterations to existing pools and/or spas with existing heating systems or equipment.

Exception 3 to Section 110.4(c): A pool and/or spa that is heated solely by a solar pool heating system without any backup heater.

Exception 4 to Section 110.4(c): Heating systems which are used exclusively for permanent spa applications in existing buildings with gas availability.

Exception 5 to Section 110.4(c): Heating systems which are used exclusively for permanent spa applications where there is inadequate Solar Access Roof Area (SARA) as specified in Section 150.1(c)14 for a solar pool heating system to be installed.

«» Commentary for Section 110.4(c):

The pool heater shall be chosen from among the five options unless one of the five exceptions apply, in which case no requirement exists. Each of the first four options requires a primary heating system other than a gas pool water heater. The fifth option must be shown to use no more energy as determined by the CEC Executive Director through a CEC process. A supplementary gas pool water heater may be used to meet load when conditions or heating load do not allow the primary heating system to maintain the desired pool temperature. The exceptions allow for deviation from the primary heating system requirements when circumstances do not allow for a feasible or cost-effective use of the options. «»

(d) Controls for Heat Pump Pool Heaters with Supplementary Heating. Heat pump pool heaters with supplementary heaters shall have controls that meet the following:

1. Supplementary heater shall not operate when the heating load can be met by the heat pump pool heater alone; and
2. The cut-on temperature for heat pump heating is higher than the cut-on temperature for supplementary heating, and the cut-off temperature for heat pump heating is higher than the cut-off temperature for supplementary heating.

«» Commentary for Section 110.4(d):

The heat pump pool heater should be able to carry the pool heating load in most mild coastal climates. In climates where heating is desired in colder winter months, the controls should sense when conditions allow for use of only the heat pump pool heater to maintain energy savings versus using a backup electric resistance or gas pool water heater. «»

SECTION 110.5 – NATURAL GAS CENTRAL FURNACES, COOKING EQUIPMENT, POOL AND SPA HEATERS, AND FIREPLACES: PILOT LIGHTS PROHIBITED

Any natural gas system or equipment listed below may be installed only if it does not have a continuously burning pilot light:

(a) Fan-type central furnaces.

(b) Household cooking appliances.

Exception to Section 110.5(b): Household cooking appliances without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/hr.

(c) Pool heaters.

(d) Spa heaters.

(e) Indoor and outdoor fireplaces.

Note**:** Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.8, and 25943, Public Resources Code.

«» Commentary for Section 110.5:

Pool and spa heaters shall not have a continuously burning pilot light. A continuously burning pilot light uses gas while not providing useful heating for the pool or spa. «»

SECTION 160.7 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

(b) Pool and spa systems. Pool and spa systems available to multiple tenants or to the public shall comply with the applicable requirements of Section 110.4. Pool and spa systems installed for exclusive use by a single tenant shall comply with the applicable requirements of Section 150.0(p). Pool and spa systems installed for public use shall comply with Section 150.0(p)2, Section 150.0(p)3, and Section 150.0(p)4.

«» Commentary for Section 160.7(b):

Pool and spa systems available to multiple tenants or to the public must comply with the applicable requirements of Section 110.4, detailed above. Pool and spa systems available to the public must also comply with Section 150.0(p)2, Section 150.0(p)3, and Section 150.0(p)4.

Pool and spa systems installed for exclusive use by a single tenant shall comply with the applicable requirements of Section 150.0(p). «»

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8 and 25943, Public Resources Code.

SECTION 150.0 – MANDATORY FEATURES AND DEVICES

Single-family residential buildings shall comply with the applicable requirements of Sections 150(a) through 150.0(v).

NOTE: The requirements of Sections 150.0(a) through 150.0(v) apply to newly constructed buildings. Sections 150.2(a) and 150.2(b) specify which requirements of Sections 150.0(a) through 150.0(v) also apply to additions or alterations.

(p) Pool systems and equipment installation. Pool system or equipment shall comply with the applicable requirements of Section 110.4, as well as the requirements listed in this section.

«» Commentary for Section 150.0(p):

As noted in Section 160.7, above, pools in multifamily buildings must comply with all applicable requirements in Section 150.0(p), as outlined below. «»

A. Dedicated-purpose pool pumps and replacement dedicated-purpose pump motors subject to State or federal appliance standards shall be listed in the Commission's directory of certified equipment. Dedicated-purpose pool pumps shall meet the applicable standards set forth in 20 CCR § 1605.1(g)(7) of the Appliance Efficiency Regulations. Replacement dedicated-purpose pool pump motors shall meet the applicable standards set forth in 20 CCR § 1605.3 of the Appliance Efficiency Regulations;

B. All pump flow rates shall be calculated using the following system equation:

$H = C \times F^2$

where:

H – is the total system head in feet of water.

F – is the flow rate in gallons per minute (gpm).

C – is a coefficient based on the volume of the pool:

0.0167 for pools less than or equal to 17,000 gallons.

0.0082 for pools greater than 17,000 gallons.

C. Filtration pumps shall be sized, or if programmable shall be programmed, so that the filtration flow rate is not greater than the rate needed to turn over the pool water volume in 6 hours or 36 gpm, whichever is greater; and

«» Commentary for Section 150.0(p)1C:

All pool pumps sold in California must be tested and listed with the Energy Commission according to the *Appliance Efficiency Regulations*. The pool pump must be chosen such that the flow rate calculated by the system curve is less than the 6-hour turnover rate or 36 gpm, whichever is greater. The following equation is used to calculate the system curve. The coefficient included in the equation is dependent on the capacity of the pool.

$$H = C \times F \times 2$$

Where,

1. H = The total system head in feet of water
2. F = The flow rate in gallons per minute (gpm)
3. C =0.0167 for pools less than or equal to 17,000 gallons, or 0.0082 for pools greater than 17,000 gallons «»

D. Dedicated-purpose pool pumps with more than one speed shall have controls which default to the filtration flow rate when no auxiliary pool loads are operating; and

«» Commentary for Section 150.0(p)1D:

For maximum energy efficiency, pool filtration should be operated at the lowest possible flow rate for a period that provides sufficient water turnover for clarity and sanitation. Auxiliary pool loads that require high flow rates, such as spas, pool cleaners, and water features, should be operated separately from the filtration to allow the filtration flow rate to be kept to a minimum.

Pool controls are a critical element of energy efficient pool design. Modern pool controls allow for auxiliary loads such as cleaning systems, solar heating, and temporary water features without compromising energy savings. «»

E. For dedicated-purpose pool pumps with more than one speed, the controls shall default to the filtration flow rate setting within 24 hours and shall have an override capability for servicing.

2. **System piping.**

A. A length of straight pipe that is greater than or equal to at least 4 pipe diameters shall be installed before the pump; and

B. Pool piping shall be sized so that the velocity of the water at maximum flow for auxiliary pool loads does not exceed 8 feet per second in the return line and 6 feet per second in the suction line; and

C. All elbows shall be sweep elbows or of an elbow-type that has a pressure drop of less than the pressure drop of straight pipe with a length of 30 pipe diameters.

«» Commentary for Section 150.0(p)2

Correct sizing of piping, filters, and valves reduces overall system head, reduces noise and wear, and increases energy efficiency. Other mandatory requirements include leading straight pipe into the pump, directional inlets for mixing, and piping to allow for future solar thermal heating installations.

There must be a length of straight pipe that is greater than or equal to at least 4 times the pipe diameters installed before the pump. That is, for a 2-inch suction pump, there must be at least 8 inches of straight pipe before the pump.

Pool piping must be sized according to the maximum flow rate needed for all auxiliary loads. The maximum velocity allowed is 8 feet per second (fps) in the return line and 6 fps in the suction line. Table 8-2: Hour Turnover Pipe Sizing shows the minimum pipe sizes required by pool volume based on a 6-hour turnover filtration flow rate. These pipe sizes would need to be increased if there are auxiliary loads that operate at greater than the filtration flow rate. Conversely, they could be reduced if the pump is sized for greater than a 6-hour turnover filtration flow rate.

Table 8-2: Hour Turnover Pipe Sizing

Pool Volume, min (gallons)	Pool Volume, max (gallons)	Minimum Pipe Diameter (in), return	Minimum Pipe Diameter (in), suction
-	13,000	1.5	1.5
13,000	17,000	1.5	2.0
17,000	21,000	2.0	2.0
21,000	30,000	2.0	2.5
30,000	42,000	2.5	3.0
42,000	48,000	3.0	3.0
48,000	65,000	3.0	3.5

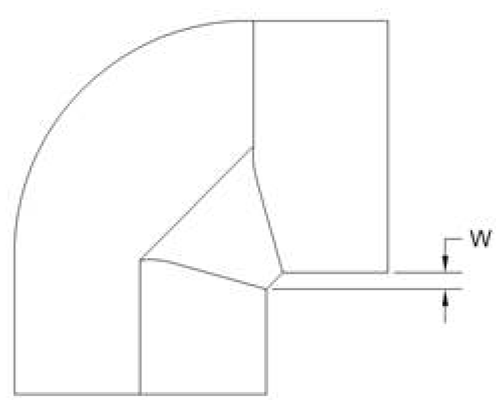
Source: California Energy Commission

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 times the pipe diameters. For example, a 2-inch elbow must have a pressure drop less than a 5-foot length of a 2-inch straight pipe.

Field verification of sweep elbows may be performed by checking that the distance "w" of the installed sweep elbow is greater than that for a hard 90 elbow. (See Figure 8-3: Measuring "W" at the Pool Site.) The difference in measurement between the radial edge of one sleeve to the perpendicular side of the elbow is found to be distinct between sweep elbows and hard 90s. There is sufficient difference in distance "w" such that all sweep elbows exceed the minimum values listed in Table 8-3: Pool Site Measurement for Sweep Elbows.

Figure 8-3: Measuring "W" at the Pool Site below illustrates "w" the dimension between the elbow sleeves, and Table 8-3: Pool Site Measurement for Sweep Elbows shows the minimum distances "w" for an acceptable sweep elbow.

Figure 8-3: Measuring "W" at the Pool Site



Source: California Energy Commission

Table 8-3: Pool Site Measurement for Sweep Elbows

Pipe Diameter	Minimum W (inch)
1.5	3/8
2	1/2
2.5	5/8
3	3/4
4	1

Source: California Energy Commission

«»

3. **Filters.** Filters shall be at least the size specified in NSF/ANSI 50 for public pool intended applications.

«» Commentary for Section 150.0(p)3:

Filters shall be sized using NSF/ANSI 50 based on the maximum flow rate through the filter. The filter factors that should be used to determine the proper size are in ft^2/gpm.

1. Cartridge: 0.375
2. Sand: 15
3. Diatomaceous Earth: 2

«»

4. **Valves.** Minimum diameter of backwash valves shall be 2 inches or the diameter of the return pipe, whichever is greater.

«» Commentary for Section 150.0(p)4:

Multiport backwash valves have a high-pressure drop and are discouraged. Low-loss slide and multiple three-way valves can provide significant energy savings. «»

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INTRODUCTION

Chapter 9 Introduction

This chapter covers covered process system requirements for all dwelling units and common use areas and requirements for enclosed parking garages in multifamily buildings for newly constructed buildings and additions or alterations to existing buildings.

Guidance on general requirements is included in the Multifamily Compliance Manual Chapter 1: General Requirements. Guidance on administrative requirements is included in the Multifamily Compliance Manual Chapter 2: Compliance and Enforcement. This chapter includes guidance on covered process system requirements.

Table 9-1: Excerpt from Table 100.0-A Application of Standards provides an overview of the location of the covered process requirements and enclosed parking garage requirements that apply to multifamily occupancies in the Energy Code.

Table 9-1: Excerpt from Table 100.0-A Application of Standards

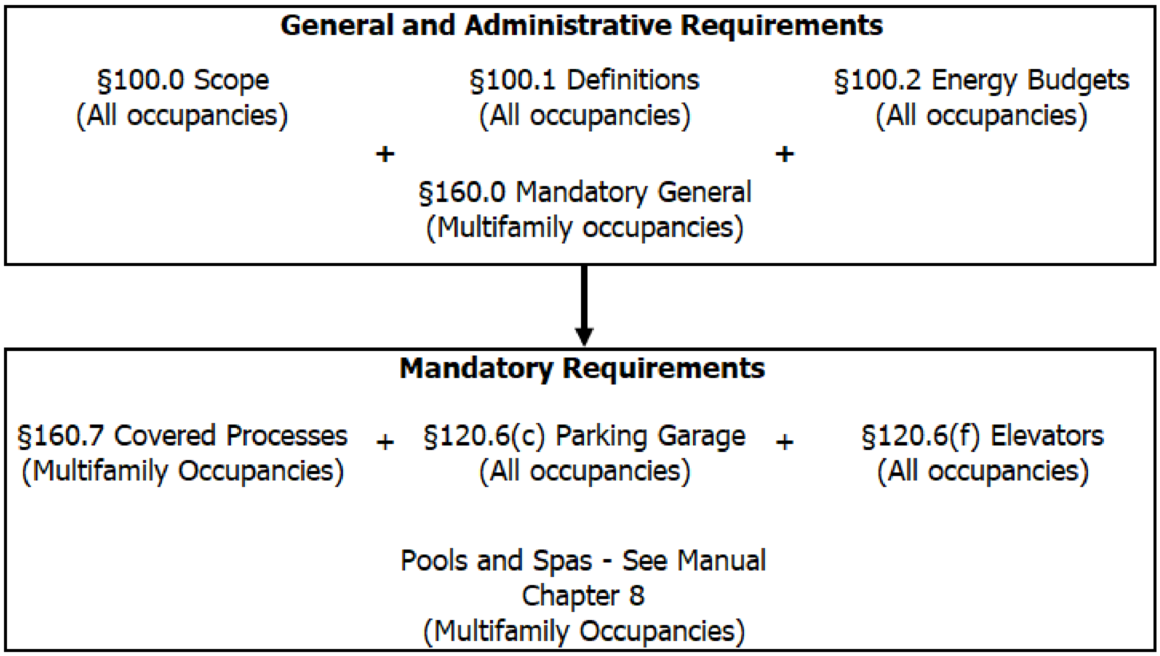
Application	Mandatory	Prescriptive	Performance	Additions/ Alterations
General[1]	160.0	N/A	N/A	180.0
Covered Process and Enclosed Parking Garage	160.7, 120.6(c), 120.6(f) Pools and Spas – See Chapter 8	N/A	N/A	See Mandatory Requirements

1. Guidance on General Requirements from Sections 160.0 and 180.0 are included in the Multifamily Compliance Manual Chapter 1 General Requirements. Guidance specific to multifamily covered processes is included in this chapter.

Source: California Energy Commission

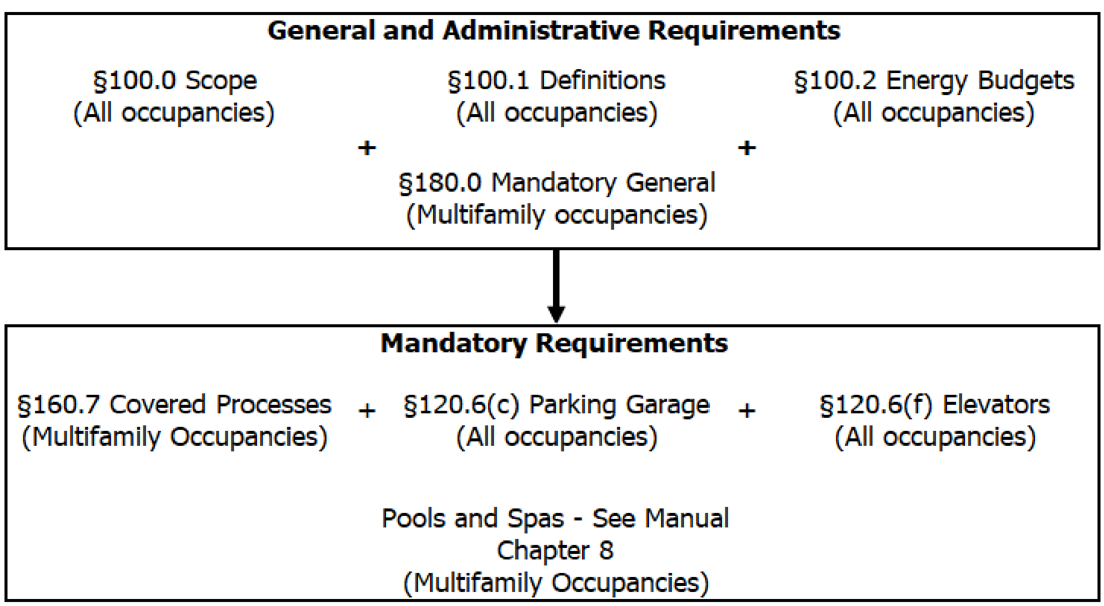
Figure 9-1: Flowchart Guidance for Application of New Construction Multifamily Covered Process and Enclosed Parking Garage Requirements and Figure 9-2: Flowchart Guidance for Application of Addition or Alteration Multifamily Covered Process and Enclosed Parking Garage Requirements below illustrate the applicable sections for newly constructed buildings and additions or alterations to existing buildings.

Figure 9-1: Flowchart Guidance for Application of New Construction Multifamily Covered Process and Enclosed Parking Garage Requirements



Source: California Energy Commission

Figure 9-2: Flowchart Guidance for Application of Addition or Alteration Multifamily Covered Process and Enclosed Parking Garage Requirements



Addition, Alteration Compliance Approaches

Source: California Energy Commission

SECTION 160.7 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

(a) Elevators. Elevators shall meet the requirements of Section 120.6(f).

«» Commentary for Section 160.7(a):

Per Section 160.7(a), Section 120.6(f) applies to all elevators in multifamily new construction, as well as existing elevators undergoing major alterations involving mechanical equipment, lighting, and/or controls. The requirement reduces light power density of the elevator cab lighting and requires a minimum wattage per cfm for ventilation fans in cabs without air conditioning. Both the lighting and ventilation fans are to be controlled in such a way to shut off when the elevator has been unoccupied for an extended period. Please refer to the sections below for more information on specific requirements for elevators. **«»**

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1, 25402.4, 25402.5, 25402.8 and 25943, Public Resources Code.

SECTION 120.6 – MANDATORY REQUIREMENTS FOR COVERED PROCESSES

Nonresidential and hotel/motel buildings shall comply with the applicable requirements of Sections 120.6(a) through 120.6(k), and the applicable requirements of Sections 110.2(a) and 120.3.

«» Commentary for Section 120.6:

Relevant covered processes in multifamily buildings, including enclosed parking garages and elevators, must comply with applicable requirements in the nonresidential covered processes sections, as outlined below. Additions and alterations to covered processes in multifamily buildings must also comply with applicable requirements in Section 120.6. Elevator additions, alterations and repairs are defined as follows:

1. An elevator installation is considered an addition when the location of the installation did not previously contain an elevator.
2. An alteration is a change to an existing elevator system that is not an addition or repair. An alteration could include installing new controls or a new lighting system.
3. A repair is the reconstruction or renewal of any part of an existing elevator system for its maintenance, for example, the replacement of lights or cosmetic features.
4. Any addition or altered space must meet all applicable mandatory requirements. Repairs must not increase the preexisting energy consumption of the repaired component, system, or equipment; otherwise, it is considered an alteration. «»

(c) Mandatory requirements for enclosed parking garages. Enclosed Parking Garages. Mechanical ventilation systems for enclosed parking garages where the total design exhaust rate for the garage is greater than or equal to 10,000 cfm shall conform to all of the following:

1. Automatically detect contaminant levels and stage fans or modulate fan airflow rates to 50 percent or less of design capacity, provided acceptable contaminant levels are maintained.
2. Have controls and/or devices that will result in fan motor demand of no more than 30 percent of design wattage at 50 percent of design airflow.

«» Commentary for Section 120.6(c)2:

This mechanical ventilation requirement can be achieved by either a two-speed motor or a variable-speed drive. «»

3. CO shall be monitored with at least one sensor per 5,000 square feet, with the sensor located in the highest expected concentration locations, with at least two sensors per

proximity zone. A proximity zone is defined as an area that is isolated from other areas either by floor or other impenetrable obstruction.

«» Commentary for Section 120.6(c)3:

The typical design for garage exhaust is to have the exhaust fans located on the other side of the parking areas from the source of makeup air. The ventilation air moves across the parking areas and toward the exhaust fans. Good practice is to locate sensors close to the exhaust registers or in dead zones where air is not between the supply and exhaust. Floors and rooms separated by walls should be treated as separate proximity zones. «»

4. CO concentration at all sensors is maintained at ≤ 25 ppm or less at all times.
5. The ventilation rate shall be at least 0.15 cfm/ft^2 when the garage is scheduled to be occupied.
6. The system shall maintain the garage at negative or neutral pressure relative to other occupiable spaces when the garage is scheduled to be occupied.
7. CO sensors shall be:

   A. Certified by the manufacturer to be accurate within plus or minus 5 percent of measurement.

   B. Factory calibrated.

   C. Certified by the manufacturer to drift no more than 5 percent per year.

   D. Certified by the manufacturer to require calibration no more frequently than once a year.

   E. Monitored by a control system. The system shall have logic that automatically checks for sensor failure by the following means. Upon detection of a failure, the system shall reset to design ventilation rates and transmit an alarm to the facility operators.

      i. If any sensor has not been calibrated according to the manufacturer’s recommendations within the specified calibration period, the sensor has failed.

      ii. During unoccupied periods the system compares the readings of all sensors, e.g., if any sensor is more than 15 ppm above or below the average of all sensors for longer than four hours, the sensor has failed.

      iii. During occupied periods the system compares the readings of sensors in the same proximity zone, e.g., if the 30 minute rolling average for any sensor in a proximity zone is more than 15 ppm above or below the 30 minute rolling average for other sensor(s) in that proximity zone, the sensor has failed.

8. **Parking garage ventilation system acceptance.** Before an occupancy permit is granted for a parking garage system subject to Section 120.6(c), the following equipment and systems shall be certified as meeting the acceptance requirements for code compliance,

as specified by the Reference Nonresidential Appendix NA7. A certificate of acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the acceptance requirements specified in NA7.12.

Exception 1 to Section 120.6(c): Any garage, or portion of a garage, where more than 20 percent of the vehicles expected to be stored have non-gasoline combustion engines.

Exception 2 to Section 120.6(c): Additions and alterations to existing garages where less than 10,000 cfm of new exhaust capacity is being added.

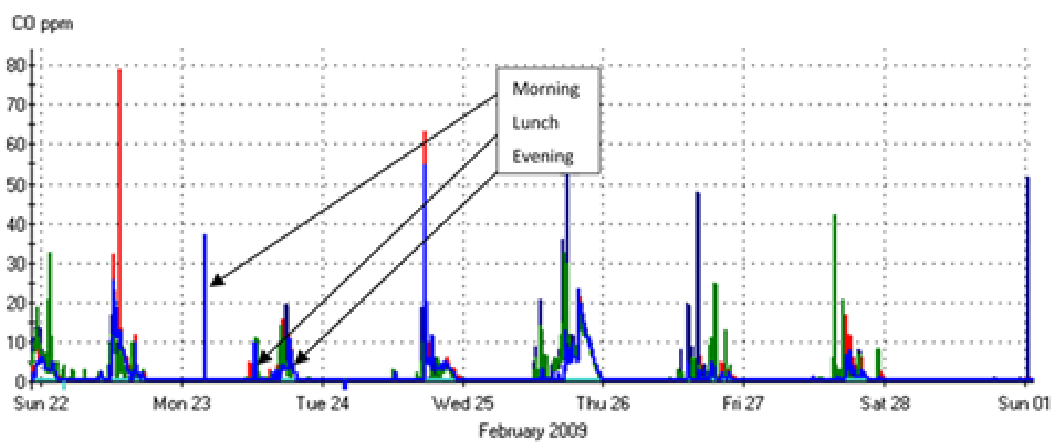
«» Commentary for Section 120.6(c)8:

Garage exhaust systems are sized to dilute the auto exhaust at peak conditions to an acceptable concentration for human health and safety. Energy management control system (EMCS) monitoring of garage carbon monoxide (CO) concentrations show that in a typical enclosed garage, there are three periods of concern:

1. In the morning when cars enter the garage
2. During the lunch break when cars leave and reenter
3. At the end of the day when cars leave

This mandatory measure requires modulating ventilation airflow in large, enclosed parking garages based on pollutant concentrations. By modulating airflow based on need rather than running constant volume, the system will save energy and maintain a safe environment.

Figure 9-3: Garage CO Trends



Source: California Energy Commission

«»

(f) Mandatory requirements for elevators. Elevators shall meet the following requirements:

1. The light power density for the luminaires inside the elevator cab shall be no greater than 0.6 watts per square foot.

Exception to Section 120.6(f)1: Interior signal lighting and interior display lighting are not included in the calculation of lighting power density.

«» Commentary for Section 120.6(f)1:

This light power density is determined by taking the total wattage of the elevator lighting and dividing by the floor area of the elevator in square feet. Interior signal lighting and interior display lighting are not included in the total wattage of the elevator lighting. «»

2. Elevator cab ventilation fans for cabs without space conditioning shall not exceed 0.33 watts per cfm as measured at maximum speed.

«» Commentary for Section 120.6(f)2:

Elevator cabs with space conditioning are excluded from this requirement. «»

3. When the elevator cab is stopped and unoccupied with doors closed for over 15 minutes, the cab interior lighting and ventilation fans shall be switched off until elevator cab operation resumes.

«» Commentary for Section 120.6(f)3:

This requirement can be accomplished with an occupancy sensor or through integrated elevator controls. «»

4. Lighting and ventilation shall remain operational in the event that the elevator cabin gets stuck when passengers are in the cabin.
5. Elevator Lighting and Ventilation Control Acceptance. Before an occupancy permit is granted for elevators subject to 120.6(f), the following equipment and systems shall be certified as meeting the Acceptance Requirement for Code Compliance, as specified by the Reference Nonresidential Appendix NA7. A Certificate of Acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the acceptance requirements specified in NA7.14.

«» Commentary for Section 120.6(f)4-5:

Elevator lighting and ventilation controls must be tested according to NA7.14 to verify that shut off controls installed in an elevator cab turn lighting and ventilation fans off when the elevator is not occupied for more than 15 minutes, and on when elevator cab operation resumes.

The control system must be able to detect occupancy, and keep the lighting and ventilation fan on, in the event that someone is occupying the elevator cabin and the elevator conveyance or doors malfunction. «»

Exception to Section 120.6(f): Elevators located in healthcare facilities.

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APPENDIX A:
Compliance Documents

NOTE: For Documents and User Instructions, please visit our website at:
https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency

Table A- 1: Certificate of Compliance (LMCC) Documents

Title	Category	Document Description
LMCC-CXR-01-E	Commissioning	Nonresidential Building Commissioning
LMCC-ELC-01-E	Electrical	Electrical Power Distribution
LMCC-ENV-01-E	Envelope	Envelope Component Approach
LMCC-LTI-01-E	Lighting	Indoor Lighting
LMCC-LTO-01-E	Lighting	Outdoor Lighting
LMCC-LTS-01-E	Lighting	Sign Lighting
LMCC-MCH-01-E	Mechanical	Mechanical System
LMCC-MCH-02-E	Mechanical	Prescriptive Alterations HVAC
LMCC-PLB-01-E	Plumbing	Domestic Water Heating System
LMCC-PRC-01-E	Process	Process Systems
LMCC-SAB-01-E	Solar and Battery	Solar and Battery
LMCC-PRF-01	Performance	Low-rise Multifamily Performance Compliance Method

Source: California Energy Commission

Table A- 2: Certificate of Installation (LMCI) Documents

Title	Category	Document Description
LMCI-ELC-E	Electrical	Electrical Power Distribution
LMCI-ENV-E	Envelope	Envelope Component Approach
LMCI-LTI-E	Lighting	Indoor Lighting
LMCI-LTO-E	Lighting	Outdoor Lighting
LMCI-LTS-E	Lighting	Sign Lighting
LMCI-MCH-E	Mechanical	Mechanical Systems
LMCI-PLB-E	Plumbing	Domestic Water Heating System

Title	Category	Document Description
LMCI-PRC-E	Process	Process System
LMCI-SRB-E	Solar and Battery	Solar and Battery
LMCI-ELC-01-E	Electrical	Electric Ready Requirements
LMCI-ENV-21-H	Envelope	QII Framing Stage
LMCI-ENV-22-H	Envelope	QII Insulation Installation Stage
LMCI-MCH-01a-E	Mechanical	Space Conditioning System-Performance
LMCI-MCH-01b-E	Mechanical	Space Conditioning System-Prescriptive Alterations
LMCI-MCH-01c-E	Mechanical	Space Conditioning System-Prescriptive NCB
LMCI-MCH-01d-E	Mechanical	Space Conditioning System-Performance-E+A+A
LMCI-MCH-20-H	Mechanical	Duct Leakage Diagnostic Test
LMCI-MCH-21-H	Mechanical	Duct Location Verification
LMCI-MCH-22-H	Mechanical	Space Conditioning System Fan Efficacy
LMCI-MCH-23-H	Mechanical	Space Conditioning System Airflow Rate
LMCI-MCH-24-H	Mechanical	Enclosure Air Leakage Worksheet
LMCI-MCH-25-H	Mechanical	Refrigerant Charge Verification
LMCI-MCH-26-H	Mechanical	Rated Space Conditioning System Equipment Verification
LMCI-MCH-27-H	Mechanical	Indoor Air Quality And Mechanical Ventilation
LMCI-MCH-28-H	Mechanical	Return Duct and Filter Grille Design-Table 160.3 A or B
LMCI-MCH-29-H	Mechanical	Supply Duct Surface Area Buried Ducts
LMCI-MCH-32-H	Mechanical	Local Mechanical Exhaust
LMCI-MCH-33-H	Mechanical	VCHP Compliance Credit
LMCI-PLB-01-E	Plumbing	Multifamily Central Hot Water System Distribution
LMCI-PLB-02-E	Plumbing	Individual Dwelling Unit Hot Water System Distribution
LMCI-PLB-03-E	Pluming	Pool and Spa Heating Systems
LMCI-PLB-21-H	Plumbing	Multifamily Central Hot Water System Distribution

Title	Category	Document Description
LMCI-PLB-22-H	Plumbing	Individual Dwelling Unit Hot Water System Distribution

Source: California Energy Commission

Table A- 3: Certificate of Verification (LMCV) Documents

Title	Category	Document Description
LMCV-ENV-21-H	Envelope	QII Framing Stage
LMCV-ENV-22-H	Envelope	QII Insulation Installation Stage
LMCV-EXC-20-H	Existing Conditions	Verification of Existing Conditions for Residential Alterations
LMCV-MCH-20-H	Mechanical	Duct Leakage Diagnostic Test
LMCV-MCH-21-H	Mechanical	Duct Location
LMCV-MCH-22-H	Mechanical	Space Conditioning System Fan Efficacy
LMCV-MCH-23-H	Mechanical	Space Conditioning System Airflow Rate
LMCV-MCH-24-H	Mechanical	Enclosure Air Leakage Worksheet
LMCV-MCH-25-H	Mechanical	Refrigerant Charge Verification
LMCV-MCH-26-H	Mechanical	Rated System Verification
LMCV-MCH-27-H	Mechanical	Indoor Air Quality And Mechanical Ventilation
LMCV-MCH-28-H	Mechanical	Return Duct And Filter Grille Design-Table 150
LMCV-MCH-29-H	Mechanical	Supply Duct Surface Area Buried Ducts
LMCV-MCH-32-H	Mechanical	Local Mechanical Exhaust
LMCV-MCH-33-H	Mechanical	VCHP Compliance Credit
LMCV-PLB-21-H	Plumbing	Multifamily Central Hot Water System Distribution
LMCV-PLB-22-H	Plumbing	Individual Dwelling Unit Hot Water System Distribution

Source: California Energy Commission

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TABLE T-1
NORMAL IMPEDANCE RANGES FOR LIQUID-IMMERSED TRANSFORMERS

Single-phase		Three-phase	
kVA	***Impedance (%)***	***kVA***	***Impedance (%)***
10	1.0–4.5	15	1.0–4.5
15	1.0–4.5	30	1.0–4.5
25	1.0–4.5	45	1.0–4.5
37.5	1.0–4.5	75	1.0–5.0
50	1.5–4.5	112.5	1.2–6.0
75	1.5–4.5	150	1.2–6.0
100	1.5–4.5	225	1.2–6.0
167	1.5–4.5	300	1.2–6.0
250	1.5–6.0	500	1.5–7.0
333	1.5–6.0	750	5.0–7.5
500	1.5–7.0	1000	5.0–7.5
667	5.0–7.5	1500	5.0–7.5
833	5.0–7.5	2000	5.0–7.5
		2500	5.0–7.5

TABLE T-2
NORMAL IMPEDANCE RANGES FOR DRY-TYPE TRANSFORMERS

Single-phase		Three-phase	
kVA	***Impedance (%)***	***kVA***	***Impedance (%)***
15	1.5–6.0	15	1.5–6.0
25	1.5–6.0	30	1.5–6.0
37.5	1.5–6.0	45	1.5–6.0
50	1.5–6.0	75	1.5–6.0
75	2.0–7.0	112.5	1.5–6.0
100	2.0–7.0	150	1.5–6.0
167	2.5–8.0	225	3.0–7.0
250	3.5–8.0	300	3.0–7.0
333	3.5–8.0	500	4.5–8.0
500	3.5–8.0	750	5.0–8.0
667	5.0–8.0	1000	5.0–8.0
833	5.0–8.0	1500	5.0–8.0
		2000	5.0–8.0
		2500	5.0–8.0

TABLE A-1
NON-COMMERCIAL REFRIGERATOR, REFRIGERATOR-FREEZER, AND FREEZER TEST METHODS

Appliance	*Test Method*
Non-commercial refrigerators, designed for the refrigerated storage of food at temperatures above 32°F and below 39°F, configured for general refrigerated food storage; refrigerator-freezers; and freezers.	10 C.F.R. sections 430.23(a) (Appendix A1 to Subpart B of part 430) and 430.23(b) (Appendix B1 to Subpart B of part 430), as applicable for models manufactured before September 15, 2014 10 C.F.R. sections 430.23(a) (Appendix A to Subpart B of part 430) and 430.23(b) (Appendix B to Subpart B of part 430), as applicable for models manufactured on or after September 15, 2014
Wine chillers that are consumer products	10 C.F.R. section 430.23(a) (Appendix A1 to Subpart B of part 430), with the following modifications: Standardized temperature as referred to in Section 3.2 of Appendix A1 shall be 55°F (12.8°C). The calculation of test cycle energy expended (ET) in section 5.2.1.1 of Appendix A1 shall be made using the modified formula: ET=(EP x 1440 x k)/T Where k = 0.85

TABLE A-2
COMMERCIAL REFRIGERATORS, REFRIGERATOR-FREEZER, AND FREEZER TEST METHODS

Appliance	*Test Method*
Automatic commercial ice makers	10 C.F.R. sections 431.133 and 431.134
Refrigerated bottled or canned beverage vending machines	10 C.F.R. sections 431.293 and 431.294
Refrigerated buffet and preparation tables	ANSI/ASTM F2143-01
Other commercial refrigerators, refrigerator-freezers, and freezers, with doors	10 C.F.R. sections 431.63 and 431.64
Other commercial refrigerators, refrigerator-freezers, and freezers, without doors	10 C.F.R. sections 431.63 and 431.64
Walk-in coolers and walk-in freezers	10 C.F.R. sections 431.303 and 431.304

TABLE B-1
ROOM AIR CONDITIONER, ROOM AIR-CONDITIONING HEAT PUMP, PACKAGED TERMINAL AIR CONDITIONER, AND PACKAGED TERMINAL HEAT PUMP TEST METHODS

Appliance	*Test Method*
Room air conditioners and room air-conditioning heat pumps	10 C.F.R. section 430.23(f) (Appendix F to Subpart B of part 430)
Packaged terminal air conditioners and packaged terminal heat pumps	10 C.F.R. sections 431.95 and 431.96

TABLE C-1
CENTRAL AIR CONDITIONER TEST METHODS

Appliance	*Test Method*
Computer Room Air Conditioners evaporatively-cooled air-cooled, glycol-cooled, water-cooled	ANSI/ASHRAE 127-2001 10 C.F.R. sections 431.95 and 431.96
Other electric-powered unitary air-conditioners and electric-powered heat pumps air-cooled air conditioners and air-source heat pumps < 65,000 Btu/hr, single-phase < 65,000 Btu/hr, three-phase ≥ 65,000 and < 760,000 Btu/hr evaporatively-cooled air conditioners < 240,000 Btu/hr water-cooled air conditioners and water-source heat pumps < 240,000 Btu/hr ground water-source heat pumps ground-source closed-loop heat pumps	10 C.F.R. section 430.23(m) (Appendix M to Subpart B of part 430) 10 C.F.R. sections 431.95 and 431.96 10 C.F.R. sections 431.95 and 431.96 10 C.F.R. sections 431.95 and 431.96 10 C.F.R. sections 431.95 and 431.96 ARI/ISO-13256-1:1998 ARI/ISO-13256-1:1998
Variable Refrigerant Flow Multi-Split Systems	10 C.F.R. sections 431.95 and 431.96
Single Package Vertical Air Conditioners and Single Package Vertical Heat Pumps	10 C.F.R. sections 431.95 and 431.96
Gas-fired air conditioners and gas-fired heat pumps	ANSI Z21.40.4-1996 as modified by CEC, Efficiency Calculation Method for Gas-Fired Heat Pumps as a New Compliance Option (1996)

TABLE D-1
SPOT AIR CONDITIONER, CEILING FAN, CEILING FAN LIGHT KIT, EVAPORATIVE COOLER, WHOLE HOUSE FAN, RESIDENTIAL EXHAUST FAN, AND DEHUMIDIFIER TEST METHODS

Appliance	*Test Method*
Spot Air Conditioners	ANSI/ASHRAE 128-2001
Ceiling Fans, Except Low-Profile Ceiling Fans	10 C.F.R. section 430.23(w) (Appendix U to Subpart B of part 430)
Ceiling Fan Light Kits	10 C.F.R. section 430.23(x) (Appendix V to Subpart B of part 430)
Evaporative Coolers	ANSI/ASHRAE 133-2008 for packaged direct evaporative coolers and packaged indirect/direct evaporative coolers; ANSI/ASHRAE 143-2007 for packaged indirect evaporative coolers
Whole House Fans	HVI-916, tested with manufacturer-provided louvers in place (2009)
Dehumidifiers	10 C.F.R. section 430.23(z) (Appendix X to Subpart B of part 430) OR 10 C.F.R. section 430.23(z) (Appendix X1 to Subpart B of part 430) (at manufacturer's discretion) for models manufactured before April 29, 2013 10 C.F.R. section 430.23(z) (Appendix X1 to Subpart B of part 430) for models manufactured on or after April 29, 2013
Residential Exhaust Fans	HVI-916 (2009)

TABLE E-1
GAS AND OIL SPACE HEATER TEST METHODS

Appliance	*Test Method*
Central furnaces < 225,000 Btu/hr, single phase < 225,000 Btu/hr, three phase ≥ 225,000 Btu/hr	10 C.F.R. section 430.23(n) (Appendix N to Subpart B of part 430) 10 C.F.R. section 430.23(n) (Appendix N to Subpart B of part 430) or 10 C.F.R. sections 431.75 and 431.76 (at manufacturer's option) 10 C.F.R. sections 431.75 and 431.76
Gas infrared heaters patio heaters gas-fired high-intensity infrared heaters gas-fired low-intensity infrared heaters	ASTM F2644-07 ANSI Z83.19- 001 ANSI Z83.20-
Unit heaters gas- fired oil-fired	ANSI Z83.8-2002* UL 731-1995*
Gas duct furnaces	ANSI Z83.8-
Boilers < 300,000 Btu/hr ≥ 300,000 Btu/hr	10 C.F.R. section 430.23(n) (Appendix N to Subpart B of part 430) 10 C.F.R. sections 431.85 and 431.86
Wall furnaces, floor furnaces, and room heaters	10 C.F.R. section 430.23(o) (Appendix O to Subpart B of part 430)
*To calculate maximum energy consumption during standby, measure the gas energy used in one hour (in Btus) and the electrical energy used (in watt-hours) over a one-hour period, when the main burner is off. Divide Btus and watt-hours by one hour to obtain Btus per hour and watts. Divide Btus per hour by 3.412 to obtain watts. Add watts of gas energy to watts of electrical energy to obtain standby energy consumption in watts.	

TABLE F-1
SMALL WATER HEATER TEST METHODS

Appliance	*Test Method*
Small water heaters that are federally regulated consumer products	10 CFR Section 430.23(e) (Appendix E to Subpart B of Part 430) (2008)
Small water heaters that are not federally regulated consumer products	
Gas and oil storage-type < 20 gallons rated capacity	ANSI/ASHRAE 118.2-1993
Booster water heaters	ANSI/ASTM F2022-00 (for all matters other than volume) ANSI Z21.10.3-1998 (for volume)
Hot water dispensers	Test Method in 1604(f)(4)
Mini-tank electric water heaters	Test Method in 1604(f)(5)
All others	10 CFR Section 430.23(e) (Appendix E to Subpart B of Part 430) (2008)

TABLE F-2
STANDARDS FOR LARGE WATER HEATERS EFFECTIVE OCTOBER 29, 2003

Appliance	*Input to Volume Ratio*	*Size (Volume)*	*Minimum Thermal Efficiency (%)*	*Maximum Standby Loss*[1,2]
Gas storage water heaters	< 4,000 Btu/hr/gal	Any	80	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Gas instantaneous water heaters	≥ 4,000 Btu/hr/gal	< 10 gal	80	–
		≥ 10 gal	80	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Gas hot water supply boilers	≥ 4,000 Btu/hr/gal	< 10 gal	80	–
		≥ 10 gal	80	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Oil storage water heaters	< 4,000 Btu/hr/gal	Any	78	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Oil instantaneous water heaters	≥ 4,000 Btu/hr/gal	< 10 gal	80	–
		≥ 10 gal	78	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Oil hot water supply boilers	≥ 4,000 Btu/hr/gal	< 10 gal	80	–
		≥ 10 gal	78	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Electric storage water heaters	< 4,000 Btu/hr/gal	Any	–	$0.3 + 27/V_m$ %/hr

[1] Standby loss is based on a 70°F temperature difference between stored water and ambient requirements. In the standby loss equations, Vr is the rated volume in gallons, Vm is the measured volume in gallons, and Q is the nameplate input rate in Btu/hr.

[2] Water heaters and hot water supply boilers having more than 140 gallons of storage capacity are not required to meet the standby loss requirement if the tank surface is thermally insulated to R- 12.5, if a standing pilot light is not installed, and for gas- or oil-fired storage water heaters, there is a flue damper or fan-assisted combustion.

TABLE G-1
POOL HEATER TEST METHODS

Appliance	*Test Method*		
Gas-fired and oil-fired pool heaters	10 C.F.R. section 430.23(p) (Appendix P to Subpart B of part 430)		
Electric resistance pool heaters	ANSI/ASHRAE 146-1998		
Heat pump pool heaters	ANSI/ASHRAE 146-1998, as modified by Addendum Test Procedure published by Pool Heat Pump Manufacturers Association dated April 1999, Rev 4: Feb. 28, 2000:		
Reading	***Standard Temperature Rating***	***Low-Temperature Rating***	***Spa Conditions Rating***
Air Temperature Dry bulb Wet bulb	 27.0°C (80.6°F) 21.7°C (71.0°F)	 10.0°C (50.0°F) 6.9°C (44.4°F)	 27.0°C (80.6°F) 21.7°C (71.0°F)
Relative Humidity	63%	63%	63%
Pool Water Temperature	26.7°C (80.0°F)	26.7°C (80.0°F)	40.0°C (104.0°F)

TABLE R-1
COOKING PRODUCT AND FOOD SERVICE EQUIPMENT TEST METHODS

Appliance	*Test Method*
Cooking products that are consumer products	10 CFR Section 430.23(i) (Appendix I to Subpart B of Part 430) (2008)
Commercial hot food holding cabinets	ANSI/ASTM F2140-01 (Test for idle energy rate-dry test) and US EPA's Energy Star Guidelines, "Measuring Interior Volume" (Test for interior volume)
Commercial convection ovens	ANSI/ASTM F1496-99 (Test for energy input rate and idle energy consumption only)
Commercial range tops	ANSI/ASTM F1521-96 (Test for cooking energy efficiency only)

TABLE A-3 STANDARDS FOR NON-COMMERCIAL REFRIGERATORS, REFRIGERATOR-FREEZERS, AND FREEZERS

Appliance	Defrost	Compact, Built- in, Neither	Ice		Maximum Energy Consumption (kWh/year)	
			Equipped with Automatic Ice Maker?	Dispense Ice Through Door?	July 1, 2001[1]	Sept. 15, 2014[2]
Refrigerators						
Not 'all refrigerator'	Manual	Neither	--	--	8.82AV + 248.4	7.99AV + 225.0
Not 'all refrigerator'	Manual	Compact	--	--	10.70AV + 299.0	9.03AV + 252.3
'All refrigerator'	Manual	Compact	--	--	10.70AV + 299.0	7.84AV + 219.1
'All refrigerator'	Manual	Neither	--	--	--	6.79AV + 193.6
'All refrigerator'	Automatic	Neither	--	--	9.80AV + 276.0	7.07AV + 201.6
'All refrigerator'	Automatic	Built-in	--	--	--	8.02AV + 228.5
'All refrigerator'	Automatic	Compact	--	--	12.70AV + 355.0	9.17AV + 259.3
Refrigerator-freezers	Manual	Neither	--	--	8.82AV + 248.4	7.99AV + 225.0
	Partial	Neither	--	--	8.82AV + 248.4	7.99AV + 225.0
	Manual	Compact	--	--	--	9.03AV + 252.3
	Partial	Compact	--	--	7.00AV + 398.0	5.91AV + 335.8
Refrigerator-freezers Bottom-Freezer	Automatic	Neither	No	--	4.60AV + 459.0	8.85AV + 317.0
	Automatic	Neither	Yes	No	--	8.85AV + 401.0
	Automatic	Neither	Yes	Yes	--	9.25AV + 475.4
	Automatic	Compact	No	--	13.10AV + 367.0	11.80AV + 339.2
	Automatic	Compact	Yes	--	--	11.80AV + 423.2
	Automatic	Built-in	No	--	--	9.40AV + 336.9
	Automatic	Built-in	Yes	No	--	9.40AV + 420.9
	Automatic	Built-in	Yes	Yes	--	9.83AV + 499.9
Refrigerator-freezers Side-by-side	Automatic	Neither	No	--	4.91AV+507.5	8.51AV + 297.8
	Automatic	Neither	Yes	No	--	8.51AV + 381.8
	Automatic	Neither	Yes	Yes	10.10AV + 406.0	8.54AV + 432.8
	Automatic	Compact	No	--	7.60AV + 501.0	6.82AV + 456.9
	Automatic	Compact	Yes	--	--	6.82AV + 540.9
	Automatic	Built-in	No	--	--	10.22AV + 357.4
	Automatic	Built-in	Yes	No	--	10.22AV + 441.4
	Automatic	Built-in	Yes	Yes	--	10.25AV + 502.6
Refrigerator-freezers Top-Freezer	Automatic	Neither	No	--	9.80AV + 276.0	8.07AV + 233.7
	Automatic	Neither	Yes	No	--	8.07AV + 317.7
	Automatic	Neither	Yes	Yes	10.20AV + 356.0	8.40AV + 385.4
	Automatic	Compact	No	--	12.70AV + 355.0	11.80AV + 339.2
	Automatic	Compact	Yes	--	--	11.80AV + 423.2
	Automatic	Built-in	No	--	--	9.15AV + 264.9
	Automatic	Built-in	Yes	No	--	9.15AV + 348.9
Freezers Upright Freezer	Manual	Neither	No	--	7.55AV + 258.3	5.57AV + 193.7
	Manual	Compact	--	--	9.78AV + 250.8	8.65AV + 225.7
	Automatic	Neither	No	--	12.43AV + 326.1	8.62AV + 228.3
	Automatic	Neither	Yes	--	--	8.62AV + 312.3
	Automatic	Compact	--	--	11.40AV + 391.0	10.17AV + 351.9
	Automatic	Built-in	No	--	--	9.86AV + 260.9
	Automatic	Built-in	Yes	--	--	9.86AV + 344.9
Freezers Chest Freezer	Manual	NOT Compact	No	--	--	7.29AV + 107.8
	Partial	NOT Compact	No	--	--	7.29AV + 107.8
	Automatic	NOT Compact	No	--	9.88AV + 143.7	10.24AV + 148.1
	--	Compact	--	--	10.45AV + 152.0	9.25AV + 136.8

Appliance	Defrost	Compact, Built-in, Neither	Ice		Maximum Energy Consumption (kWh/year)	
			Equipped with Automatic Ice Maker?	Dispense Ice Through Door?	July 1, 2001[1]	Sept. 15, 2014[2]
Freezers Neither Chest Freezer nor Upright Freezer	--	NOT Compact	No	--	--	7.29AV + 107.8

[1]AV = adjusted total volume, expressed in ft^3, as determined in 10 C.F.R., part 430, Appendices A1 and B1 of Subpart B, which is:
[1.44 x freezer volume (ft^3)] + refrigerator volume (ft^3) for refrigerators;
[1.63 x freezer volume (ft^3)] + refrigerator volume (ft^3) for refrigerator-freezers;
[1.73 x freezer volume (ft^3)] for freezers.
[2]AV = adjusted total volume, expressed in ft^3, as determined in 10 C.F.R., part 430, Appendices A and B of Subpart B.

Note: Maximum energy consumption standards for refrigerator-freezers with internal freezers are same as those for refrigerator-freezers with top-mounted freezers.

TABLE A-4
STANDARDS FOR COMMERCIAL REFRIGERATORS AND FREEZERS WITH A SELF-CONTAINED CONDENSING UNIT THAT ARE NOT COMMERCIAL HYBRID UNITS

	Condensing Unit Configuration	Equipment Family	Rating Temperature (°F)	Operating Temperature (°F)	Equipment Class Designation*	Maximum Daily Energy Consumption (kWh)
Refrigerators and Freezers Effective January 1, 2010	Self-Contained (SC)	Vertical Closed Transparent (VCT)	38 (M) 0 (L)	≥ 32 < 32	VCT, SC, M VCT, SC, L	0.12 × V + 3.34 0.75 × V + 4.10
		Horizontal Closed Transparent (HCT)	38 (M) 0 (L)	≥ 32 < 32	HCT, SC, M HCT, SC, L	0.12 × V + 3.34 0.75 × V + 4.10
		Vertical Closed Solid (VCS)	38 (M) 0 (L)	≥ 32 < 32	VCS, SC, M VCS, SC, L	0.10 × V + 2.04 0.40 × V + 1.38
		Horizontal Closed Solid (HCS)	38 (M) 0 (L)	≥ 32 < 32	HCS, SC, M HCS, SC, L	0.10 × V + 2.04 0.40 × V + 1.38
		Service Over Counter (SOC)	38 (M) 0 (L)	≥ 32 < 32	SOC, SC, M SOC, SC, L	0.12 × V + 3.34 0.75 × V + 4.10
Refrigerators with transparent doors designed for pull-down temperature applications Effective January 1, 2010	Self-Contained (SC)	Vertical Closed Transparent (VCT)	38 (P)	≥ 32	VCT, SC, P	0.126 × V + 3.51
		Horizontal Closed Transparent (HCT)	38 (P)	≥ 32	HCT, SC, P	0.126 × V + 3.51
Refrigerators and Freezers without doors Effective January 1, 2012	Self-Contained (SC)	Vertical Open (VOP)	38 (M) 0 (L)	≥ 32 < 32	VOP, SC, M VOP, SC, L	1.74 × TDA + 4.71 4.37 × TDA +11.82
		Semi-vertical Open (SVO)	38 (M) 0 (L)	≥ 32 < 32	SVO, SC, M SVO, SC, L	1.73 × TDA + 4.59 4.34 × TDA +11.51
		Horizontal Open (HZO)	38 (M) 0 (L)	≥ 32 < 32	HZO, SC, M HZO, SC, L	0.77 × TDA + 5.55 1.92 × TDA + 7.08

* The meaning of the letters in this column is indicated in the *Condensing Unit Configuration*, *Equipment Family*, and *Rating Temperature (°F)* columns to the left.

TABLE A-5
STANDARDS FOR COMMERCIAL REFRIGERATORS AND FREEZERS WITH A REMOTE CONDENSING UNIT THAT ARE NOT COMMERCIAL HYBRID UNITS

Equipment Category	*Condensing Unit Configuration*	*Equipment Family*	*Rating Temperature (°F)*	*Operating Temperature (°F)*	*Equipment Class Designation**	*Maximum Daily Energy Consumption (kWh)*
Refrigerators and Freezers	Remote (RC)	Vertical Open (VOP)	38 (M) 0 (L)	≥ 32 < 32	VOP, RC, M VOP, RC, L	0.82 × TDA + 4.07 2.27 × TDA + 6.85
Effective January 1, 2012		Semi-vertical Open (SVO)	38 (M) 0 (L)	≥ 32 < 32	SVO, RC, M SVO, RC, L	0.83 × TDA + 3.18 2.27 × TDA + 6.85
		Horizontal Open (HZO)	38 (M) 0 (L)	≥ 32 < 32	HZO, RC, M HZO, RC, L	0.35 × TDA + 2.88 0.57 × TDA + 6.88
		Vertical Closed Transparent (VCT)	38 (M) 0 (L)	≥ 32 < 32	VCT, RC, M VCT, RC, L	0.22 × TDA + 1.95 0.56 × TDA + 2.61
		Horizontal Closed Transparent (HCT)	38 (M) 0 (L)	≥ 32 < 32	HCT, RC, M HCT, RC, L	0.16 × TDA + 0.13 0.34 × TDA + 0.26
		Vertical Closed Solid (VCS)	38 (M) 0 (L)	≥ 32 < 32	VCS, RC, M VCS, RC, L	0.11 × V + 0.26 0.23 × V + 0.54
		Horizontal Closed Solid (HCS)	38 (M) 0 (L)	≥ 32 < 32	HCS, RC, M HCS, RC, L	0.11 × V + 0.26 0.23 × V + 0.54
		Service Over Counter (SOC)	38 (M) 0 (L)	≥ 32 < 32	SOC, RC, M SOC, RC, L	0.51 × TDA + 0.11 1.08 × TDA + 0.22

* The meaning of the letters in this column is indicated in the *Condensing Unit Configuration, Equipment Family*, and *Rating Temperature (°F)* columns to the left.

TABLE A-7
STANDARDS FOR AUTOMATIC COMMERCIAL ICE MAKERS MANUFACTURED ON OR AFTER JANUARY 1, 2010

Equipment type	*Type of cooling*	*Harvest rate (lbs ice/24 hours)*	*Maximum energy use (kWh/100 lbs ice)*	*Maximum condenser water use* (gal/100 lbs ice)*
Ice Making Head	Water	< 500	7.80–0.0055H	200–0.022H.
Ice Making Head	Water	≥ 500 and < 1436	5.58–0.0011H	200–0.022H.
Ice Making Head	Water	≥ 1436	4.0	200–0.022H.
Ice Making Head	Air	< 450	10.26–0.0086H	Not applicable.
Ice Making Head	Air	≥ 450	6.89–0.0011H	Not applicable.
Remote Condensing (but not remote compressor)	Air	< 1000	8.85–0.0038H	Not applicable.
Remote Condensing (but not remote compressor)	Air	≥ 1000	5.1	Not applicable.
Remote Condensing and Remote Compressor	Air	< 934	8.85–0.0038H	Not applicable.
Remote Condensing and Remote Compressor	Air	≥ 934	5.3	Not applicable.
Self-Contained	Water	< 200	11. 40–0.019H	191–0.0315H.
Self-Contained	Water	≥ 200	7.6	191–0.0315H.
Self-Contained	Air	< 175	18.0–0.0469H	Not applicable.
Self-Contained	Air	≥ 175	9.8	Not applicable.

H Harvest rate in pounds per 24 hours.
*Water use is for the condenser only and does not include potable water used to make ice.

TABLE B-2
STANDARDS FOR ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONING HEAT PUMPS MANUFACTURED ON OR AFTER OCTOBER 1, 2000 AND BEFORE JUNE 1, 2014

Appliance	*Louvered Sides*	*Cooling Capacity (Btu/hr)*	*Minimum EER*
Room Air Conditioner	Yes	< 6,000	9.7
Room Air Conditioner	Yes	≥ 6,000 – 7,999	9.7
Room Air Conditioner	Yes	≥ 8,000 – 13,999	9.8
Room Air Conditioner	Yes	≥ 14,000 – 19,999	9.7
Room Air Conditioner	Yes	≥ 20,000	8.5
Room Air Conditioner	No	< 6,000	9.0
Room Air Conditioner	No	≥ 6,000 – 7,999	9.0
Room Air Conditioner	No	≥ 8,000 – 19,999	8.5
Room Air Conditioner	No	≥ 20,000	8.5
Room Air Conditioning Heat Pump	Yes	< 20,000	9.0
Room Air Conditioning Heat Pump	Yes	≥ 20,000	8.5
Room Air Conditioning Heat Pump	No	< 14,000	8.5
Room Air Conditioning Heat Pump	No	≥ 14,000	8.0
Casement-Only Room Air Conditioner	Either	Any	8.7
Casement-Slider Room Air Conditioner	Either	Any	9.5

TABLE B-3
STANDARDS FOR ROOM AIR CONDITIONERS AND ROOM AIR-CONDITIONING HEAT PUMPS
MANUFACTURED ON OR AFTER JUNE 1, 2014

Appliance	*Louvered Sides*	*Cooling Capacity (Btu/hr)*	*Minimum Combined EER*
Room Air Conditioner	Yes	< 6,000	11.0
Room Air Conditioner	Yes	≥ 6,000 – 7,999	11.0
Room Air Conditioner	Yes	≥ 8,000 – 13,999	10.9
Room Air Conditioner	Yes	≥ 14,000 – 19,999	10.7
Room Air Conditioner	Yes	≥ 20,000 – 27,999	9.4
Room Air Conditioner	Yes	≥ 28,000	9.0
Room Air Conditioner	No	< 6,000	10.0
Room Air Conditioner	No	≥6,000 – 7,999	10.0
Room Air Conditioner	No	≥ 8,000 – 10,999	9.6
Room Air Conditioner	No	≥ 11,000 – 13,999	9.5
Room Air Conditioner	No	≥ 14,000 – 19,999	9.3
Room Air Conditioner	No	≥ 20,000	9.4
Room Air Conditioning Heat Pump	Yes	< 20,000	9.8
Room Air Conditioning Heat Pump	Yes	≥ 20,000	9.3
Room Air Conditioning Heat Pump	No	< 14,000	9.3
Room Air Conditioning Heat Pump	No	≥ 14,000	8.7
Casement-Only Room Air Conditioner	Either	Any	9.5
Casement-Slider Room Air Conditioner	Either	Any	10.4

TABLE B-6 STANDARDS FOR STANDARD SIZE PACKAGED TERMINAL AIR CONDITIONERS AND STANDARD SIZE PACKAGED TERMINAL HEAT PUMPS MANUFACTURED ON OR AFTER OCTOBER 8, 2012

Appliance	*Cooling Capacity (Btu/hour)*	*Minimum Efficiency*	
		Minimum EER	*Minimum COP*
Packaged Terminal Air Conditioners	< 7,000	11.7	—
	≥ 7,000 < 15,000	13.8 – (0.300 x Cap[1])	—
	≥ 15,000	9.3	—
Packaged Terminal Heat Pumps	< 7,000	11.9	3.3
	≥ 7,000 < 15,000	14.0 – (0.300 x Cap[1])	3.7 - (0.052 x Cap[1])
	≥ 15,000	9.5	2.9

[1] Cap means cooling capacity in thousand British thermal units per hour (Btu/h) at 95°F outdoor dry-bulb temperature.

TABLE C-2
STANDARDS FOR SINGLE PHASE AIR-COOLED AIR CONDITIONERS WITH COOLING CAPACITY LESS THAN 65,000 BTU PER HOUR AND SINGLE-PHASE AIR-SOURCE HEAT
PUMPS WITH COOLING CAPACITY LESS THAN 65,000 BTU PER HOUR, NOT SUBJECT TO EPACT

Appliance	*Minimum Efficiency*					
	Effective January 23, 2006		*Effective January 1, 2015*			
	Minimum SEER	*Minimum HSPF*	*Minimum SEER*	*Minimum HSPF*	*Minimum EER*	*Average Off-Mode Power Consumption $P_{W,OFF}$ (watts)*
Split system air conditioners with rated cooling capacity < 45,000 Btu/hour[1]	13.0	—	14.0	—	12.2	30
Split system air conditioners with rated cooling capacity ≥ 45,000 Btu/hour[1]			14.0	—	11.7	30
Split system heat pumps	13.0	7.7	14.0	8.2	—	33
Single package air conditioners[1]	13.0	—	14.0	—	11.0	30
Single package heat pumps	13.0	7.7	14.0	8.0	—	33
Space constrained air conditioners – split system	12.0		12.0	—	—	30
Space constrained heat pumps – split system	12.0	7.4	12.0	7.4	—	33
Space constrained air conditioners – single package	12.0		12.0	—	—	30
Space constrained heat pumps – single package	12.0	7.4	12.0	7.4	—	33
Small duct, high velocity air conditioner systems	13.0		13.0	—	—	30
Small duct, high velocity heat pump systems	13.0	7.7	13.0	7.7	—	30

[1] See 10 C.F.R. section 430.32(c) for less stringent federal standards applicable to these units that are manufactured on or after January 1, 2015 and installed in states other than Arizona, California, Nevada, or New Mexico

TABLE C-3
STANDARDS FOR AIR-COOLED AIR CONDITIONERS AND AIR-SOURCE HEAT PUMPS SUBJECT TO EPACT
(STANDARDS EFFECTIVE JANUARY 1, 2010 DO NOT APPLY TO SINGLE PACKAGE VERTICAL AIR CONDITIONERS)

Appliance	*Cooling Capacity (Btu/hr)*	*System Type*	*Minimum Efficiency*		
			Effective June 15, 2008	*Effective January 1, 2010*	
				Air Conditioners	*Heat Pumps*
Air-cooled unitary air conditioners and heat pumps (cooling mode)	< 65,000 *	Split system	13.0 SEER		
	< 65,000 *	Single package	13.0 SEER		
	≥ 65,000 and < 135,000	All		11.2 EER[3] 11.0 EER[4]	11.0 EER[3] 10.8 EER[4]
	≥ 135,000 and < 240,000	All		11.0 EER[3] 10.8 EER[4]	10.6 EER[3] 10.4 EER[4]
	≥ 240,000 and < 760,000	All		10.0 EER[3] 9.8 EER[4]	9.5 EER[3] 9.3 EER[4]
Air-cooled unitary air-conditioning heat pumps (heating mode)	< 65,000 *	Split system	7.7 HSPF		
	< 65,000 *	Single package	7.7 HSPF		
	≥ 65,000 and < 135,000	All		3.3 COP	
	≥ 135,000 and < 240,000	All		3.2 COP	
	≥ 240,000 and < 760,000	All		3.2 COP	

* Three phase models only.
[3] Applies to equipment that has electric resistance heat or no heating.
[4] Applies to equipment with all other heating-system types that are integrated into the unitary equipment.

TABLE C-4
STANDARDS FOR WATER-COOLED AIR CONDITIONERS, EVAPORATIVELY COOLED AIR CONDITIONERS, AND WATER-SOURCE HEAT PUMPS

Appliance	*Cooling Capacity (Btu per hour)*	*Minimum Efficiency*							
		Effective Prior to October 29, 2012		*Effective January 10, 2011*		*Effective †October 29, 2012 or ††October 29, 2013*		*Effective *June 1, 2013 or **June 1, 2014*	
		Minimum EER	*COP*	*Minimum EER*	*COP*	*Minimum EER*	*COP*	*Minimum EER*	*COP*
Water-cooled air conditioners and evaporatively cooled air	< 17,000	12.1	—						
Water-source heat pumps	< 17,000	11.2	4.2						
Water-source VRF multi-split heat pumps	< 17,000	—	4.2			12.0[1]†	4.2		
Water-cooled air conditioners and evaporatively cooled air	≥17,000 and < 65,000	12.1	—						
Water-source heat pumps, including VRF	≥17,000 and < 65,000	12.0	4.2						
Water-cooled air conditioners and evaporatively cooled air	≥65,000 and < 135,000	11.5[1]	–					12.1[1]*	—
Water-source heat pumps, including VRF	≥65,000 and < 135,000	12.0	4.2					11.9*	4.2
Water-cooled air conditioners	≥135,000 and < 240,000	11.0	—					12.5[1]**	—
Evaporatively cooled air conditioners	≥135,000 and < 240,000	11.0	—					12.0[1]**	—
Water-source heat pumps	≥135,000 and < 240,000	11.0	2.9					12.3**	2.9
Water-source VRF multi-split heat pumps	≥135,000 and < 760,000					10.0[1]††	3.9††		
Water-cooled air conditioners	≥240,000 and < 760,000	11.0[1]	–	11.0[1]	—			12.4[1]**	—
Evaporatively cooled air conditioners	≥240,000 and < 760,000	11.0[1]	–	11.0[1]	—			11.9[1]**	—
Water-source heat pumps	≥240,000 and < 760,000	11.0[1]	–	11.0[1]	—			12.2**	—

[1] Deduct 0.2 from the required EER for units with heating sections other than electric resistance heat. For VRF multi-split heat pumps this applies to units with heat recovery.

TABLE C-5
STANDARDS FOR SINGLE PACKAGE VERTICAL AIR CONDITIONERS AND SINGLE PACKAGE VERTICAL HEAT PUMPS MANUFACTURED ON OR AFTER JANUARY 1, 2010

Appliance	*Cooling Capacity (BTU/hr)*	*System Type*	*Minimum Efficiency*	
			Cooling Mode	*Heating Mode*
Single package vertical air conditioners	< 65,000	Single-phase	9.0 EER	N/A
	< 65,000	3-phase	9.0 EER	N/A
	≥ 65,000 and < 135,000	All	8.9 EER	N/A
	≥ 135,000 and < 240,000	All	8.6 EER	N/A
Single package vertical heat pumps	< 65,000	Single-phase	9.0 EER	3.0 COP
	< 65,000	3-phase	9.0 EER	3.0 COP
	≥ 65,000 and < 135,000	All	8.9 EER	3.0 COP
	≥ 135,000 and < 240,000	All	8.6 EER	2.9 COP

TABLE D-2
STANDARDS FOR DEHUMIDIFIERS

Product capacity (pint/day)	*Minimum energy factor (liters/kWh)*	
	Effective October 1, 2007	*Effective October 1, 2012*
25.00 or less	1.00	1.35
25.01 – 35.00	1.20	1.35
35.01 – 45.00	1.30	1.50
45.01 – 54.00	1.30	1.60
54.01 – 74.99	1.50	1.70
75.00 or more	2.25	2.50

TABLE E-2
STANDARDS FOR GAS WALL FURNACES, FLOOR FURNACES, AND ROOM HEATERS

Appliance	*Design Type*	*Capacity (Btu per hour)*	*Minimum AFUE (%)*	
			Effective Before April 16, 2013	*Effective On or After April 16, 2013*
Wall furnace	Fan	≤ 42,000	73	75
Wall furnace	Fan	> 42,000	74	76
Wall furnace	Gravity	≤10,000	59	65
Wall furnace	Gravity	> 10,000 and ≤ 12,000	60	
Wall furnace	Gravity	> 12,000 and ≤ 15,000	61	
Wall furnace	Gravity	> 15,000 and ≤ 19,000	62	
Wall furnace	Gravity	> 19,000 and ≤ 27,000	63	
Wall furnace	Gravity	> 27,000 and ≤ 46,000	64	66
Wall furnace	Gravity	> 46,000	65	67
Floor furnace	All	≤ 37,000	56	57
Floor furnace	All	> 37,000	57	58
Room heater	All	≤ 18,000	57	61
Room heater	All	> 18,000 and ≤ 20,000	58	
Room heater	All	> 20,000 and ≤ 27,000	63	66
Room heater	All	> 27,000 and ≤ 46,000	64	67
Room heater	All	> 46,000	65	68

TABLE E-3
STANDARDS FOR GAS- AND OIL-FIRED CENTRAL BOILERS < 300,000 BTU/HR INPUT AND ELECTRIC RESIDENTIAL BOILERS

Appliance	*Minimum AFUE (%)*	
	Effective January 1, 1992	
	75	*Effective September 1, 2012*
Gas steam boilers with single phase electrical supply	80	80 [1]
Gas hot water boilers with single phase electrical supply	—	82 [1,2]
Oil steam boilers with single phase electrical supply	—	82
Oil hot water boilers with single phase electrical supply	—	84 [2]
Electric steam residential boilers	—	NONE
Electric hot water residential boilers	80	NONE [2]
All other boilers with single phase electrical supply	—	—

[1] No constant burning pilot light design standard effective September 1, 2012.
[2] Automatic means for adjusting temperature design standard effective September 1, 2012. (Boilers equipped with tankless domestic water heating coils do not need to comply with this requirement.)

TABLE E-5
STANDARDS FOR GAS- AND OIL-FIRED CENTRAL FURNACES

Appliance	*Rated Input (Btu/hr)*	*Minimum Thermal Efficiency*
Gas central furnaces	≥ 225,000	80
Oil central furnaces	≥ 225,000	81

TABLE F-2
STANDARDS FOR LARGE WATER HEATERS EFFECTIVE OCTOBER 29, 2003

Appliance	*Input to Volume Ratio*	*Size (Volume)*	*Minimum Thermal Efficiency (%)*	*Maximum Standby Loss*[1,2]
Gas storage water heaters	< 4,000 Btu/hr/gal	any	80	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Gas instantaneous water heaters	≥ 4,000 Btu/hr/gal	< 10 gal	80	–
		≥ 10 gal	80	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Gas hot water supply boilers	≥ 4,000 Btu/hr/gal	< 10 gal	80	–
		≥ 10 gal	80	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Oil storage water heaters	< 4,000 Btu/hr/gal	any	78	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Oil instantaneous water heaters	≥ 4,000 Btu/hr/gal	< 10 gal	80	–
		≥ 10 gal	78	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Oil hot water supply boilers	≥ 4,000 Btu/hr/gal	< 10 gal	80	–
		≥ 10 gal	78	$Q/800 + 110(V_r)^{1/2}$ Btu/hr
Electric storage water heaters	< 4,000 Btu/hr/gal	Any	–	$0.3 + 27/V_m$ %/hr

[1] Standby loss is based on a 70° F temperature difference between stored water and ambient requirements. In the standby loss equations, V_r is the rated volume in gallons, V_m is the measured volume in gallons, and Q is the nameplate input rate in Btu/hr.

[2] Water heaters and hot water supply boilers having more than 140 gallons of storage capacity are not required to meet the standby loss requirement if the tank surface is thermally insulated to R-12.5, if a standing pilot light is not installed, and for gas- or oil-fired storage water heaters, there is a flue damper or fan-assisted combustion.

TABLE F-3
STANDARDS FOR SMALL FEDERALLY REGULATED WATER HEATERS

Appliance	*Rated Storage Volume (gallons)*	*Minimum Energy Factor*	
		Effective January 20, 2004	*Effective April 16, 2015*
Gas-fired storage-type water heaters	≤ 55	0.67 – (.0019 x V)	0.675−(0.0015 × V)
	> 55		0.8012−(0.00078 × V)
Oil-fired water heaters (storage and instantaneous)	Any	0.59 – (.0019 x V)	0.68 – (.0019 x V)
Electric storage water heaters (excluding tabletop water heaters)	≤ 55	0.97 – (.00132 x V)	0.960−(0.0003 × V)
	> 55		2.057−(0.00113 × V)
Electric tabletop water heaters	Any	0.93 – (.00132 x V)	0.93 – (.00132 x V)
Gas-fired instantaneous water heaters	Any	0.62 – (.0019 x V)	0.82 – (.0019 x V)
Electric instantaneous water heaters (excluding tabletop water heaters)	Any	0.93 – (.00132 x V)	0.93 – (.00132 x V)
Heat pump water heaters	Any	0.97 – (.00132 x V)	0.97 – (.00132 x V)
V = Rated storage volume in gallons.			

TABLE H-1
STANDARDS FOR PLUMBING FITTINGS

Appliance	*Maximum Flow Rate*
Showerheads	2.5 gpm at 80 psi
Lavatory faucets	2.2 gpm at 60 psi
Kitchen faucets	2.2 gpm at 60 psi
Replacement aerators	2.2 gpm at 60 psi
Wash fountains	$2.2 \times \frac{\text{rim space (inches)}}{20}$ gpm at 60 psi
Metering faucets	0.25 gallons/cycle[1,2]
Metering faucets for wash fountains	$0.25 \times \frac{\text{rim space (inches)}}{20}$ gpm at 60 psi[1,2]

1 **Sprayheads with independently controlled orifices and metered controls.** The maximum flow rate of each orifice that delivers a pre-set volume of water before gradually shutting itself off shall not exceed the maximum flow rate for a metering faucet.

2 **Sprayheads with collectively controlled orifices and metered controls.** The maximum flow rate of a sprayhead that delivers a pre-set volume of water before gradually shutting itself off shall be the product of (a) the maximum flow rate for a metering faucet and (b) the number of component lavatories (rim space of the lavatory in inches (millimeters) divided by 20 inches (508 millimeters)).

TABLE J-1
STANDARDS FOR FLUORESCENT LAMP BALLASTS AND REPLACEMENT FLUORESCENT LAMP BALLASTS

Application for Operation of	*Ballast Input Voltage*	*Total Nominal Lamp Watts*	*Minimum Ballast Efficacy Factor*	
one F40T12 lamp	120 or 277	40	2.29[1]	1.805[2]
two F40T12 lamps	120	80	1.17[1]	1.060[2]
	277	80	1.17[1]	1.050[2]
two F96T12 lamps	120 or 277	150	0.63[1]	0.570[2]
two F96T12HO lamps	120 or 277	220	0.39[1]	0.390[2]

[1] For fluorescent lamp ballasts manufactured on or after April 1, 2005; sold by the manufacturer on or after July 1, 2005; or incorporated into a luminaire by a luminaire manufacturer on or after April 1, 2006.
[2] For fluorescent lamp ballasts designed, marked, and shipped as replacement ballasts.

TABLE J-2
STANDARDS FOR FLUORESCENT LAMP BALLASTS[1]

Application for Operation of	*Ballast Input Voltage*	*Total Nominal Lamp Watts*	*Minimum Ballast Efficacy Factor*
one F34T12 lamp	120 or 277	34	2.61
two F34T12 lamps	120 or 277	68	1.35
two F96T12/ES lamps	120 or 277	120	0.77
two F96T12HO/ES lamps	120 or 277	190	0.42

[1] For fluorescent lamp ballasts manufactured on or after July 1, 2009; sold by the manufacturer on or after October 1, 2009; or fluorescent lamp ballasts incorporated into a luminaire by a luminaire manufacturer on or after July 1, 2010.

TABLE K-1
STANDARDS FOR FEDERALLY REGULATED GENERAL SERVICE FLUORESCENT LAMPS MANUFACTURED BEFORE JULY 15, 2012

Appliance	*Nominal Lamp Wattage*	*Minimum Color Rendering Index (CRI)*	*Minimum Average Lamp Efficacy (LPW)*
4-foot medium bi-pin lamps	> 35	69	75.0
	≤ 35	45	75.0
2-foot U-shaped lamps	> 35	69	68.0
	≤ 35	45	64.0
8-foot slimline lamps	> 65	69	80.0
	≤ 65	45	80.0
8-foot high output lamps	> 100	69	80.0
	≤ 100	45	80.0

TABLE K-2
STANDARDS FOR FEDERALLY REGULATED GENERAL SERVICE FLUORESCENT LAMPS MANUFACTURED ON OR AFTER JULY 15, 2012

Appliance	*Correlated Color Temperature*	*Minimum Average Lamp Efficacy (LPW)*
4-foot medium bipin lamps	≤ 4,500K	89
	> 4,500K and ≤ 7,000K	88
2-foot U-shaped lamps	≤ 4,500K	84
	> 4,500K and ≤ 7,000K	81
8-foot slimline lamps	≤ 4,500K	97
	> 4,500K and ≤ 7,000K	93
8-foot high output lamps	≤ 4,500K	92
	> 4,500K and ≤ 7,000K	88
4-foot miniature bipin standard output	≤ 4,500K	86
	> 4,500K and ≤ 7,000K	81
4-foot miniature bipin high output	≤ 4,500K	76
	> 4,500K and ≤ 7,000K	72

TABLE K-3
STANDARDS FOR FEDERALLY REGULATED INCANDESCENT REFLECTOR LAMPS MANUFACTURED BEFORE JULY 15, 2012

Nominal Lamp Wattage	*Minimum Average Lamp Efficacy (LPW)*
40-50	10.5
51-66	11.0
67-85	12.5
86-115	14.0
116-155	14.5
156-205	15.0

TABLE K-4
STANDARDS FOR FEDERALLY REGULATED INCANDESCENT REFLECTOR LAMPS MANUFACTURED ON OR AFTER JULY 15, 2012

Lamp Spectrum	*Lamp Diameter (inches)*	*Rated Voltage*	*Minimum Average Lamp Efficacy (LPW)*[1]
Standard Spectrum	> 2.5	≥ 125	$6.8 \times P^{0.27}$
		< 125	$5.9 \times P^{0.27}$
	≤ 2.5	≥ 125	$5.7 \times P^{0.27}$
		< 125	$5.0 \times P^{0.27}$
Modified Spectrum	> 2.5	≥ 125	$5.8 \times P^{0.27}$
		< 125	$5.0 \times P^{0.27}$
	≤ 2.5	≥ 125	$4.9 \times P^{0.27}$
		< 125	$4.2 \times P^{0.27}$

[1]P = Rated Lamp Wattage, in Watts

TABLE K-5
STANDARDS FOR MEDIUM BASE COMPACT FLUORESCENT LAMPS

Factor	*Requirements*
Lamp Power (Watts) and Configuration[1]	*Minimum Efficacy: lumens/watt (Based upon initial lumen data)*[2]
Bare Lamp: Lamp Power < 15 Lamp Power ≥ 15	 45.0 60.0
Covered Lamp (no reflector) Lamp Power < 15 15 ≥ Lamp Power < 19 19 ≥ Lamp Power < 25 Lamp Power ≥ 25	 40.0 48.0 50.0 55.0
1,000-hour Lumen Maintenance	The average of at least 5 lamps must be a minimum 90% of initial (100-hour) lumen output @ 1,000 hours of rated life.
Lumen Maintenance	80% of initial (100-hour) rating at 40 percent of rated life (per ANSI C78.5 Clause 4.10).
Rapid Cycle Stress Test	Per ANSI C78.5 and IESNA LM-65 (Clauses 2, 3, 5, and 6) *Exception:* Cycle times must be 5 minutes on, 5 minutes off. Lamp will be cycled once for every two hours of rated life. At least 5 lamps *must meet or exceed* the minimum number of cycles.
Average Rated Lamp Life	≥ 6,000 hours as declared by the manufacturer on the packaging. 80% of rated life, statistical methods may be used to confirm lifetime claims based on sampling performance.

[1] Take performance and electrical requirements at the end of the 100-hour aging period according to ANSI Standard C78.5. The lamp efficacy shall be the average of the lesser of the lumens per watt measured in the base up and/or other specified positions. Use wattages placed on packaging to select proper specification efficacy in this table, not measured wattage. Labeled wattages are for reference only.

[2] Efficacies are based on measured values for lumens and wattages from pertinent test data. Wattages and lumens placed on packages may not be used in calculation and are not governed by this specification. For multi-level or dimmable systems, measurements shall be at the highest setting. Acceptable measurement error is ±3%.

TABLE K-6
STANDARDS FOR FEDERALLY REGULATED GENERAL SERVICE INCANDESCENT LAMPS

Rated Lumen Ranges	*Maximum Rate Wattage*	*Minimum Rate Lifetime*	*Effective Date*
1490-2600	72	1,000 hours	January 1, 2012
1050 – 1489	53	1,000 hours	January 1, 2013
750 – 1049	43	1,000 hours	January 1, 2014
310 – 749	29	1,000 hours	January 1, 2014

TABLE K-7
STANDARDS FOR FEDERALLY REGULATED MODIFIED SPECTRUM GENERAL SERVICE INCANDESCENT LAMPS

Rated Lumen Ranges	*Maximum Rate Wattage*	*Minimum Rate Lifetime*	*Effective Date*
1118-1950	72	1,000 hours	January 1, 2012
788-1117	53	1,000 hours	January 1, 2013
563-787	43	1,000 hours	January 1, 2014
232-562	29	1,000 hours	January 1, 2014

TABLE M-1
STANDARDS FOR TRAFFIC SIGNALS FOR VEHICLE AND PEDESTRIAN CONTROL

Appliance	*Maximum Wattage (at 74°C)*	*Nominal Wattage (at 25°C)*
Traffic Signal Module Type:		
12-inch; Red Ball	17	11
8-inch; Red Ball	13	8
12-inch; Red Arrow	12	9
12-inch; Green Ball	15	15
8-inch; Green Ball	12	12
12-inch; Green Arrow	11	11
Pedestrian Module Type:		
Combination Walking Man/Hand	16	13
Walking Man	12	9
Orange Hand	16	13

TABLE O
STANDARDS FOR DISHWASHERS

Appliance	*Effective January 1, 2010*		*Effective May 30, 2013*	
	Maximum Energy Use (kWh/year)	*Maximum Water Use (gallons/cycle)*	*Maximum Energy Use (kWh/year)*	*Maximum Water Use (gallons/cycle)*
Compact dishwashers	260	4.5	222	3.5
Standard dishwashers	355	6.5	307	5.0

TABLE P-1
STANDARDS FOR RESIDENTIAL CLOTHES WASHERS MANUFACTURED ON OR AFTER JANUARY 1, 2007 AND MANUFACTURED BEFORE MARCH 7, 2015

Appliance	*Minimum Modified Energy Factor Effective January 1, 2007*	*Maximum Water Factor Effective January 1, 2011*
Top-loading compact clothes washers	0.65	--
Top-loading standard clothes washers	1.26	9.5
Top-loading, semi-automatic	N/A[1]	--
Front-loading clothes washers	1.26	9.5
Suds-saving	N/A[1]	--

[1] Must have an unheated rinse water option.

TABLE P-2
STANDARDS FOR RESIDENTIAL CLOTHES WASHERS MANUFACTURED ON OR AFTER MARCH 7, 2015

Appliance	*Minimum Integrated Modified Energy Factor*		*Maximum Integrated Water Factor*	
	March 7, 2015	*January 1, 2018*	*March 7, 2015*	*January 1, 2018*
Top-loading, Compact	0.86	1.15	14.4	12.0
Top-loading, Standard	1.29	1.57	8.4	6.5
Front-loading, Compact	1.13	1.13	8.3	8.3
Front-loading, Standard	1.84	1.84	4.7	4.7

TABLE P-3
STANDARDS FOR CLOTHES WASHERS

Appliance	Minimum Modified Energy Factor		Maximum Water Factor	
	Effective January 1, 2007	Effective January 8, 2013	Effective January 1, 2007	Effective January 8, 2013
Top-loading clothes washers	1.26	1.60	9.5	8.5
Front-loading clothes washers	1.26	2.00	9.5	5.5

TABLE Q-1
STANDARDS FOR CLOTHES DRYERS MANUFACTURED ON OR AFTER MAY 14, 1994
AND BEFORE JANUARY 1, 2015

Appliance	Minimum Energy Factor (lbs/kWh)
Electric, standard clothes dryers	3.01
Electric, compact, 120-volt clothes dryers	3.13
Electric, compact, 240-volt clothes dryers	2.90
Gas clothes dryers	2.67

TABLE S-1
STANDARDS FOR ELECTRIC MOTORS

Motor Horsepower/Standard Kilowatt Equivalent	Minimum Nominal Full-Load Efficiency					
	Open Motors			Enclosed Motors		
	6 poles	4 poles	2 poles	6 poles	4 poles	2 poles
1/0.75	80.0	82.5	. . .	80.0	82.5	75.5
1.5/1.1	84.0	84.0	82.5	85.5	84.0	82.5
2/1.5	85.5	84.0	84.0	86.5	84.0	84.0
3/2.2	86.5	86.5	84.0	87.5	87.5	85.5
5/3.7	87.5	87.5	85.5	87.5	87.5	87.5
7.5/5.5	88.5	88.5	87.5	89.5	89.5	88.5
10/7.5	90.2	89.5	88.5	89.5	89.5	89.5
15/11	90.2	91.0	89.5	90.2	91.0	90.2
20/15	91.0	91.0	90.2	90.2	91.0	90.2
25/18.5	91.7	91.7	91.0	91.7	92.4	91.0
30/22	92.4	92.4	91.0	91.7	92.4	91.0
40/30	93.0	93.0	91.7	93.0	93.0	91.7
50/37	93.0	93.0	92.4	93.0	93.0	92.4
60/45	93.6	93.6	93.0	93.6	93.6	93.0
75/55	93.6	94.1	93.0	93.6	94.1	93.0
100/75	94.1	94.1	93.0	94.1	94.5	93.6
125/90	94.1	94.5	93.6	94.1	94.5	94.5
150/110	94.5	95.0	93.6	95.0	95.0	94.5
200/150	94.5	95.0	94.5	95.0	95.0	95.0

TABLE T-3
STANDARDS FOR LOW-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMERS

Single phase			*Three phase*		
kVA	*Efficiency (%)*[1]		*kVA*	*Efficiency (%)*[1]	
	Effective January 1, 2007	*Effective January 1, 2016*		*Effective January 1, 2007*	*Effective January 1, 2016*
15	97.7	97.70	15	97.0	97.89
25	98.0	98.00	30	97.5	98.23
37.5	98.2	98.20	45	97.7	98.40
50	98.3	98.30	75	98.0	98.60
75	98.5	98.50	112.5	98.2	98.74
100	98.6	98.60	150	98.3	98.83
167	98.7	98.70	225	98.5	98.94
250	98.8	98.80	300	98.6	99.02
333	98.9	98.90	500	98.7	99.14
			750	98.8	99.23
			1000	98.9	99.28

[1] Efficiencies are determined at the following reference conditions:
(1) for no-load losses, at the temperature of 20°C, and (2) for load-losses, at the temperature of 75°C and 35 percent of nameplate load.
(Source: Table 4–2 of NEMA Standard TP–1–2002, "Guide for Determining Energy Efficiency for Distribution Transformers.")

TABLE T-4
STANDARDS FOR LIQUID-IMMERSED DISTRIBUTION TRANSFORMERS

Single phase			Three phase		
kVA	Efficiency (%)[1]		kVA	Efficiency (%)[1]	
	Effective January 1, 2007	*Effective January 1, 2016*		*Effective January 1, 2007*	*Effective January 1, 2016*
10	98.62	98.70	15	98.36	98.65
15	98.76	98.82	30	98.62	98.83
25	98.91	98.95	45	98.76	98.92
37.5	99.01	99.05	75	98.91	99.03
50	99.08	99.11	112.5	99.01	99.11
75	99.17	99.19	150	99.08	99.16
100	99.23	99.25	225	99.17	99.23
167	99.25	99.33	300	99.23	99.27
250	99.32	99.39	500	99.25	99.35
333	99.36	99.43	750	99.32	99.40
500	99.42	99.49	1000	99.36	99.43
667	99.46	99.52	1500	99.42	99.48
833	99.49	99.55	2000	99.46	99.51
			2500	99.49	99.53

[1] Note: All efficiency values are at 50 percent of nameplate-rated load, determined when tested according to the test procedure in Section 1604(t).

TABLE T-5
STANDARDS FOR MEDIUM-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMERS MANUFACTURED ON OR AFTER JANUARY 1, 2010 AND BEFORE JANUARY 1, 2016

Single phase				*Three phase*			
BIL kVA	***20-45 kV Efficiency[1] (%)***	***46-95 kV efficiency[1] (%)***	***≥ 96 kV efficiency[1] (%)***	***BIL kVA***	***20-45 kV Efficiency[1] (%)***	***46-95 kV efficiency[1] (%)***	***≥ 96 kV efficiency[1] (%)***
15	98.10	97.86		15	97.50	97.18	
25	98.33	98.12		30	97.90	97.63	
37.5	98.49	98.30		45	98.10	97.86	
50	98.60	98.42		75	98.33	98.12	
75	98.73	98.57	98.53	112.5	98.49	98.30	
100	98.82	98.67	98.63	150	98.60	98.42	
167	98.96	98.83	98.80	225	98.73	98.57	98.53
250	99.07	98.95	98.91	300	98.82	98.67	98.63
333	99.14	99.03	98.99	500	98.96	98.83	98.80
500	99.22	99.12	99.09	750	99.07	98.95	98.91
667	99.27	99.18	99.15	1000	99.14	99.03	98.99
833	99.31	99.23	99.20	1500	99.22	99.12	99.09
				2000	99.27	99.18	99.15
				2500	99.31	99.23	99.20

[1] All efficiency values are at 50 percent of nameplate rated load, determined when tested according to the test procedure in Section 1604(t).

TABLE T-6
STANDARDS FOR MEDIUM-VOLTAGE DRY-TYPE DISTRIBUTION TRANSFORMERS
MANUFACTURED ON OR AFTER JANUARY 1, 2016

Single phase				*Three phase*			
BIL kVA	*20-45 kV Efficiency[1] (%)*	*46-95 kV efficiency[1] (%)*	*≥ 96 kV efficiency[1] (%)*	*BIL kVA*	*20-45 kV Efficiency[1] (%)*	*46-95 kV efficiency[1] (%)*	*≥ 96 kV efficiency[1] (%)*
15	98.10	97.86		15	97.50	97.18	
25	98.33	98.12		30	97.90	97.63	
37.5	98.49	98.30		45	98.10	97.86	
50	98.60	98.42		75	98.33	98.13	
75	98.73	98.57	98.53	112.5	98.52	98.36	
100	98.82	98.67	98.63	150	98.65	98.51	
167	98.96	98.83	98.80	225	98.82	98.69	98.57
250	99.07	98.95	98.91	300	98.93	98.81	98.69
333	99.14	99.03	98.99	500	99.09	98.99	98.89
500	99.22	99.12	99.09	750	99.21	99.12	99.02
667	99.27	99.18	99.15	1000	99.28	99.20	99.11
833	99.31	99.23	99.20	1500	99.37	99.30	99.21
				2000	99.43	99.36	99.28
				2500	99.47	99.41	99.33

[1] All efficiency values are at 50 percent of nameplate rated load, determined when tested according to the test procedure in Section 1604(t).

TABLE U-1
STANDARDS FOR CLASS A EXTERNAL POWER SUPPLIES THAT ARE FEDERALLY REGULATED

Nameplate Output	*Minimum Efficiency in Active Mode (Decimal equivalent of a Percentage)*
< 1 watt	0.5 * Nameplate Output
≥ 1 and ≤ 51 watts	0.09*Ln(Nameplate Output) + 0.5
> 51 watts	0.85
	Maximum Energy Consumption in No-Load Mode
≤ 250 watts	0.5 watts
Where Ln (Nameplate Output) = Natural Logarithm of the nameplate output expressed in watts.	

TABLE A-9
STANDARDS FOR WINE CHILLERS

Appliance	*Maximum Annual Energy Consumption (kWh)*
Wine chillers with manual defrost	13.7V + 267
Wine chillers with automatic defrost	17.4V + 344
V = volume in ft³.	

TABLE A-10
STANDARDS FOR FREEZERS THAT ARE CONSUMER PRODUCTS

Appliance	*Maximum Annual Energy Consumption (kWh)*
Upright Freezers with manual defrost	7.55AV + 258.3
Upright Freezers with automatic defrost	12.43AV + 326.1
Chest Freezers	9.88AV + 143.7
AV = adjusted total volume, expressed in ft³, which is 1.73 x freezer volume (ft³).	

TABLE A-12
STANDARDS FOR REFRIGERATED CANNED AND BOTTLED BEVERAGE VENDING MACHINES

Appliance	*Doors*	*Maximum Daily Energy Consumption (kWh)*	
		January 1, 2006	*January 1, 2007*
Refrigerated canned and bottled beverage vending machines when tested at 90° F ambient temperature except multi-package units	Not applicable	0.55(8.66 + (0.009 × C))	0.55(8.66 + (0.009 × C))
Refrigerated multi-package canned and bottled beverage vending machines when tested at 75° F ambient temperature	Not applicable	0.55(8.66 + (0.009 × C))	0.55(8.66 + (0.009 × C))
V = total volume (ft³) AV = Adjusted Volume = [1.63 x freezer volume (ft³)] + refrigerator volume (ft³) C=Rated capacity (number of 12-ounce cans)			

TABLE C-7
STANDARDS FOR GROUND WATER-SOURCE AND GROUND-SOURCE HEAT PUMPS

Appliance	*Rating Condition*	*Minimum Standard*
Ground water-source heat pumps (cooling)	59°F entering water temperature	16.2 EER
Ground water-source heat pumps (heating)	50°F entering water temperature	3.6 COP
Ground-source heat pumps (cooling)	77°F entering brine temperature	13.4 EER
Ground-source heat pumps (heating)	32°F entering brine temperature	3.1 COP

TABLE C-8
STANDARDS FOR EVAPORATIVELY COOLED COMPUTER ROOM AIR CONDITIONERS

Appliance	*Cooling Capacity (Btu/hr)*	*Minimum EER (Btu/watt-hour)*	
		Air-Cooled Effective January 1, 2006	*Water-Cooled, Glycol-Cooled, and Evaporatively-Cooled Effective October 29, 2006*
Computer room air conditioners	< 65,000	11.0	11.1
	≥ 65,000 and < 135,000	10.4	10.5
	≥ 135,000 and < 240,000	10.2	10.0

TABLE E-7
STANDARDS FOR BOILERS

Appliance	*Output (Btu/hr)*	*Standards*		
		Minimum AFUE %	*Minimum Combustion Efficiency % **	*Maximum Standby Loss (watts)*
Gas steam boilers with 3-phase electrical supply	< 300,000	75	—	—
All other boilers with 3-phase electrical supply	< 300,000	80	—	—
Natural gas, non-packaged boilers	≥ 300,000	—	80	147
LPG Non-packaged boilers	≥ 300,000	—	80	352
Oil, non-packaged boilers	≥ 300,000	—	83	—

*At both maximum and minimum rated capacity, as provided and allowed by the controls.

TABLE E-8
STANDARDS FOR FURNACES

Appliance	*Application*	*Minimum Efficiency %*
Central furnaces with 3-phase electrical supply < 225,000 Btu/hour	Mobile Home	75 AFUE
	All others	78 AFUE or 80 Thermal Efficiency (at manufacturer's option)

TABLE E-9
STANDARDS FOR DUCT FURNACES

Appliance	*Fuel*	*Standards*		
		Minimum Thermal Efficiency %[1]		*Maximum Energy Consumption during standby (watts)*
		At maximum rated capacity	*At minimum rated capacity*	
Duct furnaces	Natural gas	80	75	10
Duct furnaces	LPG[2]	80	75	147

[1] As provided and allowed by the controls.
[2] Designed expressly for use with LPG.

TABLE F-4
STANDARDS FOR SMALL WATER HEATERS THAT ARE NOT FEDERALLY REGULATED CONSUMER PRODUCTS

Appliance	*Energy Source*	*Input Rating*	*Rated Storage Volume (gallons)*	*Minimum Energy Factor*[1]
Storage water heaters	Gas	≤ 75,000 Btu/hr	< 20	0.62 – (.0019 x V)
Storage water heaters	Gas	≤ 75,000 Btu/hr	> 100	0.62 – (.0019 x V)
Storage water heaters	Oil	≤ 105,000 Btu/hr	> 50	0.59 – (.0019 x V)
Storage water heaters	Electricity	≤ 12 kW	> 120	0.93 – (.00132 x V)
Instantaneous Water Heaters	Gas	≤ 50,000 Btu/hr	Any	0.62 – (.0019 x V)
Instantaneous Water Heaters	Gas	≤ 200,000 Btu/hr	≥ 2	0.62 – (.0019 x V)
Instantaneous Water Heaters	Oil	≤ 210,000 Btu/hr	Any	0.59 – (.0019 x V)
Instantaneous Water Heaters	Electricity	≤ 12 kW	Any	0.93 – (.00132 x V)

[1] Volume (V) = rated storage volume in gallons.

TABLE H-2
STANDARDS FOR TUB SPOUT DIVERTERS

Appliance	*Testing Conditions*	*Maximum Leakage Rate*
Tub spout diverters	When new	0.01 gpm
	After 15,000 cycles of diverting	0.05 gpm

TABLE K-9
STANDARDS FOR STATE-REGULATED INCANDESCENT REFLECTOR LAMPS

Rated Lamp Wattage	**Minimum Average Lamp Efficacy (LPW)**
40-50	10.5
51-66	11.0
67-85	12.5
86-115	14.0
116-155	14.5
156-205	15.0

TABLE K-10
STANDARDS FOR STATE-REGULATED GENERAL SERVICE INCANDESCENT LAMPS -TIER I

Rated Lumen Ranges	*Maximum Rated Wattage*	*Minimum Rated Lifetime*	*Effective Date*
1490-2600 Lumens	72 watts	1,000 Hours	Jan 1, 2011
1050-1489 Lumens	53 watts	1,000 Hours	Jan 1, 2012
750-1049 Lumens	43 watts	1,000 Hours	Jan 1, 2013
310-749 Lumens	29 watts	1,000 Hours	Jan 1, 2013

TABLE K-11
STANDARDS FOR STATE-REGULATED GENERAL SERVICE LAMPS -TIER II

Lumen Ranges	*Minimum Lamp Efficacy*	*Minimum Rated Lifetime*	*Effective Date*
All	45 lumens per watt	1,000 Hours	Jan 1, 2018

TABLE K-12
STANDARDS FOR STATE-REGULATED MODIFIED SPECTRUM GENERAL SERVICE INCANDESCENT LAMPS -TIER I

Rated Lumen Ranges	*Maximum Rated Wattage*	*Minimum Rated Lifetime*	*Effective Date*
1118-1950 Lumens	72 watts	1,000 Hours	Jan 1, 2011
788-1117 Lumens	53 watts	1,000 Hours	Jan 1, 2012
563-787 Lumens	43 watts	1,000 Hours	Jan 1, 2013
232-562 Lumens	29 watts	1,000 Hours	Jan 1, 2013

TABLE L-1
ULTRASOUND MAXIMUM DECIBEL VALUES

Mid-frequency of Sound Pressure Third-Octave Band (in kHz)	*Maximum db Level within third-Octave Band (in dB reference 20 micropascals)*
Less than 20	80
20 or more to less than 25	105
25 or more to less than 31.5	110
31.5 or more	115

TABLE M-2
STANDARDS FOR TRAFFIC SIGNAL MODULES FOR PEDESTRIAN CONTROL SOLD OR OFFERED FOR SALE IN CALIFORNIA

Type	*at 25°C (77°F)*	*At 74°C (165.2°F)*
Hand or 'Don't Walk' sign or countdown.	10 watts	12 watts
Walking Person or 'Walk' sign	9 watts	12 watts

TABLE N-1
STANDARDS FOR UNDER-CABINET LUMINAIRES

Lamp Length (inches)	*Minimum Ballast Efficacy Factor (BEF) for one lamp*	*Minimum Ballast Efficacy Factor (BEF) for two lamps*
≤29	4.70	2.80
>29 and ≤35	3.95	2.30
>35 and ≤41	3.40	1.90
>41 and ≤47	3.05	1.65
>47	2.80	1.45

TABLE N-2
MINIMUM REQUIREMENTS FOR PORTABLE LED LUMINAIRES, AND PORTABLE LUMINAIRES WITH LED LIGHT ENGINES WITH INTEGRAL HEAT SINK

Criteria	*Requirement*
Light Output	≥ 200 lumens (initial)
Minimum LED Luminaire Efficacy	29 lumens/W
Minimum LED Light Engine Efficacy	40 lumens/W
Color Correlated Temperature (CCT)	2700 K through 5000 K
Minimum Color Rendering Index (CRI)	75
Power Factor (for luminaires labeled or sold for residential use)	≥ 0.70

TABLE U-2
STANDARDS FOR STATE-REGULATED EXTERNAL POWER SUPPLIES EFFECTIVE JANUARY 1, 2007 FOR EXTERNAL POWER SUPPLIES USED WITH LAPTOP COMPUTERS, MOBILE PHONES, PRINTERS, PRINT SERVERS, CANNERS, PERSONAL DIGITAL ASSISTANTS (PDAS), AND DIGITAL CAMERAS. EFFECTIVE JULY 1, 2007 FOR EXTERNAL POWER SUPPLIES USED WITH WIRELINE TELEPHONES AND ALL OTHER APPLICATIONS.

Nameplate Output	*Minimum Efficiency in Active Mode*
0 to < 1 watt	0.49 * Nameplate Output
≥ 1 and ≤ 49 watts	0.09 * Ln(Nameplate Output) + 0.49
> 49 watts	0.84
	Maximum Energy Consumption in No-Load Mode
0 to <10 watts	0.5 watts
≥ 10 to ≤ 250 watts	0.75 watts
Where Ln (Nameplate Output) = Natural Logarithm of the nameplate output expressed in watts.	

TABLE U-3
STANDARDS FOR STATE-REGULATED EXTERNAL POWER SUPPLIES EFFECTIVE JULY 1, 2008

Nameplate Output	*Minimum Efficiency in Active Mode*
<1 watt	0.5 * Nameplate Output
≥ 1 and ≤ 51 watts	0.09*Ln(Nameplate Output) + 0.5
> 51 watts	0.85
	Maximum Energy Consumption in No-Load Mode
Any output	0.5 watts
Where Ln (Nameplate Output) = Natural Logarithm of the nameplate output expressed in watts.	

TABLE V-1
STANDARDS FOR CONSUMER AUDIO AND VIDEO EQUIPMENT

Appliance Type	*Effective Date*	*Maximum Power Usage (Watts)*
Compact Audio Products	January 1, 2007	2 W in Audio standby-passive mode for those without a permanently illuminated clock display 4 W in Audio standby-passive mode for those with a permanently illuminated clock display
Digital Versatile Disc Players and Digital Versatile Disc Recorders	January 1, 2006	3 W in Video standby-passive mode

TABLE V-2
STANDARDS FOR TELEVISIONS

Effective Date	*Screen Size (area A in square inches)*	*Maximum TV Standby-passive Mode Power Usage (watts)*	*Maximum On Mode Power Usage (P in Watts)*	*Minimum Power Factor for (P ≥ 100W)*
January 1, 2006	All	3 W	No standard	No standard
January 1, 2011*	A < 1400	1 W	P ≤ 0.20 x A + 32	0.9
January 1, 2013	A < 1400	1 W	P ≤ 0.12 x A + 25	0.9

TABLE W-1
STANDARDS FOR LARGE BATTERY CHARGER SYSTEMS

Performance Parameter		*Standard*
Charge Return Factor (CRF)	100 percent, 80 percent Depth of discharge	CRF≤ 1.10
	40 percent Depth of discharge	CRF ≤ 1.15
Power Conversion Efficiency		Greater than or equal to: 89 percent
Power Factor		Greater than or equal to: 0.90
Maintenance Mode Power (E_b = battery capacity of tested battery)		Less than or equal to: 10 + 0.0012E_b W
No Battery Mode Power		Less than or equal to: 10 W

TABLE W-2
STANDARDS FOR SMALL BATTERY CHARGER SYSTEMS

Performance Parameter	*Standard*
Maximum 24-hour charge and maintenance energy (Wh) (E_b = capacity of all batteries in ports and N = number of charger ports)	For E_b of 2.5 Wh or less: 16 × N
	For E_b greater than 2.5 Wh and less than or equal to 100 Wh: 12 x N +1.6E_b
	For E_b greater than 100 Wh and less than or equal to 1000 Wh: 22 x N+1.5E_b
	For E_b greater than 1000 Wh: 36.4 x N +1.486E_b
Maintenance Mode Power and No Battery Mode Power (W) (E_b = capacity of all batteries in ports and N = number of charger ports)	The sum of maintenance mode power and no battery mode power must be less than or equal to: 1x N+0.0021xE_b

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APPENDIX C: California Climate Zones

Start Document Here All energy calculations used for compliance with the Standards must use the climate zone applicable to a building project is determined based on its physical location as it relates to the determinations of climate regions found in the Commission publication California Climate Zone Descriptions, which contains detailed survey definitions of the 16 climate zones.

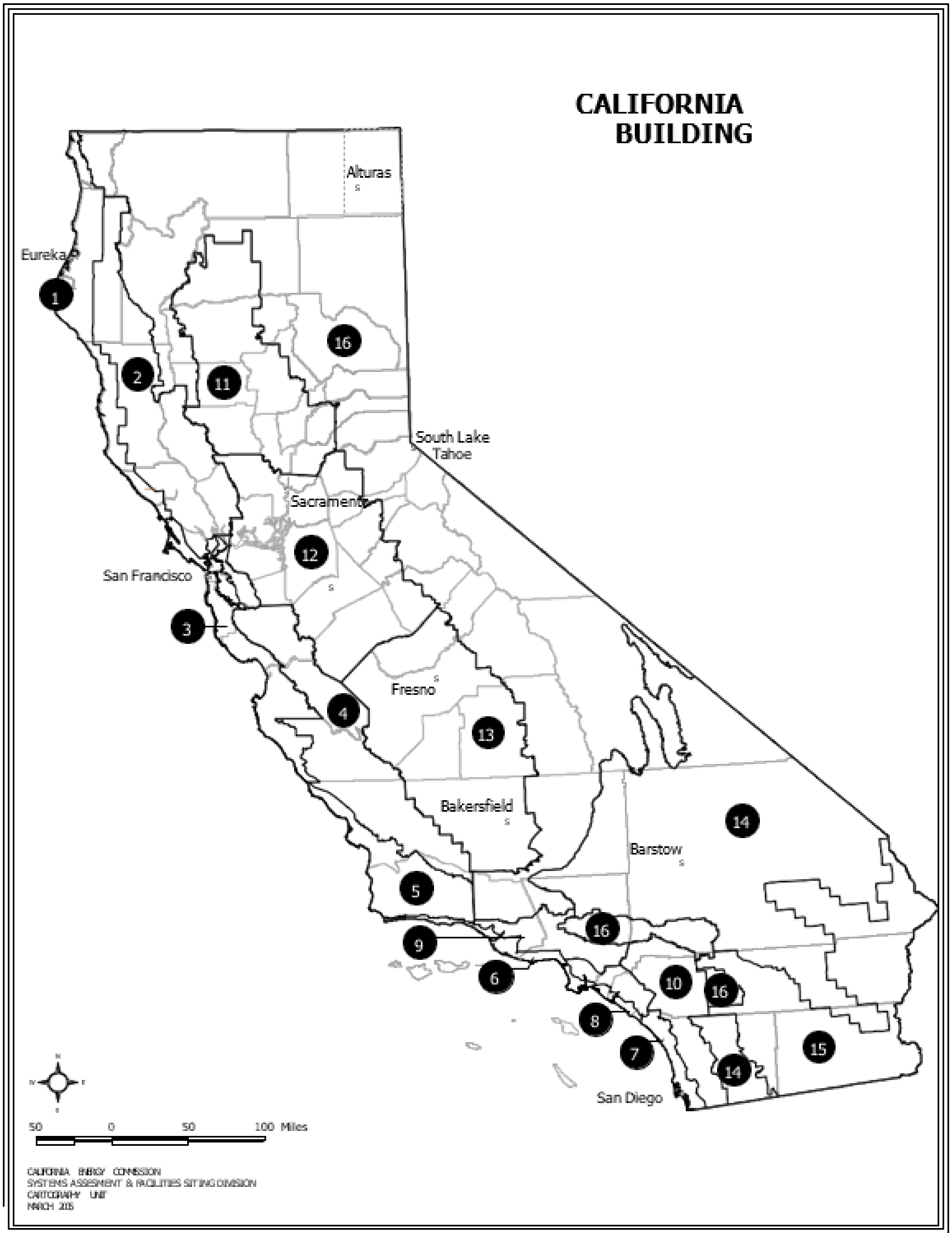
The list of climate zone areas by ZIP code is located on the CEC website here,

https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/climate-zone-tool-maps-and

CEC has also developed an interactive climate zone lookup tool that allow user to locate climate zone by address or ZIP code. The lookup tool is located here,

http://caenergy.maps.arcgis.com/apps/webappviewer/index.html?id=4831772c00eb4f729924167244bbca22

Figure C- 1 – California Climate Zones



Source: California Energy Commission

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Appendix D: Demand Responsive Controls

Please refer to Appendix D- - Demand Responsive Controls of the 2022 Nonresidential and Multifamily Compliance Manual.

This appendix to the residential compliance manual addresses the demand responsive (DR) control requirements in the 2022 Building Energy Efficiency Standards (Energy Code).

Demand response is an increasingly important function of buildings as distributed energy resources become more common and customers have access to time of use electricity rates and incentive programs designed to encourage demand side optimization. Demand response occurs on a range of timescales, from seconds to seasons, and represents any demand change in response to grid or economic needs. In addition to current time of use electricity rates, utilities in the future will likely connect electricity costs to high frequency fluctuations in both the supply and demand for electricity. Appropriate demand responsive controls allow building operators to maintain the quality of services a building provides and reduce the total cost of energy by automating a building's response to changes in electricity rates.

The following definitions from Section 100.1 are relevant to the DR control requirements:

- **Demand response** is short-term changes in electricity usage by end-use customers, from their normal consumption patterns. Demand response may be in response to:
    - Changes in the price of electricity; or
    - Participation in programs or services designed to modify electricity use.
        - In response to wholesale market prices.
        - When system reliability is jeopardized.
- **Demand response period** is a period of time during which electricity loads are modified in response to a demand response signal.
- **Demand response signal** is a signal that indicates a price or a request to modify electricity consumption for a limited time period.
- **Demand responsive control** is an automatic control that is capable of receiving and automatically responding to a demand response signal.

The DR control requirements ensure that the building is DR capable (i.e., capable of responding to a DR signal). The decision to employ demand response is up to the building owner or manager, in coordination with their utility company and/or a governing authority. A building that is capable of receiving and responding to a demand response signal is sufficient to meet the requirements of the Energy Standards. DR-capable is described as follows:

- **DR-capable:** A building is capable of DR when the building has loads that can be curtailed, DR controls are installed, and the controls have been programed/configured so the test control strategy that is defined in the building code can be deployed (note: the DR controls can be programmed with additional control strategies).

- **DR-enabled:** A building's DR is enabled when the connection between the entity that sends the DR Signal and the DR control in the building has been tested and communications have been allowed or "enabled".
- **DR-enrolled:** A building is enrolled when the building owner/occupant has enrolled in a DR program (note: this may include updating the settings or programming of the DR controls to better match the terms of the program).

The requirements for DR controls only apply if the controls are used to comply with the building standards (i.e., DR thermostats or a heat pump water heater). If DR control are installed voluntarily and do not contribute to compliance with minimum code requirements, they do not need to adhere to requirements in Title 24, Part 6.

For residential dwellings, DR controls are only required as a part of specific Exceptions to HVAC and Solar Ready requirements.

Communications Requirements for DR Controls

Reference: Section 110.12(a)1-5

There are two main communication requirements that apply to all DR controls:

- The control must, at minimum, be able to understand a signal sent using OpenADR; and
- The control must, at a minimum, be able to communicate with the virtual end node using a wired or wireless bi-directional communication pathway.

These are minimum requirements, meaning that the control can have (and use) additional communication features provided that the required features are included.

Communication With Entity That Initiates DR Signal

Reference: Section 110.12(a)1

DR controls must have the capability of communicating with the entity that initiates a DR signal by way of an OpenADR certified virtual end node (VEN).

The OpenADR is the primary open-standard protocol used in the California market. It implements a profile within the Organization of Structured Information Standards (OASIS) Energy Interoperation information and communication model that defines two types of communications entities – virtual top nodes (VTNs) and virtual end nodes (VENs). VTNs are information exchange servers typically operated by utilities or third-party providers and can dispatch events. VENs are the recipients of DR payloads and are typically the gateway or end-use devices installed at customer facilities throughout a dispatcher's territory. See OpenADR Alliance's website (http://www.openadr.org/) for more information about OpenADR certified VENs.

There are two ways to comply with the OpenADR certified VEN requirement:

Option A: Install an OpenADR 2.0a, 2.0b certified VEN, or a certified Baseline Profile OpenADR 3.0 VEN within the building as part of the DR control system (Section 110.12(a)1A)

If complying using Option A (Section 110.12(a)1A), the designer of the DR control system(s) must select a VEN that the OpenADR Alliance has certified as being compliant with the OpenADR 2.0a, 2.0b specification or Baseline Profile OpenADR 3.0. The OpenADR Alliance maintains a list of certified VENs (https://products.openadr.org/). If using Option A, the certified VEN must be installed inside the building at the time of inspection. The building can comply if the DR control system has a certified VEN that is incorporated into a networked system of devices such that the single VEN communicates control strategy information to multiple devices in the network (e.g., a gateway system), or if each device (e.g., thermostat) in the building is itself a certified VEN.

Option B: Install a DR control system that has been certified to the Energy Commission as being capable of communicating with an OpenADR 2.0b certified VEN or a Baseline Profile OpenADR 3.0 certified VEN (Section 110.12(a)1B)

If complying using Option B (Section 110.12(a)1B), the designer of the DR control system(s) must select a DR control system that the Energy Commission has approved for the certified list of DR control systems. The Energy Commission maintains a list of certified products and instructions on how manufacturers can certify products on their website at http://www.energy.ca.gov/title24/equipment_cert/. If using Option B, the manufacturer of a DR control system must submit documentation to the Energy Commission confirming that the DR control system is capable of communicating with an OpenADR 2.0b certified VEN or a Baseline Profile OpenADR3.0 certified VEN. Demand responsive controls must be programmed or configured so any test control strategy defined in building code can be deployed at the time of permitting.

Option B requires that the manufacturer of the DR control system certify to the Energy Commission that the control system is capable of communicating with an OpenADR 2.0b certified VEN or a Baseline Profile OpenADR3.0 certified VEN. This requirement does not mean that the DR control system must be connected to a 2.0b certified VEN or a Baseline Profile OpenADR3.0 certified VEN. When the DR control system is connected to a VEN, it can be connected to either a 2.0a or 2.0b certified VEN or a Baseline Profile OpenADR3.0 certified VEN.

The DR control system must comply with Option A or Option B, but the control system can also include features that allow the control system to use other communications protocols.

When specifying DR control systems, it is recommended that the controls designer check to see which DR programs are currently available in the area and specify controls that are both compliant with Title 24, Part 6, and eligible for the area’s DR programs.

Other Requirements for DR Controls

Perform Regular Functions When Not Responding to DR Events

Reference: Section 110.12(a)4

Controls that include demand response with other control functions must perform their regular control functions, as required by other parts of the building code, when the control is not performing DR-related functions. This includes when the controls are not responding to a DR event, when the DR functions are not enabled (see description of DR-enabled in the introduction to this chapter of the compliance manual) or when the DR controls are temporarily disabled or disconnected (e.g., due to a network outage).

For example, if the building owner/operator never enables the DR controls or enrolls in a DR program, the building control system(s) must comply with all other applicable controls requirements and continue to provide those control functions. Similarly, if the building owner/operator does enable the DR controls and is enrolled in a DR program, the building control system(s) must perform as required by the applicable building code requirements whenever the building is not participating in a DR event. The DR control functionality is an additional control feature on top of all of the other required building controls.

Certification Requirements for DR Thermostats

Reference: Section 110.12(a)5

Residential DR thermostats, also called Occupant Controlled Smart Thermostats (OCSTs), must comply with the technical specifications described in Joint Appendix 5 (JA5). According the requirement in JA5, manufacturers of DR thermostats must submit documentation to the Energy Commission to certify that the thermostat meets the code requirements. See the Energy Commission's website for a list of certified products and instructions on how manufacturers can certify products on their website at http://www.energy.ca.gov/title24/equipment_cert/.

DR Controls for HVAC Systems

HVAC Systems with DDC to the Zone Level

Reference: Section 110.12(b)

As specified in Section 120.2(j), the Energy Standards require certain buildings to have Direct Digital Control (DDC) to the zone level (See Chapter 4 Section 4.5.1.9 of the nonresidential compliance manual). When the building has DDC to the zone level, either to comply with the Energy Standards or if DDC was installed voluntarily, the HVAC system must also have a DR control system that complies with the requirements in Section 110.12(a) and (b).

At the time of inspection, the DR control system must be programmed so it automatically initiates the test control strategy described below. The DR control system must pass this test to comply with code, regardless of what control strategy the building operator intends to use. If a building owner/operator enables the DR controls and enrolls in a DR program (see description of these terms in the introduction to this chapter), they have the option of deploying alternate control strategies consistent with their program. The strategy described in the Energy Standards is simply a test to confirm the DR control system is installed correctly and can perform its function, while also being suitable for leaving in place after testing.

Test control strategy:

When the person performing the acceptance test manually simulates the condition where the HVAC control system receives a DR signal and a DR Period is beginning, the HVAC system must initiate the following response:

- When in cooling mode, increase the operating cooling temperature set points by 4°F or more in all non-critical zones and maintain the set points throughout the DR Period.
- When in heating mode, decrease the operating heating temperature set points by 4°F or more in all non-critical zones and maintain the set points throughout the DR Period.

- Maintain the temperature and ventilation set points in all critical zones throughout the DR Period.

When the person performing the acceptance test manually simulates a condition where the DR Period has concluded, the control system must restore the temperature set points in non-critical zones to the settings that were in place before the DR Period began.

In addition, the controls must be able to provide an adjustable rate of temperature change when the temperature is adjusted at the beginning and the end of the DR Period.

The control strategy calls for adjustments to temperature setpoints in non-critical zones while maintaining setpoints in critical zones. The Energy Standards define a critical zone as "a zone serving a process where reset of the zone temperature setpoint during a demand shed event might disrupt the process, including but not limited to computer rooms, data centers, telecom and private branch exchange (PBX) rooms, and laboratories." Non-critical zones are defined as "a zone that is not a critical zone."

(Note that the connection between the entity that initiates the DR signal and the control system within the building is not evaluated as part of the test.)

In addition to demonstrating compliance with the test condition, the DR controls for HVAC systems with DDC to the zone level must allow an authorized facilities operator to: 1) disable the DR controls, and 2) manually adjust heating and cooling setpoints from a centralized location on either the HVAC control system or the building's energy management control system.

An acceptance test is necessary to ensure that the system was programmed as required. See Nonresidential Appendix 7.5.10 and Chapter 13 of this compliance manual for more information on the acceptance test requirements.

HVAC Systems without DDC to the Zone Level

Reference: Section 120.2(b)4

In buildings that do not have DDC to the zone level, thermostatic controls for single zone air conditioners and heat pumps must be DR thermostats, also called Occupant Controlled Smart Thermostats (OCSTs). There are two exceptions to this requirement:

- Systems serving zones that must have constant temperatures to protect a process or product (e.g., a laser laboratory or a museum).
- The following HVAC systems:
    - Gravity gas wall heaters
    - Gravity floor heaters
    - Gravity room heaters
    - Non-central electric heaters
    - Fireplaces or decorative gas appliance
    - Wood stoves
    - Room air conditioners
    - Room heat pumps
    - Packaged terminal air conditioners

- Packaged terminal heat pumps

When OCSTs are required, they must comply with the technical specifications described in Joint Appendix 5 (JA5). According to the requirement in JA5, manufacturers of OCSTs must submit documentation to the Energy Commission to certify that the thermostat meets the code requirements. See the Energy Commission's website for a list of certified products and for instructions to manufacturers that wish to certify products, http://www.energy.ca.gov/title24/equipment_cert/.

DR Controls for Lighting Systems

Section 110.12(c)

Nonresidential indoor lighting systems subject to Section 130.1(b) with an installed lighting power of 4,000 watts or greater must be equipped with DR controls that comply with Section 110.12(a) and (c). There are two exceptions that impact the calculation of the 4,000 watt threshold and impact where DR controls must be installed. Specifically, spaces that fall into these two categories do not need to have DR lighting controls and do not need to be included in the calculation of the 4,000 watt threshold:

1. Lighting systems not subject to Section 130.1(b); and
2. Spaces where health or life safety statute, ordinance, or regulation does not permit lighting to be reduced.

At the time of inspection, the DR control system must be programmed to automatically initiate the test control strategy described below. The DR control must pass this test to comply with code regardless of what control strategy the building operator intends to use. If a building owner/operator enables the DR controls and enrolls in a DR program (see description of these terms in the introduction to this chapter), they have the option of deploying alternate control strategies consistent with their program. There is no acceptance test to verify such alternate control strategies. The strategy described in the Energy Standards is simply a test for confirming the DR control system is installed correctly and can perform its function, while also being suitable for leaving in place after testing.

Test control strategy:

When the acceptance test technician manually simulates the condition where the lighting control system receives a DR signal, the lighting system must automatically reduce lighting power so that the total installed lighting power of building or space, excluding lighting where health and safety statute, ordinance or regulation do not permit lighting to be reduced, is reduced by a minimum of 15 percent below the total installed lighting power. This means that lighting power for general lighting systems subject to Section 130.1(b) must be reduced by more than 15 percent to account for no reduction in the additional lighting systems, or a combination of reduction in the power of general lighting systems subject to Section 130.1(b) and additional lighting systems must be reduced to achieve at least a 15 percent reduction in total lighting power across these lighting systems. Lighting subject to Section 130.1(b) shall be reduced in a manner consistent with uniform level of illumination requirements in Table 5-1 in Chapter 5 of this compliance manual (Table 130.1-A of the Energy Standards).

(Note that the connection between the entity that initiates the DR signal and the control system within the building is not evaluated as part of the test.)

An acceptance test is necessary to ensure that the system is installed correctly and includes a basic, functional level of programming. See Nonresidential Appendix NA7.6.3 and Chapter 14 of this compliance manual for more information on the acceptance testing requirements.

Example 4-1 Compliance Method 1 – Using Centralized Powerline Dimming Control

This method requires the use of luminaires with dimmable ballasts or LED drivers, compatible with powerline controls, and the use of a lighting control panel downstream of the breaker panel. The lighting circuit relays are replaced by circuit controllers, which can send the dimming signal via line voltage wires. The panel could have several dry contact inputs that provide dedicated levels of load shed depending upon the DR signal received. Different channels can be assigned to have different levels of dimming as part of the demand response. Local controls can be provided by either line voltage or low voltage controls.

Example 4-2 Compliance Method 2 – Using Addressable Lighting System

The addressable lighting system is similar in design to that of a centralized control panel, but with additional granularity of control. With an addressable system, each fixture can be addressed individually, whereas a centralized control panel is limited to an entire channel, or circuit, being controlled in unison. The cost of enabling DR on a system with a centralized control panel is less dependent on building size or number of rooms than an addressable zone based system.

Enabling DR for the addressable lighting system entails making a dry contact input available to receive an electronic signal. This is a feature that is included in the base model of most lighting control panels. Some smaller scale addressable lighting systems may have a limited number of inputs dedicated for alternative uses, such as a time clock. If this is the case, an I/O input device can be added to the network to provide an additional closed contact input.

Example 4-3 Compliance Method 3 – Demand Response for Select Zones

Enabling demand response for a zoned system would entail adding a network adapter to each room to be controlled for purposes of demand response. The network adapter allows for each room to be monitored and controlled by an energy management control system (EMCS). These types of systems are commonly used for HVAC systems, and to respond to demand response signals. The assumption is that if the building is installing an EMCS, the preference would be to add the lighting network to that existing demand response system. There is additional functionality that results from adding the lighting system to an EMCS. In addition to being able to control the lighting for demand response, the status of the lighting system can then be monitored by the EMCS. For example, occupancy sensors would be able to be used as triggers for the HVAC system, turning A/C on and off when people entered and leave the room. Therefore, the potential for savings from this type of system is higher than the value of the lighting load shed for demand response.

DR Controls for Electronic Message Centers

Reference: Section 110.12(d)

An electronic message center (EMC) is a pixilated image producing electronically controlled sign formed by any light source. EMCs that have a lighting load greater than 15kW must have demand responsive controls unless a health or life safety statute, ordinance, or regulation does not permit EMC lighting to be reduced. The DR controls must meet the requirements in

Section 110.12(a) (as explained in Section 1 above) and be capable of reducing the lighting power by a minimum of 30 percent during a DR Period.

DR Controls for Controlled Receptacles

Reference: Section 110.12(e)

Controlled receptacles are required by Section 130.5(d) and Section 160.6(d) in nonresidential buildings, hotel/motel buildings, and multifamily common service areas. Spaces required to have controlled receptacles include office areas, lobbies, conference rooms, kitchen areas in office spaces, copy rooms.

If DR lighting controls are required in the building or space per Section 130.1(e) or Section 160.5(b)4E, DR controls are also required for controlled receptacles. The DR control must be capable of automatically turning off all loads connected to the receptacle in response to a demand response signal.

DR Controls for Power Distribution Systems

Reference: Section 130.5(e)

If DR controls are installed as part of the power distribution system (e.g., circuit-level controls), the controls must meet the requirements in Section 110.12(a) (as explained in Section 1 above).

DR controls for HVAC, lighting, or sign lighting equipment may be installed at the circuit level; in this case, the DR controls must meet the complete requirements for that application.

Energy Management Control Systems and Home Automation Systems

Required thermostatic and lighting control functions (including DR control functions) can be incorporated into and performed by an energy management control system (EMCS). Using an EMCS to perform these control functions complies with Title 24 provided that all of the criteria that would apply to the control are met by the EMCS.

A home automation system that manages energy loads (such as HVAC and lighting systems) is considered a type of energy management control system and, as such, can similarly incorporate the ability to provide required control functions.